Fruits of Warm Climates

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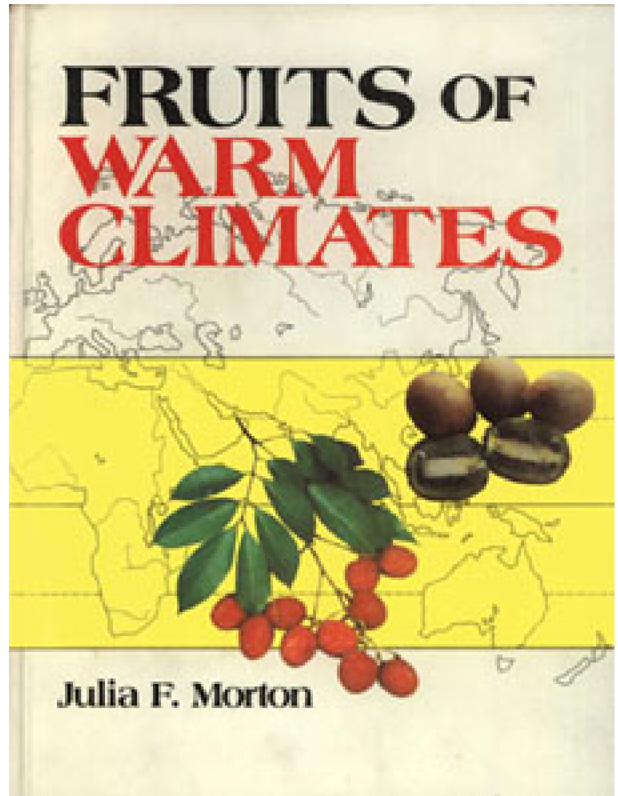

Crop Index

Crops are listed alphabetically by genus and common name.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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Online since 1995, NewCROP (New Crops Resource Online Program) is an information-rich site related to crop plants. It is a project of the Purdue University Center for New Crops and Plant Products and is associated with the New Crop Diversification project and the Jefferson Institute.

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A B C D E F G **H** I JK LM NO PQ RS TU VW XY Z

A B C DE FGH IJ KL MN OP QR ST UV WX YZ

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A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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Crops are listed alphabetically by genus and common name.

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Mabolo
Maca
Macadamia integrifolia
Macadamia Nut
Macadamia ternifolia
Macadamia tetraphylla
Macauba
Mace
Macha wheat
Machette
Madagascar periwinkle
Mad-Dog Skullcap
Madre de cacao
Mahonia nevinii
Mahuang
Maize
Malabar chestnut
Malabar, Spinach
Malay apple
Malay padauk
Malkangni
Mallontonia gnaphalodes
Malpighia glabra
Malus sp.
Mamey
Mamey Sapote
Mammea americana
Mamoncillo

A B C D E F G H I J K L M **N** O P Q R S T U V W X Y Z

A B C D E F G H I J K L M N **O** P Q R S T U V W X Y Z

A B C D E F G H I J K L M N O **P** Q R S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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A B C D E F G H I J K L M N O P Q **R** S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S **T** U V W X Y Z

Crop Index

Crops are listed alphabetically by genus and common name.

A B C D E F G H I J K L M N O P Q R S T **U** V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U **V** W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V **W** X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W **X** Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X **Y** Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y **Z**

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Abelmoschus esculentus (syn. *Hibiscus esculentus*)

Malvaceae

Bamia, *Bendi*, Bhindee, Bhindi, Bindi, Cantarela, Gombaut, Gombo, Bumbo, Lady-finger, Mesta, Ochro, Okra, Okro, Quiabo, Quimbambo, Quingombo, Rosenapfel, Vendakai

NewCROP has Okra information from:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Okra, a General Introduction

Outside links:

COOPERATIVE EXTENSION SERVICE, University of Arkansas

Commercial Production of Okra in Mississippi

The California Rare Fruit Growers

"Pushing the limits and the range of fruit growing worldwide."

Fruit Facts

Plant/Tree Descriptions List

1969-1989 Publications

Seed Bank

Fruit Specialists (Q & A)

CRFG Member Nurseries and Fruit Sources

Tidbits of Info

CRFG Publications 1969-1989 Index - A

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ABELMOSCHUS ESCULENTUS (Hibiscus esculentus) - Okra
This annual herbaceous shrub originated in Africa where it was cultivated for many generations. The fruit, large green erect pod, is eaten cooked and the seeds are toasted, ground and used as a substitute for coffee. There are many selections.

ABELMOSCHUS MANIHOT (Hibiscus manihot) - Edible Hibiscus
A shrub from the South Pacific that bears edible leaves when cooked; it grows well in warmer areas of the U.S.

ABIU - Pouteria caimito

ABYSSINIAN BANANA - Ensete ventricosum *See Bananas, Ornamental*

ACER SACCHARUM - Sugar Maple

ACEROLA

- Acerola Comes to California Loaded with Vitamin C. By Floyd L. Cooper. 1971 YB, pp 2-8
- Culture of Rare Fruits in the San Francisco Bay Area. By J. Garrin Fullington. 1974, pp 3-6
- For the Beginner: Suggestions for New Gardeners. By Phil Clark. 1985 #2, pp 6-9
- From the Editor's Mailbag. 1980 #4, pp 4-7
- Ground Cover Acerola. By Peggy Winter. 1980 #4, p 7
- Malphighia Suitable for Ground Cover. By John M. Riley. 1976 #3, pp 7-8
- More Acerolas Than You Can Eat. By Raymond F. Vincent. 1978 #4, pp 13-15
- Notes from a Grower/experimenter. By David Silber. 1987 #3, pp 20-21
- Notes on Growing Tropical Fruits in Southeast Florida. By Claude D. Reese. 1977 YB, pp 15-17
- Some Experiments on Cherimoya Pollination. By Raymond F. Vincent. 1983 YB, pp 30-36

ACHIOTE - Bixa orellana

ACHIRA - Canna edulis

ACMENA SMITHII - Acmena

- Myrtaceae: The Family of the Guava. By John F. Donan. 1984 YB, pp 5-17

ACTINIDIA ARGUTA - Siberian Gooseberry, Hardy Kiwi

ACTINIDIA DELICIOSA - Kiwi
A climbing vine from China with feather-veined simple leaves and a brown, hairy fruit about 3" long. The flesh is emerald green with many small seeds and the flavor is pleasant, slightly acid, and juicy. It grows well in California and New Zealand but cannot stand salt exposure and is

susceptible to nematodes. *See Kiwi*

ACTINIDIA KOLOMIKTA *See Kolomikta*

ACTINIDIA POLUGAMA - Silver vine

AEGLE MARMELOS - Bael Fruit, Golden Apple, Bengal Quince
A citrus family member that grows as a small spiny tree much desired in India. Fruit is round to pear-shaped, 2-4" in diameter; covered with a smooth, hard rind. Pulp is orange, sweet and aromatic with many seeds in the 8-16 fruit cells. Used for drinks, jellies and eating out-of-hand. The wood is used for carving; the shells are made into boxes and the flowers are made into perfume.

AFRICA

- Agroforestry in Zaire. By Roy M.Danforth. 1986 YB, pp 37-48
- Cultivation of Granadillas in South Africa. By Frans A. Kuhne. 1975 YB, pp 56-70
- Irrigation in South Africa; Kepel Apple. By Brian Lanton. 1983 #1, pp 3-4
- Letter from Zaire. By Roy Danforth and Paul Noren. 1987 #4, pp 20-24
- Rare Fruit in Zaire. By Roy Danforth. 1987 J, pp 13-15
- Subtropical Fruits and Nuts of Spain, Kenya and South Africa. By Muriel B. Fisch 1975 #1, pp 6-13
- Wild Fruit of South Africa Part I. By Ian Hartland. 1975 #1, pp 13-16

AFRICAN GOOSEBERRY *See Dovyalis*

AFRICAN HORNED CUCUMBER - Cucumis metuliferus. Kiwano

AFRICAN HONEYSUCKLE

- Halleria lucida. By Bernard King. 1986 #2, p 26
- Research Corner Notes. By John Riley. 1984 #2, pp 26-27

AIR LAYERING - MARCOTTING

- Cherimoya Riddle. By Jim Neitzel. 1982 #3, pp 8-12
- Coffee Tree in Folger's Commercial. By Peggy Winter. 1984 #3, pp 5-6
- Jaboticaba. By Peggy Winter. 1980 #4, p 24
- Planting Instructions for Litchis after Marcotting. By David Guggenheim. 1984 #4, pp 27-28
- Preliminary Report of a Successful Mango Air Layer. By Louis G. Lopyan. 1988 #3, pp 9-10
- Sapindaceae Family. By Bill Louscher. 1980 YB, pp 41-45
- Update from Palm Beach. By Tommy Reese. 1982 #2, pp 19-21

ALECTRYON EXCELSUS *See Titoki*

ALEURITES MOLUCCANA - Candlenut, Country Walnut
A large, open and well-formed tree native to tropical Asia. The oily nuts were used by the natives as candles, hence the name of the tree. The shells are black when ripe and, in Hawaii, are polished and used in leis. The kernels are eaten as a relish after baking and act as a laxative on some people. The plant grows in Hawaii and in the warmer protected areas of South Florida. Propagation is by seeds or cuttings.

ALLSPICE

- Bits & Pieces: By Peggy Winter. 1985 #1, pp 25-26
- Myrtaceae: The Family of the Guava. By John F. Donan. 1984 YB, pp 5-17

- News from the Hills. By David Silber. 1988 #4, pp 5-7

ALMOND

- A Naturalist in Western China. By Ernest H. Wilson. 1976 YB, p 94
- Bare Root Time Again. By Jim Neitzel. 1979 #1, pp 18-21
- Deciduous Fruit Varieties. By Jim Neitzel. 1980 YB, pp 20-40

ALPINA OFFICIANARUM *See Galangale*

AMBARELLA

- Return to the Philippines. By John McIntyre Jr. 1978 YB, pp 5-13

AMELANCHIER CANADENSIS *See Serviceberry*

AMERICAN CRABAPPLE *See Crabapple*

AMERICAN PERSIMMON

- Rare Fruit Sources. By Arlo Hale Smith. 1977 #1, pp 3-16
- Wild Fruit the United States. By Ian Hartland. 1973 #2, pp 6-7

AMERICANA (QUIZ)

- Horticultural Puzzle. By Burt and Muriel Fisch. 1979 #2, p 22

AMAIIT *See Rukam*

ANACARDIACEAE

- Anacardiaceae: Lacquer Mastic and Poison Ivy. By John F. Donan. 1986 YB, pp 1-9

ANACARDIUM OCCIDENTAL - Cashew
An easily grown evergreen relative of the mango, poison sumac and poison ivy. Very sensitive to cold, especially in warm winters followed by a freeze. Leaves are simple, leathery, light-green with a copper-red blush when young. The nut is not edible or safe when raw. Touching an uncooked nut can cause skin eruptions and the smoke given off by roasting is itself an irritant and poisonous. The cashew apple grows above the nut; it is edible and safe without treatment and makes good jelly or fermented liquor. *See Cashew*

ANANAS COSOSUS *See Pineapple*

ANNATTO - Bixa orellana

ANNONA ASIATIC (Cananga odorata) *See Yang-yang*

ANNONA CHERIMOLA - Cherimoya
This tropical highland is reportedly the best of the annonas. It is a spreading, deciduous, small tree that prefers sun, can't stand wet feet and can survive a light frost but not heavy freezes. A seedling will bear in 4-5 years. The fruit is 3-9" long, generally conical, smooth skin with bumps or dents, green to yellow when ripe. October to May in California. The pulp is white, sweet and aromatic with a custard-like texture. *See Cherimoya*

ANNONA CHERIMOLA X A. SQUAMOSA - Atemoya
A cross between cherimoya and sugar apple which does well in Florida. It resembles the sugar apple in growth but the fruit is much like the cherimoya. Propagation is by budding or grafting to seedling rootstock. *See Atemoya*

ANNONA DIVERSIFOLIA - Illama
Considered an excellent annona of the tropical lowlands, it is not well known outside Mexico and Guatemala. This slender, erect or spreading tree grows to 20-25'. Maroon-colored 1" flowers yield fruit weighing 1½ lbs., with a sweet flavor like sugar apple. *See Illama*

ANNONA GLABRA *See Pond Apple*

ANNONA MONTANA - Mountain soursop
Similar to guanabana but the fruit is less desirable and about the size of a small custard apple. Native to the West Indies, where it is called wild guanabana, the tree is larger than the guanabana and hardier, withstanding temperatures several degrees below 32°F.

ANNONA MURICATA - Soursop, Guanabana
A small, upright evergreen which cannot stand frost. It may be grown only in warmest parts of Florida or in greenhouses. The leaves are dark green and glossy. The fruit is 6-9", yellow green in color, with white flesh. The pulp is excellent for making drinks and sherbets and, though slightly sour-acid, can be eaten out-of-hand. *See Soursop*

ANNONA PURPUREA - Soncoya
From Mexico and Central America, this tropical lowland, moisture-loving tree has a fruit up to 6" in diameter. It is brownish-gray and covered with protuberances ending in hooks curved toward the stem. The flesh is bright orange and soft. *See Soncoya*

ANNONA RETICULATA - Custard apple, Bullock's Heart
A 25' low-branched deciduous tree, scraggly in appearance. The fruit is large, with yellow or brownish skin and a creamy pulp. Like all annonas, it cannot stand wet feet. Generally used as a rootstock for other annonas. *See Annona Species*

ANNONA SQUAMOSA - Sugar Apple, Sweetsop
A deciduous tree, small and open. The fruit is green, heart-shaped, 3" long, broken up by protuberances on the skin. The flesh is sweet and refreshing, considered the best of the tropical annonas. It is eaten raw, in drinks or sherbets. The flavor is best when picked before maturity and ripened in a bag. The tree does well in alkaline soils but freezes at about 27°F. *See Sweetsop*

ANNONA SPECIES

- 7th International Fruit Club Seminar. By David M. Guggenheim. 1989, #4 pp 3-10
- A Journey to Vilcabamba - the Sacred Valley of Ecuador. By Steven Spangler. 1981 #3, pp 14-17
- Bits & Pieces: Annonas. By Peggy Winter. 1988 #4, p 41
- Book Review: Classification of the Genus Annona with Descriptions of New and Imperfectly Known Species. 1988 #4. p 54
- Chelonocarpus - a New Section of the Genus Annona. By W. E. Safford. 1982 #3, pp 1-3, 28
- Chromosome Numbers in the Annonaceae. By Wray M. Bowden. 1974 YB, pp 73-81
- Two Scholars at the CRFG Meeting. By Clytia M. Chambers. 1980 #3 pp 13-14, 21-22
- Update from Palm Beach. By Tommy Reese. 1982 #2, pp 19-21

ANON *See Rollinia*

ANONILLA - Annona palmeri

ANTIDESMA BUNIUS - Bignai, Bignay
Dioecious. This large evergreen with shiny deep-green leaves is easily grown and bears large amounts of small shiny red fruits which are edible out of hand but generally used for wine or jelly. It freezes at 26°F but will recover from the roots. *See Bignai*

ANTIDESMA DALLACHYANUM - Herbert River Cherry
Small to medium Australian Tree. The best of the Antidesma species. It is dioecious, but a single female plant will bear a small amount of fruit.

Sweeter than the bignay, the fruit are large and black. Grows well in Florida and has been grown in San Diego.

APPLE CACTUS *See Pitaya*

APPLE

- (Poem) A Pie in the Sky. By Charles E. Estep Sr. 1988 J, p 48
- A Naturalist in Western China. By Ernest H. Wilson. 1976 YB, p 94
- Adapting Apples to the Tropics. By Voon Boon Hoe. 1983 #4, pp 28-32
- An Apple Experiment. By Marianne Friedman. 1987 #3, p 19
- Apple Trees and Scions Via: Covered Wagon, Pack Mule, Vacation Van. By Charles E. Estep Sr. 1988 J, pp 49-56
- Apples for a Mild Climate. By Wilbur G. Wood. 1978 YB, pp 1-2
- Apples for Low Chill Areas. By Frank James. 1989 YB, pp 6-8
- Bare Root Time Again. By Jim Neitzel. 1979 #1, pp 18-21
- Book Review: North American Apples: Varieties. Rootstocks. 1981 #1, p 13
- Containerized Layering of Malus Rootstocks. By Richard H. Munson. 1982 YB, pp 50-54
- Crusades of an Apple Lover. By Charles E. Estep, Sr.. 1989 #2, pp 20-25
- Cultural Nuggets for Would-be Apple Growers. Talk by Jim Rider. Reported by Melita Israel. 1989 #2, pp 16-19
- Deciduous Fruit Varieties. By Jim Neitzel. 1980 YB, pp 20-40
- Deciduous Fruits for Southern California. By Paul H. Thomson. 1971 #4, pp 4-8
- Early Dawn Letter. By L.D Claypool. 1983, #2 p 2
- Editor's Mailbag. By Peggy Winter. 1982 #3, pp 2-4
- Exotics: County's Hope for Top Dollar. By Frank Mickadeit. 1985 #3, pp 25-27
- Fewer Leaves Mean More Fruit. By Lynn Yarris. 1983 #4, pp 33-34
- For the Beginner: Suggestions for New Gardeners. By Phil Clark. 1985 #2, pp 6-9
- Gleanings: Triploid Apples. By Jim Neitzel. 1982 #3, pp 24-25
- Gleanings: Apples. By Jim Neitzel. 1981 #4, pp 17-19
- Gleanings: Low Chill Apples By Jim Neitzel. 1985 #3, pp 24-25
- Gleanings: Low Chill Pears and Apples By Jim Neitzel. 1982 #2, pp 14-15
- Growing Blueberries, Cherries, Cherimoyas, Longans, Apples in Thousand Oaks. By Robert F. Vieth. 1978 #4, pp 6-7
- Growing Grapes and Apples in Tropical Indonesia. By Rick Parkhurst. 1981 #2, pp 3-14
- Low Chilling Apple Varieties. By John Bregger. 1973 #2, p 4
- Miracle of Plant Propagation. By Phil Clark. 1982 #3, pp 1-4, 29
- News from the Hills. By David Silber. 1988 #4, pp 5-7
- Over Emphasis On Low Chill??? By Charles E. Estep. Sr. 1988 #1, pp 6-10
- Pest Control: Collar Rot of Apples: Prevention. By Robert W. Fitzpatrick. 1987 #2, p 24
- Plants of Interest in Hawaii. By Peggy Winter. 1983 #3, pp 15-17
- Rare Fruits, But Not New. By C.T. Kennedy. 1985 YB, pp 40-51
- Rootstock Propagation: Your Choice. By Charles E. Estep. Sr. 1987 #2, pp 11-15
- Search For an Apple , To Eat. By Charles E. Estep, Sr.. 1986 #4, pp 3-4

- The Anna Apple in Florida. By Robert S. Hardwick. 1978 #4, pp 7-8
- Two Million Apple Trees of Indonesia. By Surachmat Kusumo. 1983 #2, pp 12-13
- Update on Apple Hobby. By Charles E. Estep, Sr.. 1988 #2, pp 14-15

APRICOT

- A Naturalist in Western China. By Ernest H. Wilson. 1976 YB, p 93
- Bare Root Time Again. By Jim Neitzel. 1979 #1, pp 18-21
- CRFG Kitchen: Apricot Walnut Candy. By Rose B. Blum. 1986 #2, p 22
- Deciduous Fruit Varieties. By Jim Neitzel. 1980 YB, pp 20-40
- Deciduous Fruits for Southern California. By Paul H. Thomson. 1971 #4, pp 4-8
- Editor's Mailbag. By Clytia M. Chambers. 1989 #4, pp 31-32
- Gleanings: Apricots. By Jim Neitzel. 1985 #3, pp 24-25
- Gold-Kist Apricot. By Leo Manuel. 1982 #1, p 4
- Planting Seedlings of Tropical Fruit. By Walter V. Jerris. 1987 #3, pp 4-8
- Preliminary Apricot and Peachnectarine Comparisons. By David Guggenheim. 1986 #1, pp 22-24
- Rare Fruits, But Not New. By C.T. Kennedy. 1985 YB, pp 40-51
- Rating Deciduous Fruits. By Robert W. Fitzpatrick. 1980 #2, pp 11-15

ARATICU *See Rollinia*

ARAUCARIA ARAUCANA - Monkey Puzzle Tree
This Chilean pine tree is a relative of the Norfolk Island Pine, but the tiered branches are weirdly shaped, which accounts for its common name. Grown from North Carolina southward in the U.S., it is both lovely and grotesque. The seeds are boiled and eaten in Chile, where they are well liked.

ARAUCARIA BIDWILLI - Bunya-Bunya, Brunya
This Australian relative of the Monkey Puzzle grows to 150' in its native habitat and will grow well, though not that tall, in Florida and Southern California.

ARBUTUS UNEDO *See Strawberry Tree*

ARIZONA

- Mangoes in the Arizona Desert. By Alois Falkenstein, M.D. 1989 #4, pp 12-13

ARTOCARPUS COMMUNIS - Breadfruit, Breadnut
An exceedingly difficult to grow tree as temperatures below 40°F kill it. Fruit is green, round, to 8" and generally seedless. A seeded form is common in the tropics and called Breadnut. Fruits are cooked as vegetables. Seeds are used like chestnuts. *See Breadfruit*

ARTOCARPUS HYPARGYRAEUS - Kwaimuk
This S.E. Asian tree is extremely ornamental; moderately slow grower and not as cold sensitive as previously thought. The fruit is small, yellow and quite good to eat, with best flavor when picked dead ripe from the tree.

ARTOCARPUS INTEGRIFOLIA - Jackfruit, Jakfruit
A large interesting relative of the breadfruit. Cold sensitive (27°F) but will grow in protected areas. It bears the largest of tree fruits, on the trunk and larger branches. Spiked on the outside and weighing up to 80 lbs., the flesh is edible, soft and quite aromatic; the seeds are chestnut-like when roasted. The tree grows wild in India and S.E. Asia. Will grow in Florida and Southern California but not to its full size. Only care required is watering and fertilization. *See Jackfruit*

ARTOCARPUS ODORATISSIMUS *See Marang*

ASIAN PEAR

- Nostalgic Memories of North China Fruits. By Albert Fei. 1971 #1, pp 5-7

ASIMINA PARVIFLORA - Dwarf Pawpaw

ASIMINA TRILOBA - Pawpaw, Paw Paw
Native to North America and related to the custard apple. Cold hardy and grown as far north as New York and Michigan. This may give it promise as a rootstock for the Annonas. The fruit is edible, brown-black, with soft orange flesh tasting something like banana when ripe. The fruit must be thoroughly ripened or it is unpalatable. *See Pawpaw*

ASPARAGUS BEAN *See Winged Bean*

ATEMOYA

- Book Review: Growing Custard Apples. Reviewed by Ron Kadish. 1988 #4, p 53
- Cherimoya Riddle. By Jim Neitzel. 1982 #3, pp 8-12
- Chromosome Numbers in the Annonaceae. By Wray M. Bowden. 1974 YB, pp 73-81

AUSTRALIA

- Book Review: Growing Fruit in Australia. Reviewed by Eph Konigsberg. 1983 #2, pp 28-29
- Book Review: Tropical Tree Fruits for Australia. By P.E. Page. Reviewed by Robert R. Chambers. 1984 #4, p 26
- Down Under. By Muriel B. Fisch. 1977 YB, pp 22-31
- Growing Mangoes... Down Under. By David Wallace. 1988 #1, pp 13-14
- Newsletter, RFC of Australia. Reviewed by Ron Kadish. 1989 #1, pp 22-23
- Rare Fruit Council of Australia Common Names List. 1989 YB, pp 51-53
- RFCA Comprehensive Guide to Tropical and Subtropical Fruits. 1989 YB, pp 54-69
- Wild Fruits of Australia. By John M. Riley. 1982 YB, pp 68-75

AUSTRALIAN ALMOND - Terminalia canescens

AUSTRALIAN BRUSH CHERRY - Syzygium paniculatum

AUTUMN OLIVE

- Growing Rare Fruit in Northern Calif. By John M. Riley. 1973 YB, pp 67-90

AVERRHOA BILIMBI - Bilimbi
A medium-sized Asian tree similar to carambola but with fewer branches and longer leaves clustered at the branch tips. The red and white flowers develop on the trunk and lower branches; the fruit is 2-3" long, waxy, green cucumber-like and sour. They can be used to remove stains from clothing, can be pickled or cooked with sugar. *See Camias*

AVERRHOA CARAMBOLA - Carambola, Star Fruit
This dense, evergreen tree common in India and China grows to about 20'. Red and white flowers appear on bare branches or at leaf bases. Fruit has a thin, waxy, green-yellow, yellow or orange skin. Oblong and five-angled it is star-shaped when cut across the middle. It has a sweet, watery, slightly acid, pleasant tasting pulp that is eaten raw or preserved. Seedlings have been known to bear in 3 years. Large trees have been known to survive 26°F without damage but young trees must be protected from frost. *See*

[Carambola](#)

AVOCADO

- A Mercadante Tribute. By Gray Martin. 1987 #4, p 7
- Avocado. By Donald W. Mitchell. 1979 YB, pp 14-16
- Avocado Flower Types. USDA, U.C. San Diego. 1983 #1, pp 7-8
- Avocado Girdling and Grafting. By Orton Englehart. 1971 #1, p 15
- Avocado Notes. By Bob Fitzpatrick. 1984 #2, pp 9-10
- Avocado Pollination in the San Fernando Valley. By Phillip Frankel. 1970 #4, p 6
- Avocados for Cold Climates. By Robert W. Fitzpatrick. 1988 #4, pp 42-43
- Avocados Growing in San Jose. By J.W. Stephenson. 1984 #3, pp 4-5
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- Herb Trees for Warm Climates. By Robert E. Bond. 1989 J, pp 43-44
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- Summer Bearing Avocado Possibilities. By Jim Neitzel. 1980 #4, pp 13-14
- Unclassified Avocado Varieties on the Property of Joe Massidda. By John Delevoryas. 1974 YB, pp 207-214
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- Winter in Santa Cruz. By Andrew P. Werner. 1976 #2, p 10

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Muskdana or Ambrette (*Abelmoschus moschatus*): Aromatic and Medicinal

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Abelmoschus moschatus (L.) Medic, Malvaceae (Syn. *Hibiscus abelmoschus* L.) is a tropical weedy shrub native to India valued for its scented seed. Ambrette is a close relative to Okra, a popular horticultural crop. The genus *Abelmoschus* has six species distributed in the South and South East Asia and in North Australia. *Abelmoschus moschatus* Medic., *A. manihot* (L.) Medic., and *A. esculentus* (L.) Moench, contain wild and cultivated forms, and *A. ficulneus, A. crinitus,* and *A. angulosus*, are only wild. *Abelmoschus manihot, A. moschatus* and *A. esculentus* are compared in Table 1. In Hindi, it is popularly known as *mushkdana, kasturi bhendi* (kasturi = musk; *bhendi* = lady's finger). In other Indian languages it is known as *gukhia korai* (Assamese), *kasturi bhenda* (Telgu), *kattukasturi* (Malylam), *varttilai kasturi* (Tamil), *lalkasturika* (Sanskrit) (Krishnamurty 1993). The area under ambrette is presently low in India but is increasing rapidly (Oudhia and Tripathi 2000) with seed exports to France, Germany, Japan, Singapore, Spain for its use as an aromatic oil. Indian drug manufacturers are introducing new herbal drugs containing ambrette for medicinal use.

Table 1. Comparison of *A. esculentus, A. manihot* and *A. moschatus*.

Particulars	*A. esculentus* (n=65)	*A. manihot* (n=60)	*A. moschatus* (n=36)
English name	Okra, Gumbo	Manihot-mallow	Musk-mallow
Place of origin	Old world tropics	East Asia	India
Life cycle	Annual	Annual or perennial	Annual or biennial
Leaves	Large often 12 inch or more across; cordate-ovate.	Leaves large ovate to nearly orbicular in outline 6-12 inch or more. Manihot probably suggests the resemblance of leaves to those of cassava or manihot	With variously 3-9 lobed or divided. Margins coarsely toothed

Floral characteristics	Calyx large and spathe-like; bracts of involucre linear; pod 4-5 inch or more long.	Calyx large and spathe-like; bracts ovate to oblong.	Calyx large and spathe-like; Bracts of involucre linear; pod 3 inch or less long.
Flower colour	Yellow with a reddish center	Yellow or whitish with a dark brown center.	Yellow with a crimson center.

Botany

Erect hispid herbs or undershrubs, 0.5-2.5 meters high, with a long slender tap root. Leave extremely variable, lower suborbicular in outline, cordate, lower or palmately 3-7 lobed, upper narrower, hastate or sagittate at the base with linear-oblong or triangular lobes. Flowers regular, bisexual, involucral bracts 8-12, hairy yellow with purple centre. Fruits capsule fulvous hairy, oblong lanceolate, acute. Seeds subreniform and blackish (Verma et al. 1993; Agharkar 1991; Lindley 1985).

Uses

Ambrette oil obtained from seeds possess an odor similar to that of musk and its aromatic constitents have long been used in perfumery industry. Different grades of essential, or aromatic absolute, are marked in Europe as high-grade perfumes (Singh et al. 1996) The seeds are valued for the volatile oil present in the seed coat. Seed analysis report 11.1% moisture, 31.5% crude fiber; 14.5% lipids, 13.4% starch, 2.3% protein, volatile oil (0.2-0.6%) and ca/ 5% resin (Srivastava 1995).

Analysis of volatiles report myricetin-3-glucoside and a glycoside of cyanidin in flowers, an aromatic constituent in seeds, beta-sitosteral and its beta-D-glucoside, myricetin and its glucoside in leaves and petals and beta-sitosterol from dry fruit husk (Rastogi and Mehrotra 1991a,b).

In India, roots, leaves (rarely), and seeds of ambrette are considered valuable traditional medicines. The bitter, sweet, acrid, aromatic seeds are used as a tonic and are considered "cooling, aphrodisiac, opthalmic, cardiotonic, digestive, stomachic, constipating, carminative, pectoral, diuretic, stimulant, antispasmodic, deodorant, and effective against "*kapha*" and "*vata*," intestinal complaints, stomatitis; and diseases of the heart, allays thirst and checks vomiting. According to *Unani* system of medicine seeds allay thirst, cure stomatitis, dyspepsia, urinary discharge, gonorrhea, leucoderma and itch. Roots and leaves are cures for gonorrhea (Agharkar 1991). Even use against venomous reptiles has been reported (Lindley 1985).

Cultivation

Ambrette is cultivated as pre-kharif crop in India. It is usually sown in March–April but as late as the first week of July in Central India (Oudhia 2001a). Seed rates of 41g/kg are optimum (Oudhia 2000b). Application of dried Neem leaves (500Kg/ha) at last ploughing increased oil content and quality. April sown crop start flowering in September; fruits ripen from November to January and are harvested when fully mature. Applications of fertilizers improves growth of plant and seed yields (Krishnamurty 1993) but studies conducted by SOPAM indicate the use of chemical inputs resulted in negative impact on oil content and quality. Harvested capsules are sun dried and seeds dehisce when the capsules burst. The oil for perfumery is extracted by steam distillation of crushed seeds.

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Abies balsamea (L.) Mill.

Abietaceae
Balsam Fir, Balm of Gilead Tree, Canada Balsam

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The balsam or pitch, in extreme emergency, forms a highly concentrated, though disagreeable, food." (Fernald, Kinsey, and Rollins, 1958). Bark of conifers, mostly, was so important in the diet of some tribes that at least one tribe, the Adirondacks, owe their name to the Mohawk term for "tree eaters." Erika Gaertner devotes a four-page article to the making of breadstuff from the bark of balsam fir. In contrast to pine bark, the fir bark is a delight to chew in winter or early spring, slightly mucilaginous and sweetish, better raw than cooked (Gaertner, 1970). Inner bark that does not show any discoloration can be used for breadstuff and it takes about an hour to peel enough for one loaf. Leaves average 0.65% essential oil, ranging to 1.4% or higher. Trunks also yield oil of "Canada balsam" or turpentine, used as a permanent mounting medium in microscopy and as a cement for glassware. Canada turpentine yields 15–25% volatile oil, the resin being used for caulking and incense (Erichsen-Brown, 1979). Often used for Christmas trees. *Abies* species are commercially valuable for timber even though their wood is relatively soft, weak, and perishable. Balsam fir is used in the US for timber and plywood, and is the mainstay of the pulp wood industry in the northeast.

Folk Medicine

According to Hartwell (1967–1971), the buds, resin, and/or sap are used in folk remedies for cancers, corns, and warts. Reported to be anodyne, antiseptic, diaphoretic, diuretic, masticatory, and vulnerary, balsam fir is a folk remedy for bronchitis, burns, cancer, catarrh, cold, consumption, cough, dysentery, earache, gleet, gonorrhea, heart ailments, leucorrhea, paralysis, rheumatism, scurvy, sores, ulcers, urogenital ailments, warts, and wounds (Duke and Wain, 1981; Erichsen-Brown, 1979). Chippewa used the gum as an analgetic, the root decoction as an antirheumatic. Kwakiutl used the gum as a laxative and held the root in the mouth to cure sores there. Menominee used the gum for colds, cuts, lungs, and sores, the inner bark for chest pains, colds, and skin. Montagnai applied the gum for chest or heart pain. Ojibwa use the gum for colds, sores, sore eyes, and venereal diseases; the leaves as stimulant; Penobscot used the gum for cuts and sores; Pillagers used the needles in sweat baths and fumitories. Potawatomi used the gum for colds and sores, the bark infusion for consumption and other ailments. Caughnawaga used the gum as a cataplasm for cancer (Duke, 1983c).

Chemistry

Reducing sugars are said to account for 47% of the DM of balsam fir bark. The leaf oil contains 17.6% bornyl acetate and probably 1-α-pinene, Canada balsam contains ca 20% 1-β-phellandrene and smaller quantities of α- and β-pinene bornyl acetate, and the alcohols androl and bupleurol (Guenther, 1948-1952). Oils are also reported to contain juvabione and dehydrojuvabione (List and Horhammer, 1969–1979). The term Canada Balsam is a misnomer because balsams are supposed to contain benzoic and cinnamic acids, both absent from the Canada oleoresin. "Turpentine" is also a misnomer, implying that the oleoresin is entirely steam volatile. Actually it contains 70–80% resin, only 16-20% voaltile oil (Anderson, 1955). One analysis of the essential oils reports 14.6% bornyl acetate, 36.1% β-pinene, 11.1% 3-carene, 11.1% limonene, 6.8% camphene, and 8.4% α-pinene (Erichsen-Brown, 1979).

Toxicity

Canada balsam is reported to produce dermatitis when applied as perfume. The foliage has also induced contact dermatitis.

Description

Tree to 20 m tall; trunk 3–5 dm in diameter. Bark brown, broken into scaly plates with resin-filled pockets. Twigs pale green and pubescent when young, becoming gray, reddish, or purplish. Leaves dark green, linear, sessile, spiral in origin, but twisted at base to form two ranks; leaves persisting many years; leaf-scars circular. Lower leaves to 3 cm long, those on coniferous branches much shorter. Winter buds globose, 3–6 mm in diameter, with orange-green scales, resinous. Mature cones nearly cylindrical, 3–8.5 cm long by 2–3 cm thick, dark purple when growing. Bracts ovate, the distinct awn protruding beyond the scale below it. Seeds ovoid or oblong, acute at base, with thin wing and resinous vesicles, maturing in one summer. Germination phanerocotylar (Brown and Brown, 1972).

Germplasm

Reported from the North American Center of Diversity, balsam fir, or cvs thereof, is reported to tolerate frost and slope. ($2n = 24$)

Distribution

Labrador and Newfoundland south to New York and Pennsylvania, west to central-Wisconsin and Minnesota, north and west to Alberta; generally south of 55°N latitude, except in Alberta and Saskatchewan (Ag. Handbook 450, 1974).

Ecology

Estimated to range from Cool Temperate Moist to Wet through Boreal Moist to Wet Forest Life Zones, balsam fir is estimated to tolerate annual precipitation of 6 to 15 dm, annual temperature of 5 to 12°C, and pH of 4.5 to 7.5. Female strobili may be wholly or partially aborted up to 6 to 8 weeks after bud burst by late spring frosts. Pollen dispersal can be reduced by adverse weather (Ag. Handbook No. 450)

Cultivation

Flowering in May, fruiting August-September; seeds are dispersed in late September. Extensive data on seed vitality etc. are reported in Agriculture Handbook No. 450. Seeds should be moist stratified 14–28 days at 1–5°C. Seed may be sown in autumn without stratification, with target seedling densities in the nursery ca 450–500/m^2, often mulched with sawdust. Of slow initial growth, the stock is usually outplanted as 2- to 3-year-old seedlings or 3- to 4-year-old transplants (Ag. Handbook 450, 1974).

Harvesting

"Turpentine" is usually collected July-August by breaking the turpentine blisters into small metal cans with sharp-pointed lids. Trees are then allowed to recuperate 1–2 years. For the leaf oil, it would appear that branches should be snipped off younger trees in early spring (January-March).

Yields and Economics

Fifteen year old trees yield 70% more leaf oil than 110-year-old trees; oil yields are highest in January–March and September, lowest from April to August. Around 1800, one author reported averaging nearly a ton of balsam at "6 pence a lb." (Erichsen-Brown, 1979).

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges from 9 to 13 MT/ha, standing biomass from 77–200 MT/ha. Gaertner cites references dealing with the potential use of bark for fuel, as charcoal or briquets.

Biotic Factors

The following are listed as affecting *Abies balsamea*: Acanthostigma parasiticum, *Adelopus nudus, Aleurodiscus abietis, A. amorphus, Armillaria mellea, Ascocalyx abietis, Bifusella faulii, B. linearis, Cenangium ferruginosum, Cephalosporium* sp., *Coniophora puteana, Corticium galactinum, Coryne sarcoides, Cryptosporium macrospermum, Cyptospora pinastri, Dasyscypha agassizii, D. arida, D. calyciformis, D. calycina, D. resinaria, Dermea balsamea, Dimerosporium balsamicola, Echinodontium tinctorium, Flammula alnicola, Fomes pini, F. pinicola, F. robustus, F. roseus, F. subroseus, Fusicoccum abietinum, Gloeosporium balsameae, Herpotrichia nigra, Hyalopsora aspidiotus, Hydnum balsameum, Hymenochaete tabacina, H. mirabilis, H. nervata, H. punctata, Lenzites saepiaria, Leucostoma kunzei, Limacina alaskensis, Lophodermium autumnale, L. lacerum, L. piceae, Melampsora abieti-capraearum, M. epitea, Melampsorella caryophyllacearum, M. cerastii, Merulius himantoides, Micropera abietis, Milesina fructuosa, M. laeviuscula, M. marginalis, M. polypodophila, M. pycnograndis, M. vogesiaca, Nectria cucurbitula, Nothophacidium abietinellum, Odontia bicolor, Ophionectria scolecospora, Peniophora gigantea, Peridermium balsameum, Phacidium abietinellum, P. abietis, P. balsameae, P. infestans, Phaeocryptopus nudus, Phaeophacidium abietinum, Polyporus abietinus, P. anceps, P. balsameus, P. circinatus, P. fragilis, P. guttulatus, P. hirtus, P. mollis, P. resinosus, P. schweinitzii, P. tomentosus, Poria sericeo-mollis, P. subacida, P. vaporaria, Potebniamyces balsamicola, Pucciniastrum epilobii, P. goeppertianum, P. pustulatum, Rehmiel-lopsis abietis, R. balsamea, Rhizosphaera pini, Rhizothyrium abietis, Sarcotrochila balsamea, Scoleconectria cucurbitula, Sphaeropsis abietis, Stereum chailletii, S. pini, S. sanguinolentum, Thyronectria balsamea, Trametes heteromorpha, Trichoscyphella resinaria, Tympanis pinastri, Uredinopsis ceratophora, U. longimucronata, U. mirabilis, U. osmundae, U. phegopteris, U. struthiopteridis, Valsa abietis, V. pini* (Ag. Handbook 165, 1960; Browne, 1968). Also listed in Browne (1968) are the following: Angiospermae: *Viscum album*; Acarina: *Trisetacus grosmanni*; Coleoptera: *Dryocoetes confusus, Hylobius pales, H. pinicola, H. warreni, Melanophila drummondi, Monochamus scutellatus, Pityokteines sparsus, Pityophthorus cariniceps, P. granulatus, P. puberulus, Polygraphus rufipennis*; Diptera: *Dasyneura balsamicola*; Hemiptera: *Adelges piceae, Aphrophora parallela, Cinara curvipes, Mindarus abietinus, Prociphilus bumeliae*; Hymenoptera: *Camponotus* spp., *Gilpinia hercyniae, Megastigmus specularis, Neodiprion abietis, Pleroneura borealis, Urocerus albicornis, Xeris spectrum*; Lepidoptera: *Acleris variana, Choristoneura* *fumiferana, Cladaria limitaria, Dasychira plagiata, Dioryctria abietivorella, Hemerocampa leucostigma, Lambdina fiscellaria, Lymantria dispar, Melanolophia imitata, Orgyia antiqua, Protoboarmia porcelaria, Semiothisa granitata, Zeiraphera canadensis*; Aves: *Loxia curvirostra, L. leucoptera*; and Mammalia: *Alces alces, Erethizon dorsatum, Euarctos americanus, Odocoileus virginianus, Peromyscus* sp., *Tamiasciurus hudsonicus*. Seed production may be reduced by squirrels and birds. *Abies* cones are preferred source of food for squirrels in some localities. Large quantities of cones are cut and cached; such cutting may also reduce future cone crops. Cone and seed insects may significantly reduce seed yields and occasionally totally destroy seed crops. Seed chalcids (*Megastigmus* spp.) are most common and may be abundant enough to have a major impact. For example, *Megastigmus pinus* typically infest 8-10% of *A. concolor* seed and have destroyed as much as 60% of a crop. Cone moths (e.g., *Barbara colfaxiana siskiyouana* and *Dioryctria abietivorlla*) and cone maggots (*Earomyia* spp.) cause the most conspicuous damage; all seeds are lost in heavily infested cones. Cone and scale midges cause no significant loss, but seed or gall midges may reduce seed yields by fusing seeds to cone scales (Ag. Handbook 450, 1974). Nematodes reported include *Criconemella (Criconemoides) lobata, Paratylenchus* sp., *Rotylenchus* sp., *Tylenchorhynchus maximus* and *Xiphinema americana* (Golden, p.c. 1984).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update November 10, 1997

Pouteria caimito Radlk.

Sapotaceae

Abiu

We have information from several sources:

Abiu—Julia Morton, Fruits of warm climates

Sapotaceae—R.J. Campbell, South American fruits deserving further attention

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Artemisia absinthium L.

Asteraceae (Compositae)

Wormwood, Absinthe

NewCROP holds information from the following sources:

Herbs: An Indexed Bibliography. 1971-1980—J.E. Simon, A.F. Chadwick and L.E. Craker

The Herb Hunters Guide—Sievers, A.F. 1930.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links to Wormwood info:

Illustration of *Artemisia absinthium* L. from Hermann A. Köhler's 3-part tomes *Medizinal Pflanzen* (1887) plates.

Wormwood and absinthe FAQ's.

Wormwood from the "Vaults of Erowid"

Acacia species

Mimosaceae or Leguminosae (Fabaceae), subfamily Mimosoideae

Acacia, Catclaw acacia, Egyptian thorn, Mimosa, Prairie acacia, Wattle

The genus *Acacia* includes about 800 species, which are mostly tropical shrubs and trees. The genus is very similar to the genus *Mimosa*, with many species having been reassigned from one genus to the other, creating synonomous epithets.

NewCROP has Acacia information at:

Acacia in Australia: Ethnobotany and Potential Food Crop. Lister, P.R., P. Holford, T. Haigh, and D.A. Morrison. 1996. p. 228-236. In: J. Janick (ed.), Progress in New Crops. ASHS Press, Alexandria, VA.

The following in-depth articles on *Acacia* species are from from Handbook of Energy Crops. James A. Duke. 1984. (unpublished).

- *Acacia albida*—Apple-Ring Acacia, Ana Tree, Winter Thorn.
- *Acacia auriculiformis*—Darwin Black Wattle.
- *Acacia cyclops* - Rooikrans
- *Acacia farnesiana* , Syn.: *Mimosa farnesiana* - Cassie, Huisache.
- *Acacia mangium* - Mange, Forest Mangrove
- *Acacia mearnsii*, Syn.: *Acacia mollissima*, Syn.: *Acacia decurrens*, var. *mollis* Lindl. - Black Wattle, Acacia Negra, Acacia Noir, Schwarze Akazie, Gomboom
- *Acacia nilotica*, Syn.: *Mimosa nilotica* - "Motse.html", Egyptian Mimosa, Thorn.
- *Acacia saligna* - Orange Wattle
- *Acacia senegal*, Syn.: *Acacia verek* - Gum Arabic, Senegal Gum, Sudan Gum Arabic, Kher, Kumta
- *Acacia seyal* - Shittim Wood, White Whistling wood
- *Acacia tortilis*, , Syn.: *Acacia raddiana*, , Syn.: *Acacia spirocarpa*, Syn.: *Acacia heteracantha* - Umbrella Thorn, Israeli Babool

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And outside links to more Acacia info:

Hundreds of Acacia photographs from the Australian National Botanic Gardens Photograph Collection

Care and cultivation information of various Acacias in California.

Acacia albida Del.

Mimosaceae
Apple-Ring Acacia, Ana Tree, Winter Thorn

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Acacia albida is a widely used tree well documented for increasing the yields of crops grown under it. According to VITA (1977) "*A. albida* is highly valued in conservation efforts. It is the only species which loses its leaves during the rainy season; therefore, farming under these trees is not only possible but profitable." It is held sacred by the Africans of the Transvaal. In Nigeria, the pod is used as camel food. The gum that exudes spontaneously from the trunk is sometimes collected like gum arabic. The timber, though straight grained, close, and weighty, is soft, fibrous, and unsuitable for agricultural implements (Watt & Breyer-Brandwijk, 1962). One writer even questions its value for fuel wood. Masai use it as the soft flat wood upon which the firestick is twirled to make fire. Wood is used for canoes, mortars, and pestles. The bark is pounded in Nigeria and used as a packing material on pack animals. Ashes of the wood are used in making soap and as a depilatory and tanning agent for hides. VITA (1977) says the wood is used for carving; the thorny branches useful for a natural barbed fence. Pods and foliage are highly regarded as livestock fodder. Some 90% of Senegalese farmers interviewed by Felker (1981) collected, stored, and rationed *Acacia alba* pods to livestock. Rhodesians use the pods to stupefy fish. Humans eat the boiled seeds in times of scarcity in Rhodesia. Apparently it is erroneously taken as an indicator of a shallow well site.

Folk Medicine

Reported to serve as an emetic in fevers (Masai), taken for diarrhea in Tanganyika. Also used for colds, diarrhea, hemorrhage, and ophthalmia in West Africa. The bark of the Ana tree is a folk remedy for diarrhea among several tribes. On the Ivory Coast it is used for leprosy. The bark decoction curtails nausea. A liniment, made by steeping the bark, is used for bathing and massage in pneumonia. The bark infusion is used for difficult delivery, and is used as a febrifuge for cough (Irvine, 1961). Pods worn as charm by African women and children to avert smallpox.

Chemistry

The following table is reproduced, with permission from FAO's Tropical Feeds (1981):

Nutritive Table (Gohl, 1981)

		As % of dry matter						
	DM	CP	CF	Ash	EE	NFE	Ca	P
Fresh flowers, Sudan	17.8	19.0	12.5	9.7	1.6	57.2		
Fresh whole leaves, Niger		19.7	19.6	7.2	1.6	51.9	1.00	0.23
Fresh leaflets, Sudan	36.3	17.1	12.4	8.4	2.3	59.8		
Pods, Tanzania		8.8	24.4	3.7	1.4	61.7	0.65	0.23
Pods, Niger		14.3	24.7	6.3	1.5	53.2	1.11	0.14

		Digestibility				
	Animal	CP	CF	EE	NFE	ME
Pods	Cattle	51.0	16.5	71.4	74.8	2.09

Bark contains 2–28% tannin, the fruit 5–13%.

Description

A large thorny tree up to 20 m high and >2 m in diameter; bole forming up to 1/3 of height of tree; bark dull grey, fissured when old, crown dense; tree puts out leaves during dry season and sheds them during rains; branchlets light grey, spiny only at nodes, spines straight, up to 1 in. long; leaves pale and glaucous, bluish grey, glabrous or pubescent, 2-pinnate, 9 to numerous pairs of pinnae, cup-like glands on rachis, each pinna with 12 or more pairs of leaflets, leaflets oblong, up to 1 cm long, hairy, unequal at base; flowers (Jan., Apr., Nov.) in yellow spikes 10–12.5 cm long; fruits (Jan., May, Nov.) bright yellowish green when dry, up to 12–15 x 4 cm, slightly curved, ends rounded (Irvine, 1961).

Germplasm

Reported from the African Center of Diversity, the Ana Tree, or cvs thereof, is reported to tolerate poor soil, drought, savanna, and some waterlogging (VITA, 1977). Back in 1978, when Senegalese farmers wanted seedlings, none were available. There is great variability in the morphology and pod yields. Selection of wild plants for pod yield and/or fast growth would be a worthwhile contribution to arid developing countries. ($2n = 26$)

Distribution

Native to the Transvaal and Southwest Africa, through West and North Africa to Egypt, East Africa.

Ecology

Probably ranging from Tropical Thorn to Subtropical Moist Forest Life Zones, the Ana Tree is reported to tolerate annual precipitation of 3 to 6dm. Irvine (1961) describes it as the largest thorn tree in Savanna Forest, especially in inhabited areas; often left untouched, sometimes gregarious. In more mesic Sahelian regions (400–600 mm/yr), yields of millet, peanuts, and sorghum are increased from ca 500 to ca 900 kg/ha/yr by growing under the canopy of *Acacia albida* (Felker, 1978). Does best in sandy soils, growing well where millet grows. Though faring best on sandy soils, it will tolerate heavier soils with some waterlogging.

Cultivation

As late as 1978, techniques for establishing new seedlings had not been worked out, according to Felker (1978). Seeds devoid of bruchid holes should be scarified and started in deep containers to accomodate development of the tap root. Good-sized plants develop in 10–14 weeks, but frequent root pruning is advised. Transplants from the wild are usually unsuccessful because of the long tap root. VITA (1977) has a novel approach, feeding the seed to livestock, which then graze the desired areas, eliminating seeds with their manure. Nursery plantings, spaced at 10 x 10 m may require watering at first, and protection from grazing animals for 5–8 years.

Harvesting

Peasants gather pods to feed to their cattle, or lop the foliage in the dry season, when most other trees are leafless.

Yields and Economics

According to FAO (1980) a full grown tree can produce more than 100 kg pod/yr. Felker (1978) notes that pod yields range from 6–135 kg/tree. Some scientists believe that yields could be managed to a much higher level than those of the grasses and annual crops grown under the tree. Trees have reached 2 to 4 m after only 3 or 4 years growth.

Energy

Related species such as *Acacia tortilis* have been reported to yield giraffe forage to the tune of 5 MT/ha/yr. Yield increases under *Acacia albida* correlate with a several fold increase in soil N and organic matter, coupled with improved soil water-holding capacity. *Acacia albida* has been shown to nodulate and reduce acetylene. While Acacias cannot be recommended for cold and/or humid or everwet climates, they are suggested by the NAS (1980a) as firewood sources in developing countries. Among the species they consider are *Acacia arabica, auriculiformis, brachystachya, cambagei, cyanophylla, cyclops, dealbata, decurrens, ehrenbergiana, fistula, heteracantha, holosericea, lysiophloia, mangium, mearnsii, mollissima, nilotica, nubica, raddiana, saligna, senegal, seyal, spirocarpa, tortilis*, and *verek*. The Ana Tree was not recommended for firewood.

Biotic Factors

Caterpillars, locusts, and grazing animals may destroy the seedlings.

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Last update November 10, 1997

Acacia auriculiformis A. Cunn.

Mimosaceae
Darwin Black Wattle

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Used for fuelwood plantations as an ornamental and shade tree, quite tolerant of heat, the Australian species is widely planted in Oceana and southeast Asia. The wood is also employed for making farm tools and furniture (NAS, 1983a). Recent Australian tests suggest that 10-year old trees can be pulped readily by the sulfate process, giving high pulp yields, with good strength properties. Also produces high quality pulp by the neutral sulfite semichemical process. The tannin produces a good quality leather, inclined to redden upon exposure to sunlight (NAS, 1980a). The plant is amazing in its ability to recolonize wastes, papermill sludge, pH ca 9.5; even uranium spoils, pH ca 3.0; the only tree found on 20-year old uranium spoil. Used for the cultivation of the lac insect in India.

Folk Medicine

No data available.

Chemistry

The gum contains 5.3% ash, 0.92% N, and 1.68% methoxyl, and ca 27.7% uronic acid. The sugar from the gum after hydrolysis, contained 10.1% 4-0-methylglucuronic acid, 17.6% glucuronic acid, 59% galactose, 8% arabinose, and 5% rhamnose (Anderson, 1978). Bark contains ca 13% water.

Description

Resilient, vigorously growing, crooked or gnarled deciduous or evergreen tree, possibly attaining 30 m height, 60 cm DBH. Leaves alternate, simple flattened phyllodes, lanceolate or oblong, arcuate, long-attenuate at both ends, 10–16 cm long, ca 1.5–2.5 cm broad, thick coriaceous, glabrous with several long parallel veins from the base. Spikes 5–8 cm long, paired at the leaf bases. Flowers sessile, ca 3 mm long, the calyx glabrous, 5-toothed, the 5 petals ca 2 mm long. Stamens numerous, filiform, ca 3 mm long. Ovary pubescent, the style filiform. Pods 6–8 cm long, 1–1.5 cm broad, flattened but coiled. Seeds several, flattened-ellipsoid, ca 5 mm long, with a reddish or orangish aril (Little, 1983). Seeds 53,000–62,000/kg.

Germplasm

Reported from the Australian Center of Diversity, *Acacia auriculiformis*, or cvs thereof, is reported to tolerate alkalinity, desiccation, drought, fire, high pH, laterite, poor soil, sand dunes, and savanna. It is intolerant of hurricane, shade, and weeds, at least in early stages. Once established, the tree is quite competitive with weeds. Though somewhat tolerant of fire, it is not so resistant as Eucalyptus. ($2n$ = 26)

Distribution

Native to the savannas of New Guinea, islands of the Torres Strait, and northern Australia, it has been widely introduced, e.g. in Fiji, India, Indonesia, Java, Malaysia, Niger, Nigeria, Philippines, Tanzania, Thailand, the Soloman Islands, Uganda, and Zanzibar.

Ecology

Estimated to range from Subtropical Moist to Wet through Tropical Dry to Wet Forest Life Zones, *Acacia auriculiformis* is reported to tolerate annual precipitation of 7.5 to 27 dm, annual temperature of 26 to 30°C, and pH of 3.0 to 9.5. With practically no maintenance it will grow on a wide range of deep and shallow soils, compacted clays, coral soils, laterites, limestone, mica schist, mine spoil, podzols, even sand dunes and unstable slopes.

Cultivation

It has been suggested as an interplant with long-term timber Dalbergias, itself serving as a short-term but renewable firewood source. Seeds, storable for 18 months in airtight containers, should be soaked in hot water for 24 hours. Sow in full light, allowing 6 days for germination (ca 80% germination after 2–4 weeks). To reforest grassland, burn and plant in holes ca 36 x 30 x 30 cm, spaced at 1–2.5 or 1–3 m if intercropped with *Cassia siamea*. Recent spacings have been 2.5 x 2.5 m.

Harvesting

In Indomalaysia, stands are operated on 10–12 year rotations. Trees coppice poorly. Indonesians have gotten some coppice when trees are cut at least 50 cm above the ground. When trees are felled, there is usually a swarm of seedlings, so cutover stands regenerate readily.

Yields and Economics

With rainfall at 2700 mm, at 3 years, average height of a stand with 1010 trees/ha was 12.4 m, average diameter 12.2 cm, standing wood volume 73.2 m^3/ha; at age 4, 13.1 m, 13.6 cm, and 96.1 m^3/ha. Stemwood volume is ca 60% of total above ground biomass. Leaf biomass is important, the LAI being 7–8, good for shading out weeds. Average amount of dead litter is 4800 kg/ha. In Java, there may be 3 MT/ha leaves and 2 MT/ha twigs and branches beneath the trees (NAS, 1982a). On infertile abandoned sites in Papua, trees grew 6 m in 2 years, 17 m in 8 years. On shallow arid soils in West Bengal, yields were only 5m^3/ha/yr at the 15th year. Under moister conditions 10 m^3 is reported, 17–20 in Indonesia and Malaysia.

Energy

Wiersum and Ramlan report that yields can run higher than 20 m^3/ha/yr on a 10–20 year rotation. On poor soils yields drop to 8–12 m^3. On the Island of Madura, with annual rainfall 1700–1900 mm, 7–12 year old rotations run 7.6–9 m^3/ha/yr, but on West Bengalese laterites with annual precipitation 1,000–14,000 mm, yields are only 2–6 m^3/ha/yr in 10–20 year rotations. With its capacity to produce good fuelwood on poor soils, even where there are extended dry seasons, the species "merits large scale testing as a fuelwood species" (NAS, 1980). Wood has specific gravity of 0.6–0.75 and calorific value of 4,800–4,900 kcal/kg. Wood yields excellent charcoal that glows well and burns without smoke or sparks. Litter beneath the trees, both branches and dried leaves, annually adds up to 4.5–6 MT/ha, all used for fuel in China. Hawaiian grown material possesses N-fixing nodules.

Biotic Factors

While no pest or disease problems are reported in Indonesia, insects and nematodes have been reported to attack seedlings in Zanzibar. The rust *Uromyces digitatus* has been a problem in Java, where it is also occasionally infested with a rather inocuous black mildew, *Meliola adenanphererae*. In India, the root rots are *Ganoderma lucidum* and *Ganoderma applanatum*. *Hypothenemus dimorphus* has caused shoot fatality in Malaysia. The weevil *Hypomeces squamosus* can be a pest in India and Malaysia. Used to cultivate *Kerria lacca* in India. On Java, the ant *Iridomyrmex rufoniger* may protect the plant from some phytophagous insects.

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Acacia cyclops A. Cunn. ex G. Don

Mimosaceae
Rooikrans

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Producing a dense high quality firewood, this species has been recommended for stabilization of coastal dunes. Goats and antelope browse the phyllodes. The seeds and their oily funicles are eaten by birds, primates, and rodents, and if crushed, might be suitable for cattle.

Folk Medicine

With its high tannin content, the species could serve as an astringent.

Chemistry

Bark has yielded 6.5% tannin, or in Natal, up to 12.1%. Seed contains 10% of fixed oil, the aril or funicle 40%.

Description

Dense, evergreen bushy shrub, often multistemmed, or small tree 3 to 8 m tall, with a rounded crown . In windy coastal sites it forms a hedge less than 0.5 m high. The foliage comprises light green phyllodes, varnished when young, and growing in a downward vertical position. Pods, maturing in summer, are not shed, but remain on the tree, exposing the seeds to predators and dispersers.

Germplasm

Reported from the Australian Center of Diversity, *Acacia cyclops* is reported to tolerate drought, salt, sand, weed, and wind.

Distribution

Native to southwestern Australia, where it grows mostly on coastal sand dunes. Used for stabilization in South Africa, it is spreading on sand and sandstone into coastal bush and heathland. This is an extremely weedy species spread by birds into indigenous vegetation. Once established, it is difficult to remove or replace. There is little vegetation cover beneath an *Acacia cyclops* thicket. The seeds remain viable in the soil for many years. It is relatively slow growing.

Ecology

Acacia cyclops can grow in dry areas with annual precipitation less than 300 mm. Tolerating salt spray, wind, sand-blast, or salinity, it is useful for dune stabilization. This species has a high light demand; it will not survive in deep shade. Monthly temperature means within the distribution range of this species vary from 5°C in winter to 31°C in summer. It is slightly resistant to frost. The species is generally found below 300 m altitude where annual rainfall is 200 to 800 mm. It grows on quartzitic or calcareous sand or limestone. It also is found in drier sites such as dune crests (NAS, 1980a).

Cultivation

Direct sowing of pretreated seed is recommended (NAS, 1980a). Seed are treated with abrasion, acid, and hot water treatment.

Harvesting

Trees may be harvested as needed. This species rarely coppices, and mature trees do not survive felling. The pods are nondeciduous and are therefore not easily gathered. Unlike many *Acacia* species, it is not considered a valuable tannin or gum producer (NAS, 1980a).

Yields and Economics

Standing biomass of *Acacia cyclops* in the southwestern cape of Africa, where it is replacing indigenous Fynbos vegetation and coastal shrub communities, was 131 MT/ha. Of this, the litterfall was said to represent 7.4% of the total biomass, 21.2% of the canopy mass.

Energy

Recommended by the NAS (1980a) as a firewood source. The wood is dense, the logs rarely exceeding 20 cm in diameter. It is a very popular firewood in South Africa, sold regularly in Cape Town. The annual litterfall of four Acacia species naturalized in the South African Cape, comprising 60% foliage and 30% reproductive structures, averages 7 MT/ha, double the value expected in evergreen scrub communities in winter rainfall regions. Standing biomass in the *Acacia* thickets is ca 10 times greater than that of mature Fynbos (11–26 MT/ha) and shrublands in other Mediterranean climates (15–30 MT/ha). *Acacias* lose ca 10% of their standing crop annually as litter, at a rate 3–4 times that of the Mediterranean heath and shrub communities. The litter accumulates on the ground. In a mature thicket, the dry mass of the ground litter per unit area exceeds that of the living canopy. The ground litter layer runs 14–28 MT/ha, which is fairly average by world standards. "The annual nitrogen and phosphorus input by Acacia litter should be about nine times as great per unit area as that of Fynbos." Assuming an N content of 1.5% and a P content of 1.13%, *Acacia* litter would contribute 105 kg N/ha and 92 kg P. In an area where the annual precipitation averages between 500 and 750 mm/yr and the annual temperature average ranges between 16 and 18°C, with radiation averaging 450–500 Langleys/day (Capetown has an average annual precipitation of ca 600 mm, average temperature approaching 18°C), the total annual litterfall is 9,680 kg/ha, with 1.4% as flowers, 35.5% as pods, 5.3% as seed, 11.3% as twigs, 39.0% as phyllodes, and 7.7% unidentified fragments. The total standing biomass was 131 MT/ha DM, ˜±4% (Milton, 1981).

Biotic Factors

Most African Acacias are thought to be cross pollinated. Pests and diseases are not an important factor in South Africa; in fact, the lack of seed destroyers is partly responsible for the weediness of the species. Grazers may damage seedlings.

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Acacia mearnsii de Wild.

Syn.: *Acacia mollissima* auct., not Willd.
Acacia decurrens var. *mollis* Lindl.
Mimosaceae
Black Wattle, Acacia Negra, Acacia Noir, Schwarze Akazie, Gomboom

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Tree of economic importance in South and East Africa, Rhodesia, India, and Rio Grande do Sul area of South America etc. for tanning of soft-leather. Ranging from 30–54 percent tannin in dried bark. Wood furnishes badly needed fuel and building material in some areas. Trees not only provide tannin and fuel, but also add nitrogen and organic material to improve the soil. Bark is used for wood adhesives and flotation agents (Duke, 1981a). The pulp is suitable for wrapping paper and hardboard. Some regard it as an attractive ornamental. Sometimes used for erosion control on poor sloping soils unsuitable for agriculture. Densely packed plantations are effective in preventing further erosion on 50° slopes. Some farmers claim that tobacco and vegetable yields are doubled in rotating with the black wattle. In places it is regarded as a "green cancer", spreading vigorously as a weed (NAS, 1980; Little, 1983).

Folk Medicine

Products are often used in folk medicine as styptics or astringents (Duke, 1981).

Chemistry

Black wattle bark contains (-)-robinetinidol and (+)-catechin; the biflavonoids (-)-fisetinidol-(+)-catechin (2 diastereoisomers), (-)-robinetinidol-(+)-catechin and (-)-robinetinidol-(+)-gallocatechin; triflavonoids and condensed tannins. The heartwood is rich in (+)-leucofisetinidin (mollisacacidin) together with (-)-fisetinidol, (+)-fustin, butin, fisetin, butein, and biflavonoid condensates (tannins) (Duke, 1981).

Description

Tree 6 to 20 m tall, 10 to 60 cm in diameter; crown conical or rounded; all parts except flowers usually pubescent or puberulous; stems without spines or prickles; leaves bipinnate, on petioles 1.5–2.5 cm long, with a gland above; rachis 4–12 cm long with numerous raised glands all along its upper side; pinnae in 8–30 pairs, pinnules in 16–70 pairs, linear-oblong, 1.5–4 mm long, 0.5–0.75 min wide; flowers in globose heads 5–8 mm in diameter, borne in panicles or racemes, on peduncles 2–6 mm long; pale yellow and fragrant; pods gray-puberulous, or sometimes glabrous, almost moniliform, dehiscing, usually 3–10 cm long, 0.5–0.8 cm wide, with 3–14 joints; seeds black, smooth, elliptic or compressed ovoid, 3–5 mm long, 2–3.5 mm wide; caruncle conspicuous; areole 3.5 mm long, 2 mm wide. Seeds 66,000 to 110,000/kg (Duke, 1981a).

Germplasm

Can be crossed with *Acacia decurrens*, hybrids show more sterility than parents. Meiosis is regular, with no gross cytological abnormalities, and sterility may be due to gene differentiation between species. There is little geographic overlap in the native Australian ranges of the species, and there are differences in phenology (flowering; seedset). Most of the characters that vary among the species are quantitative. The development of black wattle strains or of hybrids with enhanced vigor, better quality bark, outstanding stem form, or resistance to insect pests and disease would benefit the wattle industry. Assigned to the Australian Center of Diversity, black wattle or cvs thereof is reported to exhibit tolerance to drought, laterite, and poor soil (Duke, 1981). For an Acacia, it is relatively tolerant to frost, and its growth is slowed by high temperatures. ($2n = 26$.)

Distribution

Native to Southeast Australia (Victoria to New South Wales and southern Queensland) and Tasmania. Introduced and cultivated widely for afforestations. See Sherry (1971) for details.

Ecology

In Kenya grows on or near Equator at altitudes of 2,000–2,800 m, is well adjusted to the climate of East Africa. Grows well at 30°S Lat. in South America on rolling terrain at altitudes of 50–70 m. Thrives on poor, dry soils but favors deeper, moister, more fertile soils. In Australia, black wattle may occur on soils derived from shales, mudstones, sandstones, conglomerates, and alluvial deposits. In Kenya on podsols, krasnozems, sandy hills, lava flows or on mixtures of lava and contemporaneous volcanic tuffs and breccias. In South America, grown on red clay or sandy soils that have suffered from severe erosion and soil depletion (ferruginous clay loams with little or no free silica). In East Africa grows where annual rainfall is 1,041–1,321 mm, (about 75% between April and September). On the equator where black wattle is grown in South America, the rain pattern is nearly opposite, mean annual temperature range is 17–23°C; there is little seasonal variation, but considerable diurnal variation. At higher altitudes in South America, frost is a risk and heavy snows may break tree limbs. Tannin content varies inversely with precipitaton. Ranging from Warm Temperate Dry through Tropical Thorn to Tropical Moist Forest Life Zones, black wattle is reported to tolerate annual precipitation of 6.6–22.8 dm (mean of 6 cases=12.6), annual mean temperature of 14.7–27.8°C (mean of 6 cases=2.6°C), and pH of 5.0–7.2 (mean of 5 cases = 0.5).

Cultivation

Propagation by seed is easy. Seeds retain their viability for several years. For germination seed are covered with boiling water and allowed to stand until cool. This cracks the hard outer coat and facilitates germination. Seeds may be broadcast or sown in rows on any barren site. Usually they are sown about 5 cm apart in seedbeds, and are transplanted after 3–6 months. In South America, fields are usually plowed and harrowed in April or May. Seedlings are set out May–November, but usually in winter, June–August, after a rain. Plants are spaced 2 m each way, at rate of 2,500/ha. Propagation by cuttings is almost impossible without mist. Air layering is more promising. Two types of farmers grow acacia: the tanner or business man plants 200 ha or so entirely to black wattle, usually one section at a time so that he can plant and harvest within the same year and continue year after year; the farmer plants half or less of his land to black wattle and the rest to crops such as corn, beans, maniac, sugarcane, other vegetables, or pasture. He plants 2–6 hectares of acacian each year and thus evenly distributes work and production. Oxen may be useful for plowing, but most work is by hand. Usually only plows and hoes are used in Cultivation. Intercrops may be grown the first year during which trees grow about 4–5 m in height, and about 2.5 cm in diameter (Duke, 1981).

Harvesting

Trees provide bark 5–10 years after seeding (avg 7). Bark is stripped from lower part of tree, then tree is felled, the remaining bark removed, and tree and bark are cut into 1 m lengths. Thoroughly dried bark is arranged in bales of 75 to 80 kg when ready for transportation. Tanning power improves by 10–15% in bark carefully stored for a season. Percent tannin does not differ between barks harvested in dry and wet seasons. However, the amount of bark on trees may be less on poor than on rich soils. Tannin runs about 25–35% per kilo of dried bark, on either poor or rich soil. Acacia bark may be sold as baled bark, or bark powder. Dried bark may go first to commercial bark processors where it is ground or shredded in a hammermill, then sold in 40-kg sacks. Bark powder is sold in 60-kg sacks. Liquid extract is sold in 300-kg wooden barrels. In Rio Grande do Sul an estimated 5,000 MT of liquid extract is produced annually (Duke, 1981a).

Yields and Economics

Except for some mangrove species, black wattle in pure stand produces more tannin per hectare than most tanniniferous plants. In South Africa well-managed have produced the equivalent of 3 MT/ha tannin, about twice the average, when grown in rotations in excess of 12 years. One 7-yr-old tree produces 3–5 kg of dried bark. Twelve trees produce 1 cu m of firewood. The wood of debarked trees is dried and used for mine timbers, pulpwood, and fuel. Moisture loss is rapid in first 4 weeks after felling, then much slower. Wood weighs 708.7 kg/cu m. One tree can produce up to 10 cwt of bark or about 5 cwt stripped. One ton of black wattle bark is sufficient to tan 2,530 hides, best adapted for sole leather and other heavy goods; the leather is fully as durable as that tanned with oak bark. One ton of bark yields 4 cwt of extract tar. Destructive distillation of the wood yields 33.2% charcoal, 9.5% lime acetate, and 0.81 methyl alcohol. As a source of vegetable tannin, black wattle shares with quebracho and chestnut a large portion of the world market for vegetable tannins. According to Sherry (1971), plantation grown wattle in South Africa, Rhodesia, Tanzania, Kenya, and Brazil supplied about 38% of world demand for tannin. South Africa was the largest producer, with annual output of 72,000 MT of ca 120,000 MT on the world market. *Eucalyptus grandis* produces more wood than wattle, but it is inferior for fuel and charcoal. At one time in South Africa, 56% of the proceeds from wattle was from bark, the balance from timber (Duke, 1981a).

Energy

An efficient N-fixer, it is reported to annually yield 21–28 MT/ha wet leaves containing 245–285 kg N. If we put the information in our cultivation paragraph and our yields paragraph, we find the improbable 2,500 plants per hectare, with 12 producing 1 m^3 firewood, suggesting a potential of more than 200 m^3/ha for 7 year old trees, suggesting annual yields of ca 30 m^3/ha. NAS (1980a) reports annual thickwood production of 10–25 m°3/ha and bark production of 0.8–4.0 MT. The dense wood (sp. grav. = 0.7–0.85) 3,500–4,000 kcal/kg (oven-dry Indonesian specimens 4,650 kcal/kg), its ash content ca 1.5%. The charcoal (sp. grav. = 0.3–0.5) has a calorific value of 6,600 kcal/kg, with an ash content of 0.4%.

Biotic Factors

The most serious disease is disback, caused by *Phoma herbarum*. Other fungi attacking black wattle include: *Chaetomium cochliodes*, *Daldinia* sp., and *Trichoderma viride*. In Rio Grande do Sul, disease and insects cause about 20% loss of trees. Principal insects attacking Brazilian wattle are *Molippa sabina, Achryson surinamum, Placosternus cyclene, Eburodacrys dubitata, Neoclytus* *pusillus, Oncideres impluviata, Oncideres saga,* and *Trachyderes thoracica.* Ants, termites, and borers are the most damaging. The sauva ant which attacks the leaves is fought constantly with arsenicals and carbon disulfide. Nematodes reported on this species include *Meloidogyne arenaria, M. incognita acrita,* and *M. javanica* (Golden, pers. commun. 1984).

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Acacia farnesiana (L.) Willd.

Syn.: *Mimosa farnesiana* L.
Mimosaceae
Cassie, Huisache

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Cassie perfume is distilled from the flowers. Cassie absolute is employed in preparation of violet bouquets, extensively used in European perfumery. Cassie pomades are manufactured In Uttar Pradesh and the Punjab. Pods contain 23 percent tannin, a glucoside of ellagic acid, and are used for tanning leather. Bark also used for tanning and dying leather in combination with iron ores and salts. In Bengal and West Indies, pods are used for a black leather dye. Gummy substance obtained from pods used in Java as cement for broken crockery. Gum exuding from trunk considered superior to gum arabic in arts. Trees used as ingredient in Ivory Coast for arrow poison; elsewhere they are used as fences and to check erosion. Wood is hard and durable underground, used for wooden plows and for pegs. Trees often planted as an ornamental (Duke, 1981). Morton (1981) says that the seeds, containing an unnamed alkaloid, are used to kill rabid dogs in Brazil.

Folk Medicine

Bark is astringent and demulcent, and along with leaves and roots is used for medicinal purposes. Woody branches used in India as tooth brushes. The gummy roots also chewed for sore throat. Said to be used for alterative, antispasmodic, aphrodisiac, astringent, demulcent, diarrhea, febrifuge, rheumatism, and stimulant (Duke, 1981a). Morton (1981) notes that Guatemalans value the flower infusion as a stomachic. It is also used for dyspepsia and neuroses. Mexicans sprinkle powdered dried leaves onto wounds. The flowers are added to ointment, rubbed on the forehead for headache. Green pods are decocted for dysentery and inflammations of the skin and raucous membranes. Colombians bathe in the bark decoction for typhoid. Costa Ricans decoct rhe gum from the trunk for diarrhea, using the pod infusion for diarrhea, leucorrhea, and uterorrhagia. Panamanians and Cubans used the pod to treat conjunctivitis. Cubans use the pod decoction for sore throat. For rheumatic pains, West Indians bind bark strips to the afflicted joint. The root decoction has been suggested as a folk remedy for tubersulosis. According to Hartwell (1967–1971), the decoction of the root, used in hot baths, is said to help stomach cancer. A plaster, made from the pulp, is said to alleviate tumors.

Chemistry

Dried seeds of one *Acacia* sp. are reported to contain per 100 g: 377 calories, 7.0% moisture, 12.6 g protein, 4.6 g fat, 72.4 g carbohydrate, 9.5 g flber, and 3.4 g ash. Raw leaves of *Acacia* contain per 100 g: 57 calories, 81.4% moisture, 8.0 g protein, 0.6 g fat, 9.0 g carbohydrate, 5.7 g fiber, 1.0 g ash, 93 mg Ca, 84 mg P, 3.7 mg Fe, 12,255 μg β-carotene equivalent, 0.20 mg thiamine, 0.17 mg riboflavin, 8.5 mg niacin, and 49 mg ascorbic acid. Reporting 55% protein on a dryweight basis, Van Etten et al (1963) break down the amino acids as follows: lysine, 4.7 (g/16 g N); methionine, 0.9; arginine, 9.2; glycine, 3.4;. histidine, 2.3; isoleucine, 3.5; leucine, 7.5; phenylalanine, 3.5; tyrosine, 2.8; threonine, 2.5; valine, 3.9; alanine, 4.3; aspartic acid, 8.8; glutamic acid, 12.6; hydroxyproline, 0.0; proline, 5.1; serine, 4.1; with 76% of the total nitrogen as amino acids. Cassie has been reported to contain anisaldehyde, benzoic acid, benzyl alcohol, butyric acid, coumarin, cresol, cuminaidehyde, decyl aldehyde, eicosane, eugenol, farnesol, geraniol, hydroxyacetophenone, methyleugenol, methyl salicylate, nerolidol, palmitic acid, salicylic acid, and terpineol (Duke, 1981). The leaves contain lipids, carotenoids, alkaloids, and reducing and non-reducing sugars (Morton, 1981). El Sissi et al (1973) isolated and identified from pods, seven polyphenols (gallic acid, ellagic acid, m-digallic acid, methyl gallate, kaempferol, atomadendrin, and narigenin). Also they found narigenin-7-glucoside and naringenin-7-rhamnoglucoside (naringin), as well as naringenin, glucose, and gallic acid.

Description

Thorny bush or small tree, 8 m tall; bark light brown, rough; branches glabrous or nearly, purplish to gray, with very small glands; stipules spinescent, usually short, up to 1.8 cm long, rarely longer, never inflated; leaves twice pinnate, with a small gland on petiole and sometimes one on the rachis near top of pinnae; pinnae 2–8 pairs, leaflets 10–12 pairs, minute, 2–7 mm long, 0.75–1.75 mm wide, glabrous, leathery; flowers in axillary pedunculate heads, calyx and corolla glabrous, scented; pod indehiscent, straight or curved, 4–7.5 cm long, about 1.5 cm wide, subterete and turgid, dark brown to blackish, glabrous, finely longitudinally striate, pointed at both ends; seeds chestnut-brown, in 2 rows, embedded in a dry spongy tissue, 7–8 mm long, ca 5.5 mm broad, smooth, elliptic, thick, only slightly compressed; areole 6.5–7 mm long, 4 mm wide (Duke, 1981a).

Germplasm

Both *A. farnesiana* and its var *cavenia* are extensively cultivated in and around Cannes, southern France, which is the center for production of the perfume. The variety seems to be more resistant to drought and frost. Assigned to the South American Center of Diversity, cassie or cvs thereof is reported to exhibit tolerance to drought, high pH, heat, low pH, salt, sand, slope, and Savanna. ($2n = 52, 104$). (Duke, 1981a).

Distribution

Probably native to tropical America, but naturalized and cultivated all over the world, e.g. Africa (Rhodesia, Mozambique) and Australia. Planted in coastal areas of Ghana and elsewhere in tropical Africa. Grown throughout India, and often planted in gardens (Duke, 1981a).

Ecology

Thrives in dry localities and on loamy or sandy soils where it may serve as a sand binder. Will grow on loose sandy soil of river beds, on pure sand in plains of Punjab. Requires a dry tropical climate. Ranging from Warm Temperate Dry through Tropical Desert to Moist Forest Life Zones, cassie is reported to tolerate annual precipitation of 6.4–40.3 dm (mean of 20 cases 14.0 dm), annual mean temperature of 14.7–27.8°C (mean of 20 cases = 24.1°C), and pH of 5.0–8.0 (mean of 15 cases = 6.8) (Duke, 1981).

Cultivation

Propagated mainly from seed and cuttings. Seeds germinate readily and plants grow rapidly. Plants do not require much cultivation, watering or care (Duke, 1981a).

Harvesting

Trees begin to flower from the third year, mainly from November to March. Perfume is extracted from the flowers in form of concrete or pomade. Macerated flowers are placed in melted purified natural fat and allowed to stand for several hours. They are then replaced by fresh flowers and the process repeated until the fat is saturated with perfume. Fat is then melted, strained and cooled. This constitutes the pomade. Odor is that of violets but more intense. Absolute is prepared by mixing pomade with alcohol (2–3 kg to about 4 laters) and allowed to stand for 3–4 weeks at about

-5°C. The alcohol is then separated and distilled over. The extract obtained is an olive-green liquid with strong odor of cassie flowers (Duke, 1981a).

Yields and Economics

Mature trees yield up to 1 kg of flowers per season. Southern France (Cannes and Grasse) is main production center for cassie flower perfume. India and other Eastern countries produce much for local use (Duke, 1981a).

Energy

Though omitted by the recent fuelwood books (NAS, 1980; Little, 1983), this species should be considered along with other Acacias for its energy potential. Other species yield fuelwood at rates of 5–20 m^3/ha/yr, but lower yields may prevail in very humid environments. Of course the straggly bushy forms would not make very good fuel sources. Morton (1981) notes that the wood is used for fuel. Allen and Allen (1981) note that it fixes nitrogen.

Biotic Factors

Fungi reported on this plant include: *Camptomeris albizziae, Clitocybe tabescens, Hypocrea borneensis, Lenzites palisoti, L. repanda, Phyllachora acaciae, Phymatotrichum omnivorum, Polystictus flavus, Ravenelia austris, R. hieronymi, R. siliquae, R. spegazziniana, Schizophyllum commune, Systingophora hieronymi, Tryblidiella rufula*, and *Uromycladium notabile*. It may also be parasitized by the flowering plants *Dendrophthoe falcata* and *Santalum album* (Duke, 1981a).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update December 16, 1997

Acacia tortilis (Forsk.) Hayne

Syn.: *Acacia raddiana* Savi,
Acacia spirocarpa Hochst. ex A. Rich
Acacia heteracantha Burch.
Mimosaceae
Umbrella Thorn, Israeli Babool

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Since this is one of the few timber species of the Arabian deserts, it is suspected as being the wood from which the Biblical Ark of the Tabernacle was made. Kaplan (1979) says rather emphatically it is the Shittim of the Bible, which provided the Israelites with the large-size timbers for the Ark. The timber is also used for fenceposts, firewood, furniture, and wagonwheels. The prolific pods made good fodder for desert grazers and the foliage is also palatable, being one of the major dry season fodder trees for the Sahara-Sahelian belt. Bark, used for string in Tanganyika. Gum used as a poor man's gum arabic, said to be edible. It is the tree most recommended for reclaiming dunes in India and Africa (Roy et al, 1973). The thorny branches are used to erect temporary cages and pens. Bark said to be a good source of tannin (Roy et al, 1973). Africans once strung the pods into necklaces. Senegalese use the roots for spear shafts, Lake Chad natives use the stems for fish spears. African nomads often use the flexible roots for frameworks of their temporary shelters.

Folk Medicine

While I find few data specific to this species, I suspect that the gum is used like that of gum arabics in folk remedies. In French Guinea, the bark is used as a vermifuge and dusted onto skin ailments (Dalziel, 1937).

Chemistry

Pods contain close to 19% protein (Palmer and Pitman, 1972). NAS (1979) reports unconfirmed allegations that the foliage can be toxic to livestock. Certainly HCN has been reported in several Acacias. The following tables are reproduced, with permission, from FAO's Tropical Feeds (1981):

Nutritive tables (Gohl, 1981)

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, South Africa		19.2	11.6	8.7	6.1	54.4	2.27	0.17	213
Pods, South Africa		17.3	24.8	5.7	3.1	49.1	0.79	0.34	213
Seeds, South Africa		37.8	10.9	5.9	6.0	39.7	0.56	0.73	213
Pod husks, South Africa		8.7	34.3	6.2	1.6	49.2	1.10	0.14	213

Acacia tortilis (Forsk.) Hayne subsp. *heteracantha* (Burch.) Brenan

		As % of dry matter							
	DM	CP	CF	Ash	EE	NFE	Ca	P	Ref.
Fresh leaves, Sudan	90.9	13.3	9.4	9.6	8.3	59.4	4.00	0.15	64
Pods, Tanzania		12.3	22.4	5.6	1.8	57.9	0.98	0.24	166
Pods, Kenya		17.8	17.5	8.4	1.7	54.6	1.34	0.36	129

		Digestibility (%)					
	Animal	CP	CF	EE	NFE	ME	Ref
Pods	Cattle	46.2	42.0	74.0	76.6	2.30	166

Acacia tortilis (Forsk.) Hayne subsp. *spirocarpa* (Hochst. ex A. Rich) Brenan

Description

Medium umbrella-shaped tree 4–15 m tall, often with several trunks, reduced to a small wiry shrub less than 1 m tall under extremely arid conditions. Two types of thorns abound (1) long, straight, and white, and (2) small, hooked, and brownish. Leaves up to 2.5 cm long with 4–10 pairs of pinnae, each with ca 15 pairs of minute leaflets. Flowers white, aromatic, in small clusters. Pods flat, glabrose, coiled into a spring-like array.

Germplasm

Reported from North African and Middle Eastern Centers of Diversity, Umbrella Thorn, or cvs thereof, is reported to tolerate alkalinity, drought, heat, sand, slope, and stony soils. It seems to be more frost tolerant than *Prosopis juliflora*, still plants less than 2 years old are easily damaged by frost. Four subspecies are known in different ecological zones: subspecies *tortilis*—Sahel, Middle East; subspecies *raddiana*—Sudan, Middle East, Sahel(2n=104); subspecies *spirocarpa*—Eastern Africa, Sudan; and subspecies *heteracantha*—Southern Africa (2*n*= 52). The different subspecies seem to have different ecological tolerances, which is important to consider when choosing a subspecies for plantations. (2*n*= 52, 104)

Distribution

Native to much of Africa and the Middle East, this species has been introduced in many arid parts of the world. Ironically, it grows faster in the Rajastan Desert of India, where used for charcoal, firewood, and fodder, than in its native Israel (Kaplan, 1979). In Malawi, this species is already scorned by the rural public because it is thorny and difficult to work with. It is being tried for fencings (Nkaonja, 1980).

Ecology

Deemed the most promising of 56 Acacia species tried at Jodhpur, India. Probably ranging from Subtropical Desert to Dry through Tropical Desert Scrub to Very Dry Forest Life Zones, umbrella tree is reported to tolerate annual precipitation of 1 to 10 dm, estimated annual temperature of 18 to 28°C, and pH of 6.5 to 8.5. This species tolerates hot, arid climates with temperatures as high as 50°C subspecies *raddiana* grows where minimum temperatures are close to 0°C. It is best adapted to the lowlands. It thrives where rainfall is up to 1,000 mm. However, it is also extremely drought resistant and can survive in climates with less than 100 mm annual rainfall with long, erratic dry seasons. The tree favors alkaline soils. It grows fairly well in shallow soil, less than 0.25 m deep, though it develops long lateral roots that can become a nuisance in nearby fields, paths, and roadways. In shallow soil, the plants remain shrubby and must be widely spaced to allow for their lateral root growth.

Cultivation

For good seed germination, seeds should be treated with concentrated sulphuric acid for 30 minutes (Roy et al, 1973). Artificial regeneration aiming at large-scale nursery production requires full use of the germination capacity of the available seeds. This may be achieved by sulfuric acid pretreatment, which brings about the germination of all viable seeds. Treatment with boiling water is selective and mainly breaks the dormancy of bruchid-infested seeds, some of which are no longer able to germinate. Sowing of unripe seeds without pretreatment may be called for as an emergency measure in case of very severe infestation, to achieve at least partial success. Prior to storage, seeds should be fumigated to arrest progressing deterioration of seed viability by bruchids (Karschon, 1975). NAS (1980a) recommends dipping the seed in hot water to soak overnight. Seedlings require initial weeding to facilitate faster growth. Plantations can be spaced at 3 x 3 m.

Harvesting

Firewood harvested as needed, but 10-year rotations are suggested. In Jodhupr, flower initiation is ca May-June in 3-year old trees, fruits forming in July but ripening from November through February. Since the tree coppices well, there is no need to replant after every harvest.

Yields and Economics

Eleven-year old trees in deep sandy soils at Jodhpur averaged 6.4 m tall and 14 cm DBH. In shallow sandy loams over hardpan at Pali, India, 7-year old trees (98% survival) averaged 4.8 m tall, and 10 cm DBH. In sanddunes at Barmer, India, 5-year old trees averaged 3 m tall, 7 cm DBH. An average tree yields 6 kg pods of which 2.6 kg is clean seed. One tree is said to yield 14–18 kg pods and leaves per year in India (Muthana and Arora, 1980). *Acacia tortilis* has been reported to yield giraffe forage at 5 MT/ha/yr.

Energy

A 12-year-old plantation in India yielded 54 MT fuel , suggest, annual returns of 4.5 MT, not a bad return for the desert (NAS, 1980a). The heartwood has calorific value of 4,400 kcals/kg, making superior firewood and charcoal. It is one of the main firewood and charcoal sources in parts of Africa, e.g. around Khartoum. Nitrogen-fixing nodules are reported in South Africa and Zimbabwe.

Biotic Factors

Bruchids often damage or destroy the seeds, on the tree or after collecting. Herbivores, tame and wild alike, are liable to graze seedlings and innovations. Trees attacked by beetles, mimosoid blights, and caterpillars. The wood is susceptible to termites. In Tanzania, elephants which eat the bark are wiping out some park populations. In Israel, the native Acacias host several species (>40) of mostly monophagous insects, whereas on one exotic, Australian *Acacia saligna*, only a few polyphagous species occur (Halperin, 1980). Only *Microcerotermes diversus* and *Kalotermes flavicollis*, which feed on woody parts of both Acacias and *Apate monachus* (a beetle which tunnels the stems and branches, causing them to collapse in windblow), may seriously damage the tree. In nature, regeneration and spread of Acacias are probably limited by bruchids destroying much of the seed crop. Seedlings from natural regeneration may come from damaged seeds with a still intact embryo axis, since seedcoat dormancy is removed by the effect of exit holes permitting rapid water absorption and germination. Intact seeds with hard impermeable seedcoats may require a long time to germinate, and probably function as a reserve to ensure the survival of the species (Karschon, 1975).

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Complete list of references for Duke, Handbook of Energy Crops

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Acacia mangium Willd.

Mimosaceae

Mangium, Forest mangrove

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

New Crops: Solutions for Global Problems—Noel Vietmeyer

last update October 23, 1997

Acacia nilotica (L.) Del.

Syn.: *Mimosa nilotica* L.
Mimosaceae
"Motse", Egyptian Mimosa, or Thorn

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Some feel that the thorn bush of Exodus 3 was *Acacia nilotica*, the fire, the parasite *Loranthus acaciae*. Inner bark contains 18–23% tannin, used for tanning and dyeing leather black. Young pods produce a very pale tint in leather, notably goat hides (Kano leather). Pods were used by the ancient Egyptians. Young bark used as fiber, twigs esteemed for tooth brushes (chewsticks). Trees tapped for gum arabic. The gum arabic is still used in making candles, inks, matches, and paints (NAS, 1980). Tender pods and shoots used as vegetable, and used as forage for camels, sheep and goats, especially in Sudan, where it is said to improve milk from these animals. Seeds are a valuable cattle food. Roasted seed kernels, sometimes used for flavoring and when crushed provide the dye for black strings worn by Nankani women. Trees used in Sudan for afforestation of inundated areas. Sapwood is yellowish-white, heartwood reddish-brown, hard, heavy, durable, difficult to work, though taking a high polish. Because of its resins, it resists insects and water, and trees are harvested for the timber for boat-making, posts, buildings, water-pipes, well-planking, plows, cabinet-work, wheels, mallets and other implements. Wood yields excellent firewood and charcoal (Duke, 1981a). The aqueous extract of the fruit, rich in tannin (18–23%) has shown algicidal activity against *Chroccoccus*, *Closteruim*, *Coelastrum*, *Cosmarium*, *Cyclotella*, *Euglena*, *Microcystis*, *Oscillatoria*, *Pediastrum*, *Rivularia*, *Spirogyra*, and *Spirulina* (Ayoub, 1983).

Folk Medicine

Zulu take bark for cough, Chipi use root for tuberculosis. Masai are intoxicated by the bark and root decoction, said to impart courage, even aphrodisia, and the root is said to cure impotence. Astringent bark used for diarrhea, dysentery, and leprosy. Bruised leaves poulticed onto ulcers. According to Hartwell, the gum or bark is used for cancers and/or tumors (of ear, eye, or testicles) and indurations of liver and spleen, condylomas, and excess flesh. Said also to be used for cancer, colds, congestion, coughs, diarrhea, dysentery, fever, gallbladder, hemorrhage, hemorrhoids, leucorrhea, ophthalmia, sclerosis, smallpox, and tuberculosis. Bark, gum, leaves, and pods used medicinally in West Africa. Sap or bark, leaves, and young pods are strongly astringent due to tannin, and are chewed In Senegal as antiscorbutic; in Ethiopia as lactogogue. Bark decoction drunk for intestinal pains and diarrhea. Other preparations used for coughs, gargle, toothache, ophthalmia, and syphilitic ulcers. In Tonga, the root is used to treat tuberculosis. In Lebanon, the resin is mixed with orange-flower infusion for typhoid convalescence. Masai use the bark decoction as a nerve stimulant. In Italian Africa, the wood is used to treat smallpox. Egyptian Nubians believe that diabetics may eat unlimited carbohydrates as long as they also consume powdered pods (Duke, 1983a). Extracts are inhibitory to at least four species of pathogenic fungi (Umalkar et al, 1976).

Chemistry

Babul has been reported to contain l-arabinose, catechol, galactan, galactoaraban, galactose, N-acetyldjenkolic acid, N-acetyldjenkolic acid, sulphoxides pentosan, saponin, tannin. Seeds contain crude protein 18.6%, ether extract 4.4%, fiber 10.1%, nitrogen-free extract 61.2%, ash 5.7%, and silica 0.44%. Phosphorus 0.29% and calcium 0.90% of DM. When bullocks were given the seeds and bran (2:1) with dry pasture grass daily DM intakes were 1.82, 0.91, and 5.35 kg respectively. Total DM intake/100 kg bodyweight was 1.40 kg. The animals retained 20.8 g N and 7.4 g Ca daily but the P balance was slightly negative (Pande et al, 1981). Walker (1980) puts the CP content of the browse at 12.9%, the crude fiber at 15.2%

Description

Small tree, 2.5–14 m tall, quite variable in many aspects; bark of twigs not flaking off, gray to brown; branches spreading, with flat or rounded crown; bark thin, rough, fissured, deep red-brown; branchlets purple-brown, shortly or densely gray-pubescent, with lenticels; spines gray-pubescent, slightly recurved, up to 3 cm long; leaves often with 1–2 petiolar glands and other glands between all or only the uppermost pinnae; plnnae 2–11 (-17) pairs; leaflets 7–25 (-30) pairs, 1.5–7 mm long, 0.5–1.5 mm wide, glabrous or pubescent, apex obtuse; peduncles clustered at nodes of leafy and leafless branchlets; flowers bright yellow, in axillary heads 6–15 mm in diam.; involucel from near the base to about half-way up the peduncle, rarely somewhat higher; calyx 1–2 mm long, subglabrous to pubescent; corolla 2.5–3.5 mm long, glabrous or pubescent outside; pods especially variable, linear, indehiscent, 8–17 (-24) cm long, 1.3–2.2 cm broad, straight or curved, glabrous or gray-velvety, turgid, blackish, about 12-seeded; seeds deep blackish-brown, smooth, subcircular, compressed, areole 6–7 mm long, 4.5–5 mm wide. Fl. Oct.–Dec.; fr. Mar.–June (Duke, 1981a).

Germplasm

Acacia nilotica var. *kraussiana* (Benth.) Brenan is the most common form in east tropical Africa. Young branches more or less densely pubescent; pods not necklace-like, 1–1.8 cm wide, oblong, more or less pubescent all over at first with raised parts over seeds becoming glabrescent, shining and black when dry, margins shallowly crenate. Exhibits wide range of altitudinal and habitat requirements. Found in Botswana, Zambia, Rhodesia, Malawi, Tanzania, Angola, Mozambique, Transvaal, and Natal. *A. nilotica* var. *tomentosa* A. F. Hill *(A. arabica* var. *tomentosa* Benth.), has pods straight, constricted between seeds and densely tomentose; found in Senegal and northern Nigeria, to Sudan, Arabia and India. *A. nilotica* var. *adansonii* (Guill. et Perr.) Kuntze is a tree up to 17 m with dark reddish-brown bark deeply fissured, tomentose, reddish-brown twigs and gray fruits; commonest variety in West Africa, from Senegal to Nigeria and widespread in northern parts of Tropical Africa. Assigned to the African Center of Diversity, babul or cvs thereof is reported to exhibit tolerance to clay, drought, heat, heavy soil, high pH, poor soils, salt, savanna, and waterlogging. (2n=52.)

Distribution

Native from Egypt south to Mozambique and Natal; apparently introduced to Zanzibar, Pemba, and India; Arabia. Considered a serious weed in South Africa.

Ecology

Woodlands of various sorts, wooded grasslands, scrub and thickets. Thrives in dry areas, but endures floods. Grows 10–1,340 m altitude, in a wide range of conditions. Grows on a wide variety of soils, seemingly thriving on alluvial soils, black cotton soils, heavy clay soils, as well as even poorer soils (NAS, 1980). Ranging from Subtropical Desert to Subtropical Dry through Tropical Desert to Tropical Dry Forest Life Zones, babul is reported to tolerate annual precipitation of 3.8–22.8 dm (mean of 12 cases = 12.0 dm), annual mean temperature of 18.7–27.8°C (mean of 12 cases = 24.1°C), and pH of 5.0–8.0 (mean of 10 cases = 6.9) (Duke, 1981a).

Cultivation

Trees propagated in forest by seeds. Direct seeding is the common practice. Stored seed may require scarification. Young seedlings are said to "require full sun and frequent weeding" (NAS, 1980a).

Harvesting

Although there are other sources of gum arabic, trees are still tapped for the gum by removing a bit of bark 5–7.5 cm wide and bruising the surrounding bark with mallet or hammer. The resulting reddish gum, almost completely soluble and tasteless, is formed into balls. Though used in commerce to some extent, it is inferior to other forms of gum arabic, with which it is sometimes mixed.

Yields and Economics

Various products of the tree are used locally in tropical Africa, but none enter international markets. Trees usually add 2–3 cm in diameter each year (NAS, 1980a).

Energy

Extensively used, e.g. in India, for firewood and charcoal, this species has been used in locomotives and steamships as well as industry balers. It is cultivated for industrial fuel in the Sudan. The calorific value of the sapwood is 4,800 kcal/kg of the heartwood 4,950. The species does nodulate and fix nitrogen.

Biotic Factors

Wood borers may afflict the stems and bruchids may afflict the seeds. Following fungi have been reported on this plant: *Ctyospora acaciae*, *Diatryphe acaciae, Diplodia acaciae*, *Fomes badius*, *F. endotheius, F. fastuosus*, *F. rimosus, Fusicoccum indicum, Phyllactinia acaciae, Ravenelia acaciae-arabicae, Septogloeum acaciae, Septoria mortolensis*, *Sphaerostilbe acaciae*. Trees are also parasitized by *Dendrophthoe falcata* and *Loranthus globiferus* var. *verrucosus* (Duke, 1981). In a survey for phytophagous insects on *Acacia nilotica*, 43 species were recorded in Pakistan, of these, 16 appeared stenophagous. The more promising for biological control of the tree were: *Anarsia* sp. cf. *acaciae, Pseudosterrha paulula*, *Azanus ubaldus*, and *Ceutholopha isidis* feeding on flowers; *Bruchidius sahlbergi* and *Sulcobruchus* sp. damaging seeds; *Ascalenia callynella*, *Gisilia stereodoxa* and an unidentified gracillariid boring shoots; and *Cydia* sp. making stem galls (Mohyuddin, 1981).

Yields and Economics

Various products of the tree are used locally in tropical Africa, blit none enter international markets. Trees usually add 2–3 cm in diameter each year (NAS, 1980).

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New Arid Land Ornamentals: Recent Introductions for Desert Landscapes

Janet H. Rademacher

Over the past decade, water conservation has become an increasingly important issue across the southwestern United States. This concern has led local horticulturists and landscape architects to explore the use of water-thrifty ornamentals from dry climates throughout the world. The Chihuahuan and Sonoran deserts in particular have yielded a vast array of successful landscape plants. Universities, growers, and plant enthusiasts have all participated in the collection, propagation, evaluation, and promotion of new plant introductions. A group of recent proven introductions, including trees, shrubs, ground covers, and perennials are included below with information on their origins, growth habits, cultural requirements, and potential uses in the landscape.

Acacia redolens

Maslin, Desert Carpet™

Native to inland areas of Western Australia, *Acacia redolens* Maslin has been used extensively in southern California and Arizona to cover large areas inexpensively. Seedlings of *Acacia redolens* vary widely in their growth habits, often reaching heights in excess of 1.8 m (6 feet). The Desert Carpet™ clone was selected from the first Phoenix freeway plantings for its prostrate growth habit, and was released by Mountain States Wholesale Nursery in 1984. Since that time, this groundcover has performed consistently on many projects, and years after installation has maintained a height of only 0.6 m (24 inches). One plant can spread to a width of 3.6 m (12 feet), although we have observed that the cutting-grown Desert Carpet™ plants are slower to establish and reach their mature size than seedlings. The slower growth rate and prostrate nature of this clone should reduce maintenance costs, since pruning is not necessary to control vertical growth. Instead of true leaves, *Acacia redolens* has thick, leathery, gray-green phyllodes. This plant blooms in the spring with small yellow flowers. Freeway acacia will tolerate low temperatures of –11.1° to –9.4°C (12°–15°F), alkaline and slightly saline soils, and does not seem to be choosy about soil types. In coastal areas it requires little or no supplemental irrigation, but does require regular irrigation in hot desert regions. Desert Carpet™ seems to be disease and pest free.

Baccharis

hybrid 'Starn' (P.P.A.F.) Thompson™

When Dr. Tommy Thompson and Dr. Chi Won Lee of the University of Arizona released *Baccharis* hybrid 'Centennial', it filled a great void in our plant palette. Their research has been carried on, and now the improved Thompson™ clone is available. Since *Baccharis* 'Centennial' is a female plant, it has two undesirable characteristics. First, it produces pappus, or white "fluff," which litters the landscape and reduces the esthetic appearance of the plants for a short period of time. Also, since 'Centennial' is a female plant, it can be pollinated by nearby male *Baccharis sarothroides* Gray (Desert broom), and seedlings often result. This is why you sometimes see stands of 'Centennial' with taller *Baccharis* plants growing up through them. The Thompson™ clone is a male plant, eliminating these two negative characteristics. Also, Thompson™ was selected from the next generation after 'Centennial', and has 25% more *Baccharis sarothroides* for heat and disease resistance. The growth habits and uses of these two clones are essentially the same: both grow to about 0.9 m (3 feet) tall by 1.2–1.5 m (4-5) feet wide, are evergreen with bright green foliage and inconspicuous flowers, and provide a low-maintenance, long-lived alternative for difficult locations.

Cercidium

species 'Desert Museum'

This hybrid palo verde is a three-way cross between *Parkinsonia aculeata* L., *Cercidium microphyllum* (Torr.) Rose & I.M. Johnst., and *Cercidium floridum* Benth. ex Gray, and seems to combine the best qualities of all three plants. 'Desert Museum' grows very rapidly to 6.1 m (20 feet) tall and wide in 3 to 5 years, after which it needs little or no irrigation. It is completely thornless, and produces very little litter, with few seed pods. It has a sturdy, upright growth habit which requires very little pruning or staking. It blooms over a long period of time, with the heaviest bloom from about mid-March to May 1. It also tends to bloom again in June and August. The yellow flowers are larger than any of its three "parents." It does not reseed like the messy *Parkinsonia aculeata*!

Chilopsis linearis

(Cav.) Sweet, Lucretia Hamilton™

Desert willow trees occur along washes throughout the southwestern US and northern Mexico. This small deciduous tree has narrow, light green leaves that give it a weeping appearance. In the summer, the tree is covered with fragrant, trumpet-shaped flowers. In the wild, the flower colors range from white to purple, although a pale pink to lavender flower color is the most common. The Lucretia Hamilton™ clone was selected for its intense, deep pink to purple flower color, as well as its small stature. While many desert willow trees can grow to 7.6 m (25 feet) tall and wide, this clone seems to stay below 5.4–6.1 m (18-20 feet) tall and wide. After flowering, long narrow seed pods are produced. Plant *Chilopsis linearis* in full sun and well-drained soil, and in regions where temperatures do not drop below –17.8°C (0°F).

Chrysactinia mexicana

Gray (Damianita)

This small, compact shrub grows to 0.6 m (2 feet) tall and wide, and bears a very strong resemblance to turpentine bush, with needle-like green leaves and yellow daisy-like flowers. However, damianita blooms from March to September, while turpentine bush blooms from September to November. Combining the two plants would be a great way to prolong the color display! Damianita has wonderful-smelling foliage, and would be a great selection for sensory gardens. Damianita is a very tough, durable plant, tolerating extreme heat and cold, down to –17.8°C (0°F). Plant in full sun, and almost any soil. If this plant starts to look woody, prune it back severely in the early spring. Damianita ranges from New Mexico to west Texas and northeastern Mexico, at elevations of 609–2134 m (2000–7000 feet).

Dalea capitata

Sierra Gold™

This well-behaved ground cover grows to about 20 cm (8 inches) tall by 0.9 m (3 feet) wide. Because of its compact size, Sierra Gold™ is a good selection for tight planting areas, such as small planters or medians. Its fine-textured, light green foliage has a fresh, lemony scent. Rabbits seem to avoid it! Yellow flowers carpet Sierra Gold™ in the spring and the fall. This plant is hardy to at least –15°C (5°F), but it will be deciduous at –3.9°C (25°F). The one drawback to this plant is that the whiteflies seem to like it, so some insecticide applications will be necessary in heavily infested areas around Phoenix. Plant in full sun for best results. No soil amendments should be necessary. In hot desert regions this plant requires some supplemental irrigation from spring to fall. Although most dales native to Arizona and Mexico tend to rot out if overwatered, we have observed this plant thriving right next to turfgrass, where it receives heavy irrigation. More testing is needed to determine if it will tolerate coastal areas, or regions with high rainfall.

Dasylirion longissimum

This user-friendly accent plant is a great selection for high-traffic areas such as walkways and near entries. This grasslike plant does well in containers, and its symmetrical form provides a striking focal point. Its thin, stiff green leaves are completely unarmed, and have smooth edges. Eventually, its single trunk can grow to 1.8 m (6 feet), topped by a 1.5 m- (5-foot-) wide rounded head of leaves. The older, bottom leaves can be trimmed off to expose the trunk. *Dasylirion longissimum* is native to Mexico, and is hardy to about –8.3°C (17°F).

Euphorbia biglandulosa

Desf. (Gopher Plant)

This evergreen perennial or subshrub has a very unusual form and appearance. Its arching stems angle out and up, and can reach a length of 0.6 m (2 feet). The plant grows to 0.9 m (3 feet) tall by 1.2 m (4 feet) across; with narrow, fleshy grey-green leaves. Broad clusters of chartreuse flowers occur at the tips of the arching stems, usually in the late winter and early spring. Flowers are followed by small brown seed pods that explode upon ripening. The stems usually die back after fruiting, leaving a small clump of grey-green foliage near the ground. Plant *Euphorbia biglandulosa* in full sun or light shade, in a well-draining soil. It is cold hardy to –15°C (5°F).

Hesperaloe parviflora

(Torr.) J. Coult., 'Yellow' (Yellow yucca)

A clumping perennial with long, gray-green leaves, *Hesperaloe parviflora* grows slowly to form a grasslike clump 1.0–1.2 m (3–4 feet) tall and wide. From spring through fall, it produces 1.5 m- (5-foot-) tall flower spikes. Red-flowering plants have been a staple in southwestern landscapes for many years. This is simply a yellow-flowering selection. Use this tough accent plant in full sun. Since it also tolerates reflected heat, yellow yucca is a reliable plant to use along sidewalks, in parking lots, etc. Tolerant of temperature extremes, yellow yucca is cold-hardy to at least –17.8°C (0°F). Once established, it requires little or no irrigation. All in all, yellow yucca is one of the toughest and most maintenance-free plants.

Hymenoxys acaulis

(Pursh) K. Parker (Angelita Daisy)

This perennial is native to the southwestern US, where it occurs most often at elevations from 1219–2134 m (4000–7000 feet), on dry rocky slopes and mesas. Angelita daisy bears a strong resemblance to *Baileya multiradiata* Harv. & A. Gray ex Torr. (desert marigold). However, the foliage is green rather than gray, and the flower is a deeper gold color. Forming rounded clumps to fifteen inches tall and wide, *Hymenoxys acaulis* is a wonderful plant to use as a border in front of larger shrubs. I f water is available, it will naturalize in the landscape. In Phoenix, this plant blooms all year, with especially heavy bloom in the spring and fall months. This prolonged bloom period results in many dried flower stalks, which can make the plants look scruffy. We recommend cutting off the old flower spikes occasionally to rejuvenate the plant and initiate new flower production. Angelita daisy seems to prefer well-drained soils and full sun. It is very cold hardy, heat tolerant, and drought tolerant.

Leucophyllum candidum

I.M. Johnst. Thunder Cloud™

As with all of the other *Leucophyllum* species, this clone blooms when the humidity is high. The silver, pubescent foliage is a perfect foil for the masses of indigo flowers that appear in the summer and fall months. Thunder Cloud™ was selected and trademarked by Benny Simpson of Texas A&M University. His clone is highly valued because of its small, dense growth habit. Unlike most of the larger *Leucophyllum* species, Thunder Cloud™ remains reliably small, to three feet tall and wide. This plant is cold hardy to at least –12.2°C (10°F). Plant all of the *Leucophyllum* species in full sun and well-drained soil. Avoid overwatering.

Leucophyllum langmaniae

Rio Bravo™

Trademarked by Mountain States Nursery, this clone has a nice, compact growth habit very similar to *L. frutescens* 'Compacta'. Rio Bravo™ has become very popular because of its bright green foliage and rounded, dense form. It has lavender flowers and will eventually grow to 1.5 m (5 feet) tall and wide. Like the *L. candidum* species, it requires well-drained soils and full sun. It is hardy to –12.2°C (10°F).

Muhlenbergia capillaris

(Lam.) Trin. Regal Mist™

We feel that this ornamental grass shows great promise for many different regions of the country. Native to humid southeastern Texas, this grass has adapted extremely well to the hot, dry conditions of deserts in Arizona and Nevada. In fact, it has performed incredibly well in Las Vegas, which is cursed with poor soils, high winds, high summer temperatures, and cold winters. Regal Mist^{TM} is also happy in heavy soils, with ample irrigation. In short, it has worked everywhere it has been tried, so far! It is hardy to at least –17.8°C (0°F). Regal Mist^{TM} has narrow, dark green, glossy leaves. It grows quickly to form a rounded clump to 0.9 m (3 feet) tall and wide. The flower spikes on this grass have attracted a lot of attention... they form misty masses of pink to purple flowers in October and November. We recommend cutting this plant back in early spring to cut off the dead flower spikes and any dormant foliage.

Penstemon

species

There are so many wonderful *Penstemon* species to try in the garden, that is difficult to select just a few. Most of the penstemons are perennials with a basal rosette of foliage, which send up spikes of tubular flowers in the spring and early summer. They add incredible color to the landscape, and attract hummingbirds as well! Penstemons come in a wide range of colors, including blue, purple, pink, and red. After they finish blooming, allow the flower spikes to dry on the plant. Then cut off the spikes and sprinkle the seed in the garden to increase next year's mass of color. There are two new species to try: *Penstemon triflorus* Heller, which has short, 46 cm (18 inch) spikes of dark pink-purple flowers which occur along the stem in clusters of three; and *Penstemon clevelandii* Gray, native to southern and Baja California, with spikes of clear, bright pink flowers to 0.6–0.8 m (2–2.5 feet) tall.

Acacia saligna (Labill.) H.Wendl.

Mimosaceae
Orange Wattle

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Orange wattle is an extremely rugged tree, adaptable to barren slopes, derelict land, and exceptionally arid conditions in Australia and North Africa. It grows rapidly and is used for reclaiming eroded hillsides and wastelands and for stabilizing drift sands as well as for fuel. This is one of the best woody species for binding moving sand. It is useful for windbreaks, amenity plantings, beautification projects, and roadside stabilization in semiarid regions. The leaves, or phyllodes, are palatable to livestock when fresh or dried into hay, especially used as supplementary feed for sheep and goats. Crushed seeds have been fed to sheep without ill effects. Regrowth of established bushes is so good that *Acacia saligna* can be completely grazed off without harming the plants. The damaged bark exudes copious amounts of a very acidic gum that seems to show promise for use in pickles and other acidic foodstuffs (NAS, 1980).

Folk Medicine

No data observed.

Chemistry

Natal-grown bark contains up to 30.3% tannin compared to 19.1–23.0 at the Cape. The plant has given negative test for HCN.

Description

Dense, bushy shrub, usually 2–5 m tall; may grow treelike to 8 m tall with a single main stem (diameter to 30 cm). In spring its usually drooping branches are clad in beautiful and abundant yellow flowers (NAS, 1980a).

Germplasm

Reported from the Australian Center of Diversity, orange wattle, or cvs thereof, is reported to tolerate alkalinity, drought, heavy soil, poor soil, salinity, salt spray, sand, shade, slope, waterlogging, and weeds. ($2n$ = 26)

Distribution

Acacia saligna is native to the southwestern corner of western Australia. It was introduced to South Africa in the 1840s in an attempt to stabilize the shifting sand dunes. It has also been planted in Uruguay, Mexico Israel, Iran, Iraq, Jordan, Syria, Greece, Cyprus, and North African countries (NAS, 1980a).

Ecology

Acacia saligna can grow throughout the tropical and the warm temperate regions of the world (NAS, 1980a). In its native habitat, the summer temperature ranges from about 23°–36°C, winter temperatures from 4°–9°C. The plant does not withstand frost and grows best where the winter and summer means are between 13° and 30°C respectively. Grows from near sea level to about 300 m, with isolated occurrences at higher elevations. Particularly drought hardy, it grows where annual rainfall is as low as 250 mm, though it probably does better with 350–600 mm. It grows well where annual rainfall is as high as 1,000 mm. Grows mainly on sandy, coastal plains, but is found from swampy sites and riverbanks to small, rocky hills (often granitic) and coastal slopes. It occurs on poor acid or calcareous sands, under the most dry and adverse soil conditions, in moderately heavy clays and a range of podzols (NAS, 1980a).

Cultivation

Seeds germinate readily; young plants can often be found under mature trees in the hundreds. Seedlings are easily raised in a nursery and established in the field. This species develops root suckers and coppices freely. Seeds are normally treated with boiling water, but nicking the seed coat, soaking in sulfuric acid, and exposing the seeds to dry heat are also effective (NAS, 1980a).

Harvesting

In Mediterranean countries, the fuelwood from this species is harvested on a coppice rotation system of 5–10 years (NAS, 1980).

Yields and Economics

Acacia saligna grows quickly, often reaching up to 8 m tall with a spread as great as its height in just 4 or 5 years. In very dry situations, growth rate is slower. Annual yields vary from 1.5 to 10 m^3 per ha, depending on site. Because of its hardiness and profuse reproductive abilities, *Acacia saligna* has become a serious menace in parts of South Africa by invading and displacing indigenous vegetation. It infests water courses (sometimes decreasing the water available for irrigation), and has proved difficult to eradicate (NAS, 1980a).

Energy

Plantations for fuel have been established in some Mediterranean countries. But, according to one report from South Africa, the wood is "sappy, light, and not a popular fuelwood." The plant can withstand some shade and can be grown as an understory beneath pines or eucalypts in energy plantations or village fuel and fodder areas (NAS, 1980a). The annual litterfall of four *Acacia* species naturalized in the South African Cape, comprising 60% foliage and 30% reproductive structures, averages 7 MT/ha, double the value expected in evergreen scrub communities in winter rainfall regions.

Biotic Factors

Acacia saligna supports a diverse and abundant range of herbivores that cause damage to the plant. Among pests cited are *Icerya purchasi* (Hemiptera) and *Euproctis fasciata* (Lepidoptera) (NAS, 1980a) and *Meloidgogyne* sp. (Nematoda)

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Acacia senegal (L.) Willd.

Syn.: *Acacia verek* Guill. et Perr.
Mimosaceae
Gum Arabic, Senegal Gum, Sudan Gum Arabic, Kher, Kumta

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Tree yields commercial gum arabic, used extensively in pharmaceutical preparations, inks, pottery pigments, water-colors, wax polishes, and liquid gum; for dressing fabrics, giving lustre to silk and crepe; for thickening colors and mordants in calico-printing; in confections and sweetmeats. Causing partial destruction of many alkaloids including atropine, hyoscyamine, scopolamine, homatropine, morphine, apomorphine, cocaine, and physostigmine, gum arabic might be viewed as a possible antidote. Pharmaceutically used mainly in the manufacture of emulsions and in making pills and troches (as an excipient); as demulcent for inflammations of the throat or stomach and as masking agent for acrid tasting substances such as capsicum; also as a film-forming agent in peel-off masks. Its major use is in foods, for example, as suspending or emulsifying agent, stabilizer, adhesive, flavor fixative, and to prevent crystallization of sugar, etc. Used in practically all categories of processed foods (candy, snack foods, alcoholic and nonalcoholic beverages, baked goods, frozen dairy desserts, gelatins, and puddings, imitation dairy products, breakfast cereals, and fats and oils). Use levels range from less than 0.004% (40 ppm) in soups and milk products, 0.7 to 2.9% in nonalcoholic beverages, imitation dairy, and snack foods, to as high as 45% in candy products (Leung, 1980). Strong rope made from bark fibers. White wood used for tool handles, black heartwood for weaver's shuttles. The long flexible strands of surface roots provide one of the strongest of local fibers, used for cordage, well-ropes, fishing nets, horsegirdles, footropes, etc. Seeds are dried and preserved for human consumption (NAS, 1980). Young foliage makes good forage. Plants useful for afforestation of arid tracts, soil reclamation, and windbreaks (Duke, 1981a). In modern pharmacy, it is commonly employed as a demulcent in preparations designed to treat diarrhea, dysentery, coughs, throat irritation, and fevers. It serves as an emulsifying agent and gives viscosity to powdered drug materials; is used as a binding agent in making pills and tablets and particularly cough drops and lozenges. Because of its enzyme, the gum is not suitable for use in products having readily oxidizable ingredients. For example, it reduces the vitamin A content of cod liver oil by 54% within three weeks. It is incompatible with aminopyrine, morphine, vanillin, phenol, thymol, α- and β-naphthol, guiacol, cresols, creosol, eugenol, apomorphine, eserine, epinephrine, isobarbaloin, gallic acid, and tannin; also with strongly alcoholic liquids, solutions of ferric chloride and lead subacetate and strong solutions of sodium borate. It was formerly given intravenously to counteract low blood pressure after hemorrhages and surgery and to treat edema associated with nephrosis, but such practices caused kidney and liver damage and allergic reactions and have been abandoned (Morton, 1977).

Folk Medicine

The demulcent, emollient gum is used internally in inflammation of intestinal mucosa, and externally to cover inflamed surfaces, as burns, sore nipples and nodular leprosy. Also said to be used for antitussive, astringent, catarrh, colds, coughs, diarrhea, dysentery, expectorant, gonorrhea, hemorrhage, sore throat, typhoid, urinary tract (Duke and Wain, 1981).

Chemistry

Gum acacia contains neutral sugars (rhamnose, arabinose, and galactose), acids (glucuronic acid and 4-methoxyglucuronic acid), calcium, magnesium, potassium, and sodium. Its complex structure is still not completely known. Its backbone chain consists of D-galactose units, and its side chains are composed of D-glucuronic acid units with l-rhamnose or l-arabinose as end units. The molecular weight has been reported to be between 200,000 to 300,000 and as high as 600,000 (Leung, 1980).

Toxicity

Ingested orally, acacia is nontoxic. However, some people are allergic to its dust and develop skin lesions and severe asthmatic attacks when in contact with it. Acacia can be digested by rats to an extent of 71%; guinea pigs and rabbits also seem to utilize it for energy, as does man to a certain extent. Gum arabic may actually elevate serum or tissue cholesterol levels in rats (Leung, 1980).

Description

Savanna shrub or tree, up to 20 m tall, over 1.3 m in girth, spiny; bark gray to brown or blackish, scaly, rough; young branchlets densely to sparsely pubescent, soon glabrescent, crown dense; stipules not spinescent; prickles just below the nodes, either in threes up to 7 mm long, with the middle one hooked downwards and the lateral ones curved upwards, or solitary with the laterals absent; leaves bioinnate, up to 2.5 cm long; leaf-axis finely downy with 2 glands; pinnae 6–20 pairs; leaflets small, 7–25 pairs, rigid, leathery, glabrous, linear to elliptic-oblong, ciliate on margins, pale glaucous-green, apex obtuse to subacute; flowers in spikes 5–10 cm long, not very dense, on peduncles 0.7–2 cm long, normally produced with the leaves; calyx bell-shaped, glabrous, deeply toothed; corolla white to yellowish, fragrant, sessile; pod straight or slightly curved, retrap-shaped, 7.5–18 cm long, 2.5 cm wide, thin, light brown or gray, papery or woody, firm, indehiscent, glabrous, 5–6-(-15) seeded; seeds greenish-brown. Fl. Jan.–Mar.; fr. Jan.–Apr., July, Aug. or Oct. (Duke, 1981a).

Germplasm

Tree with a single central stem and a dense flat-topped crown, bark without any papery peel, rough, gray or brown, with pubescent, rarely glabrous inflorescence, and pods variable in size, rounded to somewhat pointed but not rostrate or acuminate at apex. Variety *rostrata* Brenan is a shrub, branching at or close to base, or a small tree, with a single stem, 1–6 m tall, with dense flattened crown, bark normally with a flaking papery peel, creamy-yellow to yellow-green or gray-brown, inflorescence axis always pubescent and pods 2–3.5 times as long as wide, rostrate or acuminate at apex. Variety *leiorhachis* Brenan, is always a tree with central stem, and rounded or irregular with straggling branches; bark with conspicuous yellow papery peel, and inflorescence axis always glabrous. Variety *pseudoglaucophylla* occurs on fixed sand duned in Africa. Assigned to the African Center of Diversity, gum arabic is reported to exhibit tolerance to alkali, drought, fire, high pH, poor soil, sand, slope, and wind. (2n=26) (Duke, 1981a)

Distribution

Widespread in tropical Africa from Mozambique, Zambia to Somalia, Sudan, Ethiopia, Kenya, and Tanzania. Cultivated in India, Nigeria, and Pakistan.

Ecology

Thrives on dry rocky hills, in low-lying dry savannas, and areas where annual rainfall is 25–36 cm. This hardy species survives many adverse conditions, and seems to be favored by low rainfall and absence of frost. Ranging from Warm Temperate Thorn through Tropical Thorn to Tropical Dry Forest Life Zones, gum arabic is reported to tolerate annual precipitation of 3.8–22.8 dm (mean of 9 cases = 12.4 dm), annual mean temperature of 16.2–27.8°C (mean of 9 cases 23.8°C), and pH of 5.0–7.7 (mean of 7 cases = 6.4), but Cheema and Qadir (1973) report 7.4–8.2.

Cultivation

In Sudan, trees are cultivated over a very large area. Best propagated from seeds which are produced once every few years, grown in Sudan, in special "gum gardens." Elsewhere, it is collected from wild trees. In Pakistan, the best period for afforestation is the early monsoon season (Apr.–Jun.). Surface sowing is recommended in mildly alkaline sandy soils. Plants can also be reproduced by shoot cuttings. Trees coppice well (NAS, 1980).

Harvesting

Gum exudes froin cracks in bark of wild trees, mostly in the dry season, with little or none in the rainy season when flowers are out. In some areas, a long strip of bark is torn off and the gum allowed to exude. In Africa, it is regularly tapped from trees which are about 6 years old by making narrow transverse incisions in bark in February and March. In about a month, tears of gum form on surface and are gathered. Trees begin to bear between 4–18 years of age and are said to yield only when they are in unhealthy state due to poor soil, lack of moisture or damaged. Attempts to improve conditions tend to reduce yield. Gum from wild trees is variable and somewhat darker colored than that from cultivated plants. Collected gum is carefully freed of extraneous matter, sorted and sometimes ripened in sun before export. Gum arabic is oderless with a bland taste, yellowish and some tears are vermiform in shape. Ripened or bleached gum occurs in rounded or ovoid tears over 2.5 cm in diameter, and in broken fragments. Tears are nearly white or pale yellow and break readily with a glassy fracture. Gum is almost completely soluble in an equal volume of water and gives a translucent, viscous, slightly acid solution, but is insoluble in 90% alcohol. Kordofan (Sudan) Gum is yellow or pinkish, has fewer cracks and is more transparent (Duke, 1981a).

Yields and Economics

Annual yields from young trees may range from 188 to 2856 g (avg. 900 g), from older trees, 379 to 6754 g (avg. 2,000 g). Gum arabic is important export product for some areas in tropical Africa and Mauritania. From Africa some genuine gum is shipped to India then to Europe and America. Between 1940 and 1950, United States imports range from 3,179–8,989 MT (Duke, 1981a) Morton (1977) reports >11,000 MT more recently.

Energy

Considered the best firewood in Mauritius and Senegal, this is not a big yielder, annual running 0.5–5 m^3/ha wood, with an energy value of ca 3,500 kcal/kg. A nitrogen,fixing species, it can be used to reestablish vegetation cover in degraded areas, as well as for sand-dune fixation and wind erosion control (NAS, 1980a).

Biotic Factors

Fungi reported on this crop are *Cladosporium herbarum*, *Fusarum* sp., *Ravenelia acaciae-senegalae* and *R. acaciocola*. Many insect visitors mimic the plant, the buffalo treehopper, *Stictocephala bisonia*, being a good example. Spiders (Cyclops sp.) may completely cover the young growing apex. Seedlings are often grazed by gazelles, goats, and pigs (Morton, 1977).

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Last update December 19, 1997

Acacia seyal Del.

Mimosaceae
Shittim Wood, White Whistling wood

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

According to some Biblical scholars, the Shittah tree is mentioned in the Bible only once (*I will plant in the wilderness... the Shittah tree.* Isaiah 41), but its wood is referred to many times as shittium, which is the plural of shittah in Hebrew. Some even speculate that it was only natural that Moses should turn to shittium when he came to build the Ark of the Covenant and the Tabernacle and needed beams and timber. No one can really be sure which species of Acacia was meant. Wood is white to yellow-brown, finely-striated with dark lines, coarse-grained, soft, easy to work, polishes well, but discolors eastly with mold and is susceptible to insect attack. Ancient Egyptians made coffins, some still intact, from the wood. Nigerians used sapling stems, or also the roots for spear shafts. Tree also yields a gum of good quality, inferior to that of *A. senegal*. Systematic tapping has produced a product of better color and taste. Bark contains tannin and yields a red liquid extract. The gum is said to be edible. The leaves are important for forage and the wood for fuel where the trees are abundant. In parts of Africa the tree is important for livestock, natives driving their animals to where it is common and lopping off branches for them, both leaves and young pods being eaten. The pods are sold, especially for fattening sheep. The tree is believed to provide the best firewood in Chad, and the best fodder in Sahelian savannas (NAS, 1980a; Duke, 1983a).

Folk Medicine

The gum is believed to be aphrodisiac. The bark decoction Is used for dysentery and leprosy. Tanganyikans use the bark as a stimulant in tropical Africa. The gum is used as emollient and astringent for colds, diarrhea, hemorrhage and ophhthalmia. Mixed with *Acacia sieberana* DC, it is used for intestinal ailments on the Ivory Coast. Wood used as a fumigant for rheumatic pains, and to protect puerperal mothers from colds and fevers. Eating the gum is supposed to afford some protection against bronchitis and rheumatism (Duke, 1983a).

Chemistry

This species has been reported to contain 18–20% tannin.

Description

Tree 3–12 m tall, crown flat-topped; bark powdery, white to greenish-yellow or orange-red; sparsely branched, the branches horizontal or ascending; young branchlets with sparse hairs or almost glabrous, with numerous reddish sessile glands; epidermis of twigs becoming reddish and shed annually; leaves often with a large gland on petiole and between the top 1–2 pairs of pinnae; stipules spinescent, up to 8 cm long, ant-galls present or absent; pinnae usually 3–7 pairs, the leaflets in 11–20 pairs, 3–8 cm long, 0.75–1 mm wide, sparingly ciliolate or glabrous; lateral veins invisible beneath; flowers bright yellow, in axillary, pedunculate heads 10–13 mm across, borne on terminal or short lateral shoots of current season; involucel in lower half of peduncle 2–4 mm long; apex of bracteoles rounded to elliptic, sometimes pointed; calyx 2–2.5 mm long, puberulous in upper part; corolla 3.5–4 mm long, glabrous outside; pods 7–20 cm long, 0.5–0.9 cm in diameter, dehiscent, falcate, constricted between seeds, glabrous except for sessile glands, 6–9-seeded; seeds elliptic, 7–9 mm long, 4.5–5 mm wide, compressed, minutely wrinkled, olive-brown to olive; areole 5–6 mm long, 2.5–3.5 mm wide.

Germplasm

Species has several botanical varieties. The two main ones are: *A. seyal* var. fistula (Schweinf.) Oliv. (*A. fistula* Schweinf.), is white-barked with some pairs of spines fused at base into 'ant-galls', 0.8–3 cm in diameter, grayish or whitish, often marked with sienna-red and with longitudinal furrows down center, more or less 2-lobed. Found in Zambia, Malawi, and Mozambique. *A. seyal* var. *multijuga* Schweinf. ex Baker f. (*A. stenocarpa* Oliv., pro partem), a shrub or tree, usually less than 5 m tall, sometimes up to 13 m, flattened crown; bark on main stem greenish-brown, peeling in papery rolls; bark on branchlets red-brown, thorns straight, weak, usually less than 2.5 cm long, sometimes absent; pinnae 4–12 pairs, leaflets 10–20 pairs; flowers golden-yellow; pod narrow-linear, strongly curved, up to 10 cm long, 0.6 cm wide, dehiscing on tree. Common in overgrazed pastures and widely distributed in East Africa. Hybrids, *A. seyal* var. *fistula* X *A. xanthophloea* Benth., are known from woodlands on black clay loams on flood plains in Malawi. Pods are conspicuously irregular, 4–11 cm long, 6–10 mm wide, ill-formed and curved. Assigned to the Africa Center of Diversity, shittim wood or cultivars thereof is reported to exhibit tolerance to high pH, heavy soil, insects, mycobacteria, poor soil, salt, savanna, slope, and waterlogging. (2*n*= 26.)

Distribution

Native to the Sahelian Zone from Senegal to Sudan, it also occurs in Egypt and eastern and southern Africa, from Somalia to Mozambique and Namibia (NAS, 1980a).

Ecology

Trees thrive in *Sclerocarya caffra* woodlands, wooded grasslands and especially on seasonally flooded black-cotton soils along water courses. Requires a heavy clay-alluvium, but will grow on stony ground at base of hills. Grows at 20–2,100 m altitude. A gregarious savanna tree, ranging from Subtropical Desert to Dry through Tropical Desert to Very Dry Forest Life Zones, shittim wood is reported to tolerate annual precipitation of 8.7–22.8 dm (mean of 7 cases = 15.0 dm), annual mean temperature of 18.7–27.8°C (mean of 7 cases = 24.0°C) and pH of 5.0–8.0 (mean of 5 cases = 6.9).

Cultivation

Propagated from scarified seed. large cuttings are said to strike root readity in moist soils.

Harvesting

Pods, bark or wood are harvested in season from trees or shrubs in native habitats. Gum also obtained from native plantings, in manner similar to that for other gum arabic plants.

Energy

The dense wood is highly prized for firewood, in areas where few other plants survive. Considered one of the best firewoods in Chad, it is used in the Sudan to make fragrant fires over which women perfume themselves.

Biotic Factors

Following fungi reported on this plant: *Fomes rimosus*, *Ganoderma lucidum*, *Leveillula taurica*, *Ravenelia volkensii*, *Trametes meyenii*, and *Uromyces schweinfurthii*. Although the plant is reportedly resistant to insect attacks, felled logs may be severely damaged by wood borers.

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Sarafis, V. 1999. Cucurbit resources in Namibia. p. 400–402. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Cucurbit Resources in Namibia*

Vassilios Sarafis

Namibia has several cucurbits with potential for development into commercial crops either through selection or through the introduction of genes into known crops. *Acanthosicyos horrida* Welw. ex J.D. Hook., wild *Citrullus ecirrhosus* Cogn., and *C. lanatus* (Thunb.) Matsum. & Nakai in the Cucurbitaceae are examples of gene sources. The areas from which these plants come are arid and the plants derive their water needs from dew precipitation in the mornings, very occasional rains every few years, and deep ground water (Seely l987; Lovegrove 1993).

ACANTHOSICYOS HORRIDA

Acanthosicyos horrida forms clumps of vegetation in the dunes of the Sossuvlei region near Walvis Bay (Fig. 1) (Craven and Marais 1986; Lovegrove 1993; Klopatek and Stock 1994). *Acanthosicyos horrida* is a dioecious perennial cucurbit attaining a height of about 1.5 m (Fig. 2). It forms plants of one sex in single clumps which may touch plants of the same or other sex nearby (Fig. l). It bears deep water table seeking roots (G. Wardell–Johnson, pers. commun. 1998). The plants are totally leafless (Fig. 2) and have a fruiting habit of oblong spherical fruits reaching up to 25 cm average diameter. The plants are able to build up sand deposits around themselves and continuously grow to be above these sand deposits. New plants establish only when rain falls and quickly form deeply growing roots that seek the water table (G. Wardell–Johnson, pers. commun. 1998).

Fig. 1. View of *Acanthosicyos horrida* in sand dunes at the Sossuvlei region near Walvis Bay Namibia.

Fig. 2. A close up of *Acanthosicyos horrida* plants. Note the leaflessness.

The fruit may not be spaced apart and may occur in clusters of several touching each other. The fruits are spiny (Fig. 3). Maturation of the fruits occurs between February and April. The fruits do not change color and remain green on the outside but the flesh surrounding the seeds dissociates from the skin, turns orange in color (Fig. 4), extremely sweet in taste and strongly aromatic. Maturational changes are easily detected by the bushmen living in the area without breaking the fruit in any way. The fruits are used by the bushmen for two main purposes. The first is for the extraction of the seed which are consumed as pips by splitting in the mouth and the second is for pulp processing where the flesh is boiled and poured to form a fruit leather. This fruit leather is eaten throughout the year and is considerably less flavorful than the pulp. The plant thus forms an important food resource because of the easy storage of both the seeds and the dried pulp (leather). The fruits are eaten also when immature by animals including jackals and rodents who do not seem to be bothered by the bitter taste of the fruits caused by cucurbitacins (Hylands and Magd 1986).

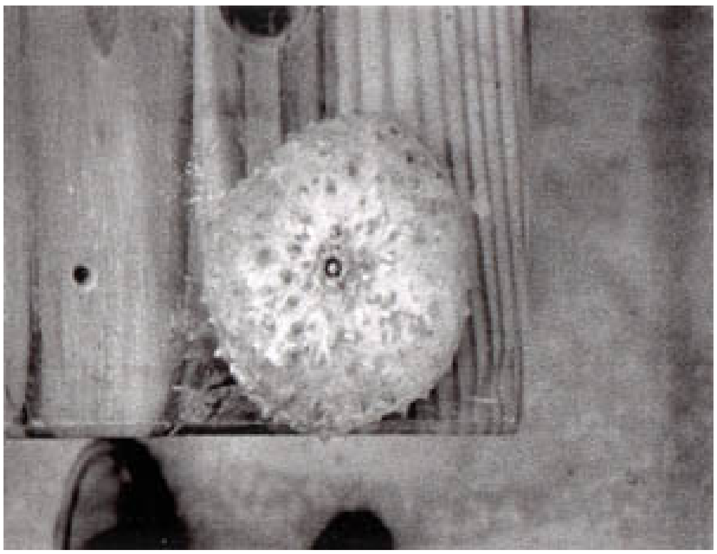

Fig. 3. Back of a mature fruit of *Acanthosicyos horrida* showing the large spines on the surface of the fruit. The distances separating the spines are small in young fruits.

Fig. 4. Cross section through three fruits of *Acanthosicyos horrida*. The one on the extreme right is a bitter immature fruit of full size. The one on the top an almost mature fruit with only a little bitterness. The bottom left hand fruit a fully mature fruit with a flesh having an orange color, no bitterness and very aromatic in flavor.

The mature pulp has a flavor which is aromatic and maybe due in part to sulphur components as in some types of *Cucumis melo* L. No trace can be tasted of cucurbitacins in the mature pulp. The pulp could be commercialized and used to make ice-cream, and could be freeze dried and chocolate coated. The seeds which are already sold to an European population in Walvis Bay can have their market expanded by selling the seeds either whole or dehusked in packaging developed for nuts. Their rarity should provide a premium price and help the economic existence of the bushmen in this area. Ice-cream manufacture and freeze drying facilities are only within 30 km of the bushmen. Partnerships with firms interested in commericalizing the unique, aromatic pulp of *Acanthosicyos horrida* could be fostered to further improve the economic existence of the native people in the area.

CITRULLUS ECIRRHOSUS

Citrullus ecirrhosus is a desert perennial (Fig. 5, 6) which is monoecious. Fruits mature (Fig. 7, 8) February to March. The leaves form an annual stems which die back each year. The leaves have a special feature where the lamina is curved over the mid-rib and the lateral veins so that when viewed from above the top surface is only visible in the vein regions and the leaves have a greenish white appearance due to the lower epidermis being reflected up as the upper surface of the leaf. This lower epidermis is covered with warts and hairs which account for the whitening effect. Both lower and upper epidermis contain similar amounts of stomata. The water relations of this plant are reliant on a deep water layer in the ground which the roots reach and possibly some water availability from morning fogs and the very occasional rainfall. The fruit and seeds contain cucurbitacins but the seeds are harvested in times of need and processed by crushing and decantation to remove the bitter substances. *Citrulls ecirrhosus* plants may be a source of drought tolerance genes for *Citrulls lanatus.* Successful crossability of *Citrulls ecirrhosus* and *C. lanatus* is discussed in Navot and Zamir (1986) and Navot et al. (1990). They have shown the way for breeding *Citrullus lanatus* containing genes from *C. ecirrhosus.*

Fig. 5. *Citrullus ecirrhosus* perennial plant growing approximately 20 km inland from Walvis Bay, showing a mature fruit on current years growth and brown dead stems from last years growth.

Fig. 6. *Citrullus ecirrhosus* perennial plant showing young developing fruit in the foreground and the bending of the leaves over the mid-rib and lateral veins.

Fig. 7. Mature *Citrullus ecirrhosus* showing folded nature of the leaves of the mid-rib and lateral veins.

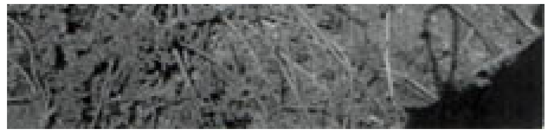

Fig. 8. Fruit of *Citrullus ecirrhosus* cut showing white creamy flesh which is non juicy and brown seeds.

CITRULLUS LANATUS

Citrullus lanatus wild plants seen near Walvis Bay have green fleshed fruit unknown from domesticated watermelons (Fig. 9). The genetics of fruit color in the watermelon, *Citrullus colocynthis* and *ecirrhosus* are discussed by Navot et al. (1990). White, yellow, orange, pink, red, and crimson flesh types are known. The green flesh color of this wild *Citrullus lanatus* (Fig. 9) is a unique feature which can be transferred to domestic watermelon due to the crossability of wild and domestic watermelons. This would offer a new fruit type for consumers to enjoy. A red flesh cultivated watermelon from the north of Namibia has some green zone within the fruit suggesting that the green flesh character can be easily introduced. However, the wild watermelon has cucurbitacins which would render them unfit for human consumption. Drought tolerance and green flesh color from *C. ecirrhosus* and wild *Citrullus lanatus*, could be valiable traits for watermelon improvement.

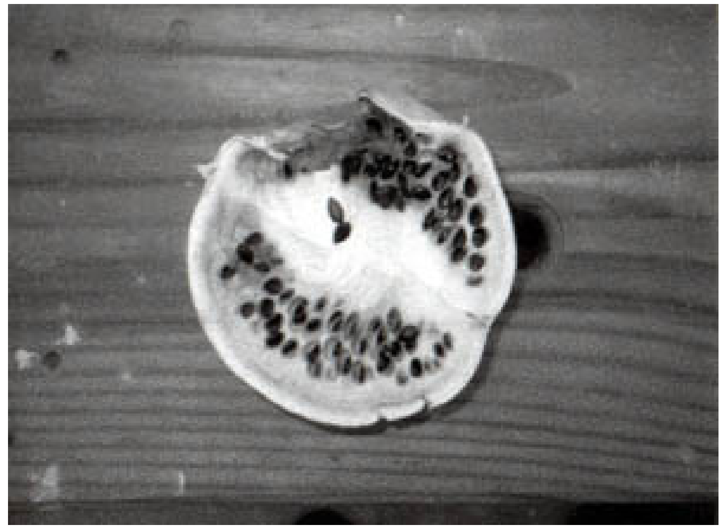

Fig. 9. *Citrullus lanatus* mature fruit from a plant growing on a dry river bed approximately 20 km inland from Walvis Bay, cut to show chlorophyll in the flesh and browny-black seeds. The more deeply colored regions of the flesh are green. The flesh is more juicy than in Citrullus ecirrhosus.

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back

Black sugar maple

Hard maple

***A. nigrum* Michx. f.**

Source: Magness et al. 1971

Maple sugar and syrup are obtained from the sap of these two species and are solely products of the United States and Canada. The Indians were making crude syrups and sugar from maple sap before the coming of white men. The preparation of maple sugar and syrup is strictly a farm industry, occurring from Kentucky northwest to Iowa, northeast to Maine and north into Canada. Native stands of these maple species are tapped to obtain the dilute juice or sap. The trees are not a cultivated crop, although competing useless trees may be removed and maple stands may be thinned to promote better growth and sugar yield. Only a small proportion of the available trees of these species are actually tapped. It is estimated that more than 200 million such trees are growing in the United States, and less than 6 million are tapped.

The tapping is done by boring a small hole (under 0.5-inch diameter) horizontally into the tree so as to penetrate through the outer or sap wood. On large trees up to four such taps may be made at one time. Tapered spouts (hollow tubes) are driven into the holes to fit tightly, and the sap flows through this tube and is collected in sap buckets. it is important to protect the buckets and contents from rain water. Tapping is done in late winter, before bud break. During periods when temperatures are above freezing at this season sap flow is quite abundant, A tap hole usuallv produces 5 to 15 gallons of sap, though much more than that is sometimes obtained. Sugar content of the sap also varies widelv, from l0 to 30°Brix or higher.

Portable tanks of various types are used to collect the sap, which is poured into the tank through strainers. An alternative method is to use pipc lines to carry the sap to the evaporation equipment.

Originally a single open kettle over a fire was used to evaporate the excess water in the sap to produce syrup. Now multiple evaporators are mainly used, the syrup being transferred as it becomes more dense. Usually 2 or 3 transfers are made. Modem evaporating pans have flues in them through which the heat from the fuel passes to speed the process and codserve fuel. For standard-density syrup, concentration is to 65.5°Brix, which is about 86 percent solids by weight. If the sap tests 2.4°Brix, 34 gallons would be required to produce one gallon of syrup.

Slow evaporation--or longer heating time--in the final stages of concentration result in a darker colored syrup. More rapid evaporation at this stage gives a lighter colored, higher grade syrup. Sensitive thermometers are used to determine when the syrup is concentrated to the standard of 65.5 Brix. The completed syrup contains solid granules, mainly calcium malate, termed sugar sand. For toable syrup these must be removed. On the farm they may be allowed to settle out or are removed by filtering. Centrifuging is efficient if available.

To produce various types of maple sugar, the syrup is further heated and additional water driven off. If heated to a boiling point of 230°F. and cooled rapidly without stirring a solid cake is formed. Stirring during cooling results in crystal formation. For fine crystals the highly supersaturated solution is seeded with fine crystals and stirred rapidly, which results in rapid formation of great numbers of fine crystals.

Numerous products, as maple cream, or butters, soft-sugar candies, maple spread, and candies utilize maple syrup or sugar. Total maple syrup production in the United States averaged approximately 1,400,000 gallons, 1961-66, inclusive. This includes that made into sugar. In addition about 800,000 gallons of syrup and 5,145,000 pounds of sugar were imported annually from Canada during those years.

Last update February 18, 1999 by ch

Malpighia glabra Millsp.

Malpighia punicifolia L.

Malpighiaceae

Acerola, Barbados cherry, *buesito*, Surinam cherry, West Indies cherry

NewCROP has acerola information at:

Barbados Cherry —Julia Morton, Fruits of warm climates

Magness J.R. et al. 1971. Food and feed crops of the United States.

Commercialization of Carambola, Atemoya, and Other Tropical Fruits in South Florida—Jonathan H. Crane

South American Fruits Deserving Further Attention— Richard J. Campbell

And outside links to more acerola info:

ACEROLA "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Digitaria exilis (Kipp.) Stapf

syn: *Digitaria iburua*

Gramineae

Fonio, *Acha*, Black fonio, Hungry rice, White fonio, Funde

We have information from several sources:

Digitaria exilis as a Crop in the Dominican Republic J. Pablo Morales-Payán, J. Richard Ortiz, Julio Cicero, and Francisco Taveras

Genetic Resources in Africa—Jack R. Harlan

Outside links:

Fonio *Digitaria exilis* from Lost Crops of Africa: Volume I: Grains

Halevy, A.H. 1999. New flower crops. p. 407–409. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

New Flower Crops

Abraham H. Halevy

Most edible crops have been introduced into cultivation thousands of years ago. There are only a few new edible plants in the contemporary western horticulture, such as pecan, blueberry, and kiwifruit, but even these plants have been cultivated since ancient days by local farmers in their native region. This is not the case with ornamental crops. Many of the commercial cut flowers and pot-plants grown today have not been cultivated commercially until several years ago.

The ornamental plant industry is characterized by its great diversity. There are more ornamental species cultivated today than all other agricultural and horticultural crops combined. In some ways the introduction of new ornamental crops is easier that of edible crops. Neither their nutritional value nor their general toxicity to human has to be considered, as evident in plants such as *Aconitum*, *Diffenbachia*, *Oleander*, and many others. Our main considerations in the introduction of new ornamental crops are the esthetic value, production costs, postproduction longevity, quality, and marketability.

The introduction of new crops includes many research stages, that start with the initial search and screening and concludes when the product is introduced commercially, as detailed in my other presentation in this proceedings (Halevy 1999).

Ten years ago the traditional major crops constituted over 60% of the cut flowers grown in and exported from Israel. This year over 60% of the exportable flowers are "new crops," most of them have not been grown commercially 10 years ago as shown in Table 1. Many of these new commercial flower crops are not even mentioned in a recently published textbook on floriculture (Dole and Wilkins 1999). There are several sources that serve for the introduction of new plant material as potential plant crops.

Table 1. Quantities of various exportable cut flowers from Israel in the 1996/7 export season.

Flowers	Exportable flowers (millions of stems)
Roses	453
Carnation	144
Gypsophila	116
Solidago	105
Ruscus	78
Wax flower	74
Hypericum	48
Gerbera	45
Limonium	41
Aster	35
Helianthus	32

Asclepias	27
Anemone	27
Safari sunset	20
Anigozanthos	17
Phlox	9
Others	210

MINOR OUTDOOR GROWN CROPS

Many of the new greenhouse floral crops, grown and exported during the winter, are the so called "Summer Flowers." They are field grown plants that were used in Europe during their natural flowering season in the summer. Their introduction as a year round crop requires developing physiological and horticultural techniques for out of season production. *Gypsophila* and peony described above (Halevy 1999) are typical examples of such crops. Other examples are listed below.

Aconitum napellus

L., Ranunculaceae (Monk's hood)

This is a tuberous plant native to Europe. For winter flowering, tubers are cold stored during the summer and pretreated with gibberellic acid before planting.

Asclepias tuberosa L., Asclepiadaceae (Butterfly weed) and *A. incarnata* L. (Swamp milkweed)

Both plants are native to the US and considered as weeds there. They are absolute long day (LD) plants that require warm temperature during their growth and flowering. For winter production they are grown in heated greenhouses and provided with supplementary light at night.

Achillea filipendulina Lam., Asteraceae (Yarrow)

Native to East Asia it is used mainly for summer harvest as dry flowers. Year round production is obtained by digging the crowns and cold storing them for a few weeks before replanting.

Liatris spicata Willd., Asteraceae

Native to Eastern US, for winter production, tubers are cold-stored during the summer and plants are lighted in the field.

Phlox paniculata L., Polemoniaceae

Native to Eastern US, this herbaceous summer perennial is now grown for year round production in greenhouses. It is a LD plant, requiring supplementary night lighting.

Solidago sp. L., Asteraceae (Goldenrod)

Species of goldenrod native to North America are considered as weeds there. New interspecific hybrids turned this plant into an important cut flowers. For winter production plants first receive LD to extend their stems and then are exposed to the natural winter short days (SD) for flower initiation and development.

Trachelium caeruleum L., Campanulaceae

Native to South Europe, it is an absolute LD plant and grown in the warmer parts of Israel for winter production.

NEW CULTIVARS OF ORNAMENTAL FIELD PLANTS

Plants of this group have been grown as minor cut flowers, but recent introduction of new cultivars, with modified and improved horticultural traits, turned them into important floral crops. Examples are:

Anigozanthos hyb., Haemodoraceae (Kangaroo Paw)

This Australian plant was grown mainly outdoors until a few years ago. Recently introduced highly yielding interspecific hybrids are now grown indoors for year round production. These new hybrids are propagated by in vitro tissue culture.

Aster hyb., Asteraceae

New interspecific hybrids of *A. novi-belgii* and other species native to Eastern North America turned these herbaceous perennial, late summer garden plant, into an important greenhouse crop. This is a LD-SD plant, requiring at first LD, until the stems reach a certain desired height and then it is exposed to natural winter SD.

Campanula medium L., Campanulaceae

This plant, native to south Europe, was used only as garden and pot-plant until recently. The original species required a long cold period followed by LD for flowering (Wellensiek 1985). However, new varieties, introduced recently, have long flowering stems and require only LD for flower induction. This enables growing the plant as a commercial cut flower crop.

Clarkia amoena Nels. & Macbr., Onagraceae (Godetia, Satin flower)

This Western North American plant was mainly a garden plant until the recent introduction of improved cultivars for use as cut flowers. The plant requires mild temperature and moderate watering and feeding. It is a facultative LD plant.

Eustoma grandiflorum Shinn (Syn. *Lisianthus russellienus*), Gentianaceae

Native to Southern US, it was used sparsely as garden and cut flower plant. Newly introduced F_1 hybrids turned the plant into an important greenhouse cut flower crop for year round production. Seed propagated, it requires mild-low temperatures in the first growing stage, followed by warmer temperatures.

Leucadendron Hyb., Proteaceae

This South African shrub became an important outdoor crop for cut flowering shoots with the introduction of new hybrid cultivars. The 'Safari Sunset' cultivar is now grown on over 200 hectares in Israel.

Limonium hyb., Plumfaginaceae

Interspecific hybrid cultivars of several perennial limoniums became important greenhouse cut flower crop, used as "filler."

GARDEN AND LANDSCAPING PLANTS

These are mainly woody or herbaceous perennials, used for many years in gardens and introduced recently into the floral trade. Examples are:

Cotinus coggygria Scop., Anacardiaceae (Smoke Tree)

A deciduous shrub, native to South Europe, used for many years as a garden plant. The cultivar 'Royal Purple' is now grown for cut foliage. LD is applied to prevent plants from entering dormancy.

Hypericum sp. (Hypericaceae)

Several species and hybrids of these shrubby plants, native to the Mediterranean and the Canary Islands, have recently became important floral crop grown both outdoors and in greenhouses for cut shoots with fruits of various colors. This is an absolute LD plant that requires night lighting for winter production.

Ruscus hypoglossum L. (Liliaceae)

This herbaceous perennial has been grown in Israel as a garden plants for many years. It is now the main cut foliage crop in Israel, grown exclusively in shaded houses.

ORNAMENTAL CULTIVARS OF FIELD CROPS

In some plants, grown mainly as field crops, new ornamental cultivars have been introduced and used as cut flowers. Examples are: sunflower (*Helianthus annuus* L., Asteraceae), cotton (*Gossypium hirsutum* L., Malvaceae), and safflower (*Carthamus tinctorius* L., Asteraceae).

PLANTS GROWN IN BOTANICAL GARDENS

Botanical gardens and specialized plant collections are rich sources for plant material, some of which can be used for introduction as potential floral crops. Some examples are the bulbous plants of the Liliaceae: *Eremurus* sp. of Central Asia, the South African *Bulbinella kookerri* of yellow, orange, and white flowers, and *Ornithogalum dubium* of yellow and orange flowers, and the South Asian *Curcuma alismatifolia* (Zingiberaceae).

WILD PLANTS IN THEIR NATIVE HABITAT

The introduction and development of Geraldton wax-flower described above (Halevy 1999) is an example of such introduction. Some such plants are currently under intensive developmental stages. They include plants originated from remote areas, but also plants native to Israel and California.

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- Halevy, A.H. 1999. Ornamentals: where diversity is king—the Israeli experience. p. 398–400. In: J. Janick (ed.), Perspectives in new crops and new uses. ASHS Press, Alexandria, VA.
- Wellensiek, S.J. 1985. *Campanula medium*. p. 123–126. In: A.H. Halevy (ed.), Handbook of flowering, Vol. II, CRC Press, Boca Raton, FL.

Achillea millefolium L.

Compositae

Yarrow, milfoil

We have information from several sources:

Herbs: An Indexed Bibliography. 1971-1980—J.E. Simon, A.F. Chadwick and L.E. Craker.

The Herb Hunters Guide—Sievers, A.F. 1930.

Bixa orellana L.

Bixaceae

Achiote, anato, annatto, arnato, bija, bijol, *bixa*, lipstick tree, roucou

We have information from several sources:

New Crops from Brazil—David Arkcoll

Achiote In: Magness, J.R., G.M. Markle, C.C. Compton. Food and Feed Crops of the United States. 1971.

Cyclanthera pedata (L.) Schrad.

Cucurbitaceae

Achocha, *Achokcha*, Caihua, Caygua, Cayua, Korila, Wild Cucumber

We have information from several sources:

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Outside links:

Achocha can be found in Lost Crops of the Incas from National Academy Press

Manilkara zapota (L.) van Royen

syn. *M. zapotilla* (Jacq.) Gilly, *Manilkara achras* (Mill.) Fosberg, *Achras zapota* (L.), *Sapota achras* Mill., *Sapota zapotilla* (Jacq.) Coville

Sapotaceae

Chicle, Chico, Chico sapote, Chico zapote, Chiku, Dilly, Mammee sapota, Marmalade plum, Naseberry, Nispero, Sapodilla, Zapote, Zapotillo

NewCROP has Sapodilla information at:

Sapodilla—Julia Morton, Fruits of Warm Climates

Sapodilla: A Potential Crop For Subtropical Climates—Michael V. Mickelbart

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Sapodilla info:

SAPODILLA "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

More Manilkara information:

Armitage, A.M. 1990. New herbaceous ornamental crops research. p. 453-456. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

New Herbaceous Ornamental Crops Research

Allan M. Armitage

INTRODUCTION

A great deal of interest in new floricultural crop research has occurred in recent years. The conferences in Davis, California, 1986 (Criley 1987) and Aarslev, Denmark. 1988 provided new and exciting avenues of study In general, three basic areas of research are presently being conducted in herbaceous ornamental crops around the world (Armitage 1987a). The first area consists of cultivar research in well-established ornamental species (type I species). For example, research evaluating new inflorescence shapes of *Dendranthema grandiflora* Tzvelev., new flower colors of *Petunia* x*hybrida* Vilm. or leaf varigation patterns of impatiens fall into this category. The second area deals with new uses for well known minor crop species (type II species). Examples include investigations into species of *Aquilegia* L., *Armeria maritima* Willd., *Calendula officinalis* L., and *Capsicum annuum* L., well known garden species, as potted plants. The third area of research involves development and evaluation of species about which little or no information concerning flowering physiology or performance under production conditions exists (type III species). The use of *Melampodium paludosum* L., *Trachelium caeruleum* L. or *Cedrela sinensis* Juss. as pot plants falls under this type of research as do investigations into *Achillea* x `Coronation Gold', *Caryopteris incana* Miq. or *Oxypetalum caeruleum* Decne. as field grown cut flower crops. The greatest amount of prior selection occurs with type I species, followed by type II while little, if any, selection has taken place in type III species. The grouping of species is dynamic and in a constant state of change. As type III species become accepted in the floriculture trade, they are relegated to type II or type I species. Examples of new crop species are listed in Table 1.

The potential for basic research is rich for type II and III species. Little is known concerning the control of flowering in these species and fruitful areas of investigation might include gas exchange, photoperiod manipulation, carbon partitioning, and factors affecting the onset of flowering. Information pertinent to commercial use, however, such as height control, irradiance levels, optimum temperatures and propagation techniques must also be understood before industry accepts a new species. In the case of cut flowers, the influence of spacing, shading, fertility and planting time on yield and shelf life may be exciting directions for research.

Little funding is available in the United States for new crop research in floriculture and scientists must balance fundamental studies on flowering physiology with applied applications to industry.

UNIVERSITY OF GEORGIA SYSTEMS APPROACH TO NEW CROP EVALUATION

The University of Georgia New Crops Program involves research on type II and type III species in two facets of floriculture: new pot plant crops for the greenhouse and new cut flower crops for the field. An enormous number of species exist with potential as new crops in one or both of these areas. The dilemma of the scientist is to not overlook potential successful species while at the same time ignoring or discarding those with little chance for acceptance. Therefore, a new crop program must have a system to choose species for research and to evaluate and develop information on those selected (Armitage, 1986). The most fundamental aspect of any system is that it be capable of quickly discarding species from the program. The systems approach used at Georgia has a number of places where the decision to terminate research on a species may be made (Fig. 1). The primary objective of our program is to develop information on crops with the following characteristics:

Potted plants must have at least 1 week shelf life without addition of extending sprays; cut flowers, 5 days without silver thiosulfate (STS). Floral preservatives are used in the case of cut flowers. If the shelf life is less than this standard, the decision may be made to terminate the species or to determine methods to extend shelf life.

The time from propagule (cutting or seed) to flower for pot plants must be less than 20 weeks. Many species occur for which rapidly flowering cultivars may one day be developed, however, there is little chance of commercial acceptance if greenhouse production time results in excessive cost of production. The program in Georgia is not in the position to spend the time necessary to breed and select new cultivars. The additional time required for slow flowering species detracts from other species to be investigated. If flowering time is felt to be too long, work on the species is terminated.

Exceptions may be made with species of outstanding potential such as *Eustoma grandiflorum* (Raf.) Shinn. In these cases, production partitioning within the industry will evolve. That is, propagation and growing occurs at one site while forcing into flower occurs at another. In this instance, it behooves the scientist to similarly partition his research on the species.

Species must be relatively tolerant of "normal" pests and diseases. Introducing species particularly attractive to whiteflies or highly susceptible to *Botrytis* should be avoided. If species being tested show weakness to diseases and pests, work may be terminated.

The new species should not have a deleterious effect on established commercial species. For example, our work with unproved cultivars of *Primula obconica* looked promising; however, the species contains primin and results in dermatitis in a small percentage of people. The adverse effects of primin could adversely affect sales of all primula species, particularly *P. acaulis*. Thus, the work was terminated.

Although the system provides objectivity, decisions to terminate are at the discretion of the scientist. Thus, the scientist in charge needs to work closely with industry.

SPECIFIC RESEARCH TOPICS

Flowering Physiology

Salvia leucantha. Plants are SD with a critical photoperiod of 12 hours for macrobud development and 10 hours for subsequent flower development. Approximately 14 cycles are necessary for initiation but 42 cycles are needed for normal anthesis and raceme elongation (Armitage and Laushman 1989).

Trachelium caeruleum. Plants are LD with a minimum of 14 hours for flower initiation but day neutral for subsequent flower development (Armitage 1988b).

Pentas lanceolata. Plants are quantitative LD, flowering 7-10 days earlier than SD (Armitage 1988a).

Oxypetalum caeruleum is day neutral for flowering but significant internode elongation occurs with LD (Armitage et al. 1990).

Gas Exchange

Trachelium caeruleum. Light compensation and light saturation are approximately 15 and 600 µmoles s^{-1} m^{-2} respectively at 25°C. At saturation, net photosynthesis is 10-12 mg CO_2 dm^{-2} h^{-1} (Armitage, 1988b).

Oxypetalum caeruleum. Light compensation occurs at 25 µmoles s^{-1} m^{-2} and saturation at 700

(Armitage et al. 1990).

Growth Regulators

Height control—Height regulation studies with *Melampodium paludosum*, *Pentas lanceolata* (Armitage 1988a), *Calendula officinalis* (Armitage et al. 1987), and *Trachelium caeruleum* (Armitage 1988b) have indicated that these crops may be useful for commercial pot plant production.

Fruit ripening—Use of 150-300 ppm of 2-(chlorethyl) phosphonic acid resulted in accelerated ripening of fruit of *Capsicum annuum* under greenhouse conditions (Armitage 1989a). Concentrations of 75 ppm was less effective and 600 ppm resulted in phytotoxicity.

Spacing

Studies on spacing were conducted with *Achillea* x 'Coronation Gold', *Physostegia virginiana* Benth. and *Salvia leucantha* as field grown cut flowers. Yield per plant increased as spacing increased but yield per area decreased (Armitage 1987b).

Shading (Field Flowers)

Anemone coronaria L. Stem length increased significantly under 55% light reduction compared with ambient (Armitage and Laushman, 1990).

Echinops ritro L., *Eryngium planum* L. Reduction of ambient light resulted in increased stem lengths for both species. Yield of *Eryngium* decreased with 55% light reduction, however, yield of *Echinops*, increased significantly. Additional shade reduced yield of both species.

Postharvest

Species with increased shelf life from dips with sodium silver thiosulfate (STS) include *Anemone coronaria*, *Physostegia virginiana* and *Salvia leucantha.*

Optimum time of bulb planting was determined for *Acidanthera bicolor* Hochst., *Anemone coronaria*, *Brodiaea laxa* Engler, *Allium sphaerocephalum* L., *Polianthes tuberosa* L. and *Liatris spicata* Willd. Perenniality and yield response was determined over a 3-year-period (Armitage and Laushman, 1990).

CONCLUSIONS

New crops are the lifeblood of the floriculture industry. New cultivars of established crops have historically kept the industry strong but entirely new crops must be introduced continually to maintain consumer interest. Research on new crops is necessary to provide information to control flowering time, manipulate plant size, and provide repeatable schedules. However, far more potential species exist than can be evaluated and developed. A systems approach to new crop research is essential in order that limited resources are used efficiently.

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- Armitage, A.M., Seager, N.G. Warrington and I.L. Greer, D. H. and J. Reyngold 1990. Response of *Oxypetalum caeruleum* to irradiance, temperature and photoperiod. J. Amer. Soc. Hort. Sci. (in press).
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Table 1. Potential species for pot and cut flower culture for new crop research.

Type I. (Species well established as ornamental plants)

- Greenhouse pot plants
    - Bedding plants (in general)
    - *Begonia* x *hiemalis*
    - *Denthanthema grandiflora* Tzvelev.
    - *Dianthus caryophyllus* L
    - *Euphorbia pulcherrima* Willd.
    - *Exacum affine* Balf.
    - *Kalanchoe blossfeldiana* Poellnitz
    - *Lilium longiflorum* Thunb.

  - *Pelargonium* x *hortorum* Bailey
  - *Sinningia speciosa* Benth & Hook.
- Greenhouse Cut Flowers
  - *Antirrhinum majus* L.
  - *Dendranthema grandiflora* Tzvelev.
  - *Dianthus caryophyllus* L.
  - *Gerbera jamesonii* Bolus.
  - *Rosa* x *hybrida*
- Field Cut Flowers
  - *Achilles filipendulina* Lam.
  - *Delphinium* sp.
  - *Gypsophila paniculata* L.
  - *Iris* sp.
  - *Iris xiphium* L.
  - *Limonium sinuatum* Mill.

Type II Species (New uses for well known minor crops)

- Greenhouse Pot Plants
  - *Alstroemeria aurantiaca* D. Don.
  - *Aquilegia* x *hybrids*
  - *Armeria maritima* Willd.
  - *Astilbe* x *arendsii*
  - *Bouvardia longiflora* HBK.
  - *Calendula officinalis* L.
  - *Campanula carpatica* Jazq.
  - *Capsicum annuum* L.
  - *Eustoma grandiflora* (Raf.) Shinn.
  - *Fressia* x *hybrids*
  - *Lilium* x *hybridum*
  - *Zantedeschia aethiopica* Spreng.

Type III Species (little information available)

- Pot Plants
  - *Allium neapolitanum* Cyr.
  - *Alonsoa warscewiczii* Regel.
  - *Cedrela sinensis* Juss.
  - *Coprosma* x *kirkii* Cheesem.
  - *Hebe speciosa* Cockayne & Allan
  - *Ixora coccinea* L.

- *Melampodium paludosum* L.
- *Nerine sarniensis* (L.) Herb.
- *Pentas lanceolata* Schum.
- *Reinwardtia indica* Dumort
- *Rhodohypoxis baurei* (Bak.) Nel
- *Tibouchina semidecandra* Aubl.
- *Trachelium caeruleum* L.
- *Veronica longiflora* L.

- Cut Flowers Field or Greenhouse
    - *Achillea* x 'Galaxy Series'
    - *Achillea* x 'Coronation Gold'
    - *Acidanthera bicolor* Hochst.
    - *Allium giganteum* L.
    - *Anemone coronaria* L.
    - *Anigozanthos mangleslii* D. Don
    - *Brodiaea* (*Triteleia*) *laxa* Benth.
    - *Caryopteris incana* Miq.
    - *Centaurea americana* Nutt.
    - *Centaurea macrocephala* Puschk.
    - *Centaurea moschata* L.
    - *Chamelaucium uncinatum* Schauer.
    - *Consolida ambigua* (L) P. W BallaHeyw.
    - *Craspedia globosa* G. Forst.
    - *Crocosmia crocosmiiflora* N.E. Br.
    - *Echinops ritro* L.
    - *Emilia javonica* Cass.
    - *Eryngiun alpinum* L.
    - *Eryngium planum* L.
    - *Euphorbia fulgens* Karw.
    - *Euphorbia marginata* Pursh.
    - *Gomphrena globosa* L.
    - Herbs (e.g. *Foeniculum*)
    - *Hypericum androsaemum* L. (fruit)
    - *Limonium* spp. (many)
    - *Nerine sarniensis* (L.) Herb.
    - *Nigella damescena* L. (fruit)
    - *Ornithogalum* spp.

- *Physalis alkekengi* L. (fruit)
- *Physostegia virginiana* Benth.
- *Polianthes tuberosa* L.
- *Salvia leucantha* Cav.

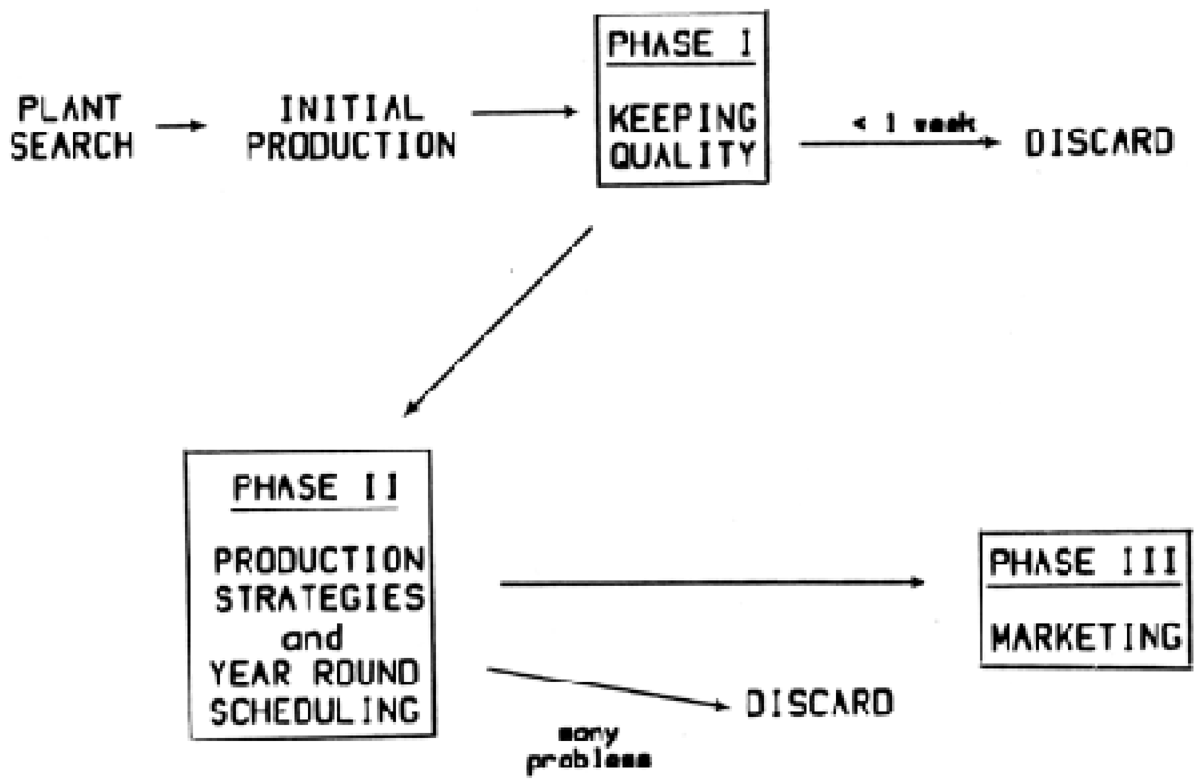

Fig. 1. Systems approach to crops research at University of Georgia New Crops Program (from Armitage 1986).

Last update September 4, 1997 by aw

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Acorus calamus L.

Araceae

Sweetflag, calamus, calamus root, flag root, myrtle flag

We have information from several sources:

The Herb Hunters Guide—Sievers, A.F. 1930.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Acroceras macrum Stapf

Poaceae
Nile Grass

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

A very palatable grass and rather extensively cultivated as pasture and hay, especially in the highyield areas of South Africa. Forms dense cover used for grazing and haymaking. Unsuitable for leys, as it is difficult to eradicate. Very useful as fodder source during dry season. The grass has been described, perhaps hyperbolically, as "the king of fodder grasses—a truly revolutionary grass" (Rhind and Goodenough, 1979).

Folk Medicine

No data available.

Chemistry

Per 100 g, the forage is reported to contain 8.7 g protein, nearly 6 g fat, 75.4 g total carbohydrate, 30.7 g fiber, 450 mg Ca, and 110 mg P (Bogdan, 1977). Other reports put the crude protein as high as 22%; one report gives 21.3% for leaves, and 7.9% for the stems; crude fiber was given as 30.0% for leaves, 38.5% for stems. On a zero moisture basis, South African hay was 8.5% CP, 31.8% CF, 6.1% ash, 1.8% EE and 51.8% NFE (Gohl, 1981). Many more nutritional details are tabulated in the excellent review by Rhind and Goodenough (1979).

Description

Perennial grass, spreading by creeping slender rhizomes and stolons; culms up to 70 cm or more, sometimes prostrate at base; leaves expanded, to 20 cm long and 12 mm broad, glabrous or minutely hairy, rounded or almost cordate at base, tapering to sharp point, bright green; panicle up to 20 cm long, spikelike, of 2–5 racemes up to 8 cm long, the lower 5–9 cm apart; spikelets light green, acuminate or obtuse, 4–5 mm long, awnless, glabrous, with conspicuous indurate rounded appendages at laterally compressed apex of glumes and lemmas; lower glume more than half as long as spikelet, 3-nerved; upper glume 5-nerved; ligule a membrane fringed with short hairs, sometimes greatly reduced. 4x = 36.

Germplasm

Reported from the Africa Center of Diversity, Nile grass or cvs thereof is reported to tolerate low pH, photoperiod, sand, savanna, virus, and waterlogging. It does not tolerate drought very well. Susceptibility to diseases and an apparent lack of seed-setting ability were partially overcomeby breeding programs initiated at Cedara. Tetraploid ($2n$= 36), pentaploid ($2n$= 45), and hexaploid ($2n$= 54) chromosome races occur. The species is self sterile, but certain combinations of strains of similar chromosome number and flowering data highly cross fertile (Rhind and Goodenough, 1976). ($2n$= 36)

Distribution

Widely distributed in Africa from Ethiopia to South Africa, also in Angola and South West Africa; introduced elsewhere e.g., Australia, Surinam, and Trinidad.

Ecology

Grows naturally in seasonally flooded valley bottoms in areas with 92–150 cm rainfall annually. It is indifferent to day length and will flower equally readily in long or short photoperiods. Flourishes on poorly drained or seasonally flooded land, and does not grow well under dry conditions. It has been successful on loams, sandy loams, and clay loams. Ranging from Warm Temperate Dry through Tropical Moist Forest Life Zones, Nile grass is reported to tolerate annual precipitation of 8 to 27 dm (mean of 4 cases = 13), annual temperature of 16° to 26°C (mean of 4 cases = 17), and pH of 4.3 to 7.3 (mean of 4 cases = 5.5). Rhind and Goodenough (1979) say it favors areas at elevation ca 600 to 2000 m, annual precipitation of 7.5–15 dm where the dry season is not too long.

Cultivation

Propagated by splits or cuttings of rhizomes or stolons. In some areas under humid conditions, grass is cut at hay stage and scattered over surface of land and then covered by a disc-harrow, as in Trinidad. Planted in holes 45 x 45 cm apart. Grass should be alllowed a full year to become established. Although its growth habit, having both rhizomes and stolons, serves for vegetative propagation and for exploring new ground, it also allows for carbohydrate storage in the rhizomes and brings some of the growing points below ground level where they are more effectively protected from frost, drought and burning. Has been used for improving natural moist pastures by planting splits or rhizome cuttings into existing natural grassland or plowed grassland following an arable crop. It was persistent although not very productive in Kenya and South Africa, and was reasonably successful in Rhodesia, Surinam and Swaziland (Bogdan, 1977). Seeds have a dormancy characteristic, germination improving after 9 months storage.

Harvesting

Grazed or cut for hay. Grass should be mown towards end of rainy season (summer) for hay or silage. Good aftermath is available for grazing during dry autumn and winter months when it is most valuable. A further flush can be grazed in spring during the early season.

Yields and Economics

Cut for hay, it yields 5–8 MT/ha (Bogdan, 1977). In one Rhodesian trial, it was one of the lowest yielders, at 7 MT/ha. Yields may attain 12.5 T/ha per season. In Natal, it averaged 9.8 MT/ha/a for three seasons (Theron and Arnott, 1979). A valuable pasture and fodder grass in areas of adaptation especially in humid tropical areas, as South Africa.

Energy

According to the phytomass files (Duke, 1981), annual productivity ranges from 4 to 12 MT/ha. Rhind and Goodenough (1979) report 2 to 18 MT DM (the latter is Swaziland). Such DM (dry matter) can be converted to energy by burning or conversion to alcohol or methane. According to Gohl (1981), ME (metabolizable energy) is 2.35 megacalories per kilogram of dry matter in hay.

Biotic Factors

The fungi, *Phyllosticta* sp. (leaf spot) and *Ustilago syntherismae* (smut) have been reported on this grass.

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Last update December 19, 1997

Arkcoll, D. 1990. New crops from Brazil. p. 367-371. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

New Crops from Brazil

David Arkcoll

INTRODUCTION

Brazil and especially the unexplored regions of the Amazon, are extremely rich sources of plant germplasm with potential as new crops. Establishing the correct selection criteria is important to evaluate the true potential of the many promising species by calling attention to their assets and to the missing information and problems facing each species. This must be accomplished efficiently to justify the considerable investment in relevant research needed to develop the most promising plants into commercially viable crops.

Much of the current interest in new crops arises from the over production of traditional cereals and soybeans by major producer and exporting countries. This has led to the expensive practice of paying farmers to leave land idle in the USA, clearly an undesirable situation. Furthermore, traditional markets like Europe and the developing world are increasing their own production to relieve their shortages and reduce their imports. In some cases, these countries are even compelling in export markets with their surpluses. Examples are the explosion of rape seed in Europe and the large amount of soybeans now being produced by Brazil and Argentina. The tendency is to replace imports, hence the interest in the USA in finding alternatives to rubber (e.g. guayule), lauric oils (e.g. *Cuphea*) and cellulose (e.g. kenaf). This in turn will force traditional producers of these products to search for alternative crops as well.

There are many other good reasons for looking to new crops. These include the need to diversify from vulnerable dependence on the few major grain crops, the increasing interest in novelty foods, the industrial requirement for new compounds (e.g. new colorants, polyvinyl plastics), and new nutritional recommendations (e.g. gamma linolenic acid and new low calorie sweeteners). There is also a need for new crops to expand agriculture into marginal lands, especially in the tropics where few viable alternatives are found. New systems like agroforestry and biomass production also may require new crops.

SELECTING NEW CROPS

Ideally, having decided on a precise need, one would then look for a plant that has the desired characteristics. In practice what has tended to happen is that a botanist studies an interesting species and then tries to find a market for it. However, there are a series of characteristics that a wild plant must have if it is to ever make the large jump from botanical curiosity into viable crop. These include agricultural industrial and marketing characteristics (Arkcoll and Clement 1989). It should be easy to propagate, precocious, rustic, productive, be easy to harvest, and fit into current farm practice. The product must be easy to transport, store, and process. It should also be able to enter an established market at a competitive price or should be so attractive that a new market can be easily created.

We have been evaluating some of the most interesting species in this light in an effort to reduce the number to a few with the greatest potential. These and other species being developed in Brazil, are examined below to draw attention to the current stage of development, the missing data and the major problems that each one faces.

Bactris gasipaes (Peach palm, Pejebaye)

The Peach palm has attracted much attention in the last decade because of the texture and composition of the fruit mesocarp which is usually similar to that of a starchy cereal or root crop. It is consequently an important backyard tree in much of tropical Latin America and is used as a dietary staple by some Amerindian tribes (FAO 1986, Clement and Arkcoll 1989). The small crown and very high yield of some trees have suggested that it could be a useful plantation crop capable of producing large amounts of basic food in the wet tropics. We have been studying this potential as an important part of attempts to create ecologically attractive "food forests" to produce food from a permanent perennial system (Arkcoll 1978, 1979, 1984). Some introductions are very rich in oil (62% of mesocarp dry matter) suggesting that selecting for this character would be an interesting alternative because of the local and world markets for oil and protein rich meals (Arkcoll and Aguiar 1984). Most fruit have a bland taste that is not exotic enough to export, however some with a sweetish flavor may have more potential as a table fruit and at least expand local markets. The crop has only been grown on a large commercial scale for palmhearts in Costa Rica where over 2000 ha have been planted. The viability of this venture has been dependent on Government subsidy as it is difficult for plantations to compete with raw material coming from wild *Euterpe edulis* in Brazil. It is especially interesting as a source of palmhearts because it tillers and grows extremely fast (Gomes and Arkcoll 1987). Unfortunately, this vegetative vigor is proving to be a problem in fruit production as the fruit are produced too high above the ground to harvest after a few years. Precocity has been observed and there are signs of different growth rates suggesting that researchers might locate dwarf phenotypes. Managing tillers as in banana plantations, is also being considered. While individual stem yields of over 80 kg/yr. have been recorded, plantation yields have been frustrated by uneven bearing and tremendous fruit drop caused by poor pollination, drought, nutrient deficiencies, and principally pests and diseases. It is hoped that these problems can be controlled the crop is better understood. The successful selection and combination of desired characteristics could make this crop as important as the coconut in the wet tropics.

Astrocaryum aculeatum (Tucuma)

Tucuma, a heavily spined palm, is of interest because of the oily mesocarp and large kernel. A very brief examination of a few dozen introductions from the Manaus market, identified one with over 30% oil in the fresh fruit (Arkcoll et al. 1986, Arkcoll 1988). However, the species is only used locally for the direct consumption of the very thin pulp. This is bitter, nutty, and oily and rarely appreciated by the newcomer. However, it is so appreciated by locals that it costs as much as a dollar a dozen. Despite the premium price, tucuma is not grown commercially because there are enough native trees to satisfy demand. The species often becomes dominant in secondary forests because of resistance to fire and perhaps this characteristic can be used to recover worn out and abandoned pasture (FAO 1986). Difficulty in breaking seed dormancy and slow initial growth, have dampened the enthusiasm of research workers, but the large variation found in *A. vulgare* (Lima et al. 1986), a similar species with several stems, suggests that both species deserve more attention.

Acrocomia aculeata (Macauba)

Macauba palm is somewhat similar to the last palm in that its fruit have a large amount of both pulp and kernel oil and together with several very similar species, is widespread throughout central and Latin America often on poor soils. Its apparent tolerance to drought, makes it an attractive species for producing oil in regions that are too dry for the African oil palm and coconuts. The very high yield predictions of 6 t/ha (Wandeck and Justo 1982) have not been confirmed yet because of difficulties in breaking dormancy and slow early growth. Rapid hydrolysis of the mesocarp oil and difficulty in separating oil from the moist, fibrous and mucilaginous pulp, are among the other problems that still have to be faced (FAO 1986, Arkcoll 1988).

Cuphea spp.

The several hundred widely spread species in this genus have been of interest for about a decade, because of the unique composition of their seed oils. This varies with species, with the most interesting having over 80% lauric acid (Graham et al. 1981, Graham and Kleiman 1985). As most species are small herbaceous plants and many are adapted to the colder regions of highland Mexico, it is hoped that a mechanized crop suitable for temperate climates might be developed and reduce the dependency of lauric oil importing countries on wildly fluctuating supplies from coconut producers. Satisfactory yields have not been achieved in the USA because of shattering (Hirsinger and Knowles 1984, Hirsinger 1985). Attention has been drawn to several other problems such as seed dormancy, slow growth and the variable chromosome numbers and fatty acid composition observed in different species (Arkcoll 1988). Many wild species have not yet been studied and an effort is being made to collect this germplasm in order to locate desirable characteristics. Research is also in progress to obtain indehiscence through mutations and also to splice the appropriate *Cuphea* genes into a conventional crop such as rape (Thompson 1984, Tokay 1985). Sudden success in either of these efforts could lead rapidly to the development of an important new crop to supply the enormous market for lauric oils. It would also help to expand markets for medium chain (mixtures of C8 and C10) triglycerides that have considerable commercial potential, especially as lubricants and nutritionally desirable and medically useful oils (Bach and Babayan 1982). There is considerable interest in the pharmacological properties of extracts from the whole plant of some species used as a cure-all in local folk medicine in Brazil. There is now scientific confirmation of several potentially useful separate effects including depression of the central nervous system and the ability to reduce blood pressure in experimental animals (Ericeira et al. 1984).

Annona muricata (Soursop)

The large fruit of the soursop is much appreciated in several Latin American countries mainly as a sweetened juice but also as an ice cream and yoghurt flavoring. Several small commercial plantations are now in operation with about 2000 ha planted in Brazil and more planned. Yields have been disappointingly low, rarely reaching 7 t/ha in plantations sown from seed. Yields from individual trees very significantly suggesting that considerable improvement could be achieved via clonal selection. Production problems include low fruit set due to poor pollination and adverse climatic conditions and the attack of several devastating pests and diseases (FAO 1986). The flavor is somewhat volatile so pasteurized products are less attractive than fresh ones, and the off white color can become an unpleasant grey unless oxidation is prevented. The premature sale of several poor bottled products is thought to have limited market penetration. Frozen and chilled products seem more successful elsewhere (Arkcoll 1987), especially in regions where the fresh fruit is well known and appreciated.

Eugenia stipitata (Araçá-boi)

Araçá-boi, a little known fruit from the Western Amazon is very attractive in appearance and has an exquisite fragrance. Although extremely sour to the taste, the sweetened juice has performed well in acceptance trials. In early performance trials two-year old bushes produced high yields

(FAO 1986). The main production drawbacks are susceptibility to anthracnose, soft fruit texture and volatility of aroma. Consequently, resistance is being sought, firm fruit are harvested a little green with small loss in quality and the market will probably be restricted to fresh and frozen products. Studies on the aroma are planned as this may have a market in its own right.

Psidium angulatum (Araçá-Pera)

This is one of the most interesting of the many wild acidic guavas known collectively in Brazil as Araçá. Its sour juice is so concentrated that it must be diluted 10 times and well sweetened to produce a very acceptable drink. Once again, the delicate flavor is affected by heating so that fresh and frozen products are superior to pasteurized juices. The fruit comes from the eastern Amazon and there are only a few experimental plantations at the moment. Initial impressions are that the plant is rustic and productive although the yields are low compared to guavas. Interspecific breeding may be promising. The leathery skin should avoid damage during transport and together with the high acidity, give some resistance to insect attack. Fruit are quite variable and clonal selection is needed to obtain superior introductions (FAO 1986). Another wild acidic guava receiving attention *is Feijoa sellowiana* from the extreme south of the country (Mattos 1986).

Spondias lutea (Taperebá, Cajá)

Taperebá or Cajá is one of the most popular fruit in the North and Northeast of Brazil. The fruit itself is rarely eaten directly as the pulp is thin and usually quite sour, however it makes a superb sweetened juice and ice cream or ice lollipop of excellent flavor. The flavor is volatile and pasteurized products are not attractive. No plantations are known which is surprising as the demand is in excess of the current supply from the many large trees found scattered at low density over a wide area of forest. Trees grow fast from seed but take over 5 years to fruit. Like most *Spondias,* they can be propagated easily from large cuttings to fruit quickly and reduce the size of the trees. This is important as the very soft fruit are often bruised when harvested from the ground beneath large trees. Most fruit are small and have a large seed and thin layer of pulp so a search is on for fruit said to be as large as *S. dulcis*. The tree appears to be rather rustic and productive although no data on yields is available (FAO 1986).

Theobroma grandiflorum (Cupuassu)

A highly perfumed pulp surrounding the seeds of Cupuassu, a large relative of Cacao, is much appreciated in the Amazon region for making sweetened juice, ice cream or charlotte desserts. It fetches the highest price of all fruits in the local markets and there are now several hundred hectares planted to supply the Belem and Manaus markets. Newcomers often find the aroma a little overpowering at first, but soon acquire a liking for it. This volatile aroma could be extracted and might find a market in the flavor and perfume industry. Yields are low in the field (Calzavara 1987) and there is only about 40% pulp in most fruit. Seedless fruit are known with larger amounts of pulp. However, the seed can be made into a number of chocolate-like products and so could become a useful byproduct if large scale production becomes viable (Arkcoll and Clement 1988). Selection for higher yield and resistance to witches broom is needed (FAO 1986).

Couepia longipendula (Egg nut)

Apart from the major Brazilian nuts, (cashew and brazil) there are many other interesting examples. One of these is *Couepia longipendula* (egg nut) because of its excellent flavor. This large tree is common in the forest around Manaus but although widely eaten in the rural areas, it never reaches the local market so is little known. The shell is hard and thick requiring an ax to break it. Nuts with thinner shells are said to exist in the forest. Trees are rather slow growing so grafting onto the more vigorous rootstock of *C. subcordata* is being considered (FAO 1986). The kernels are rich in oil which appears to have some unusual polyunsaturated fatty acids.

Couma utilis (Sorva)

Over 5000 t of sorva latex are exported from this plant each year as a substitute for chicle gum. Much of it is obtained by destructive tapping of wild trees. Because these are being decimated quickly, *Achras sapota* trees are slow growing and increasingly rare and industrial substitutes are contaminated with heavy metals, there is considerable interest in establishing plantations of *C. utilis*. A few experimental trees have grown very fast on poor soil but tapping yields have not been obtained yet. The tree is also very decorative and the good flavored fruit are sold in local markets. The fruit might become a useful subproduct of latex plantations, however, they are too soft and not thought to be interesting enough to consider more seriously in their own right (FAO 1986).

Paullinia cupana (Guaraná)

Roasted seeds of this plant are ground up to make an interesting cola type drink called guaraná. Over 1000 t are now produced annually in Brazil on about 5000 ha of poor oxisols. Vegetative propagation of selected plants is starting to increase yields and the local market is now thought to be saturated. An export drive is now in progress and seems to be having some success, especially in Japan. The drink owes much of its popularity to the stimulation produced by its high caffeine content and the widely held belief in its rejuvenating and aphrodisiacal properties (Cavalcanti 1988). Well formulated products can be very good although several of the most popular brands contained very little or no real guarana until recent legislation, aimed at supporting growers, made the inclusion of a small amount compulsory.

Stevia rebaudiana (Stevia)

Dried leaves from this small shrub from the south of Brazil, have been used as a local sweetener and cure-all for generations. The main active ingredient, stevioside, is said to be up to 300 times as sweet as sucrose. Extraction processes have been developed in Japan and Brazil and over 100 t/year sold in a purified form until recently when doubt has been cast over its toxicity and the mutagenicity of the metabolite, steviol (Pezzuto et al. 1985, S. Cascon pers. commun.). Studies are in progress to clarify this situation and some derivatives that are believed to be safe, have been synthesized and patented (Dubois et al. 1984). About a 100 ha are now planted annually in Brazil to satisfy the local demand, mainly by natural health shops for dried leaves. Yields of 2 to 3 t/ha of leaf with about 10% stevioside are obtained.

Bixa orellana (Annatto)

Restrictions on the use of many synthetic colorants and the relative instability of most other carotenoids, are leading to the increasing use of bixin, especially in the dairy industry. World production, estimated at about 3,000 t of annatto seed in 1983 (Anand 1983), is now thought to have risen rapidly to over 10,000 t, about half of which comes from Brazil. Until recently, annatto (or urucum as it is known in Brazil) was little more than a back garden crop. However, high prices and the good yields have resulted in a few farmers planting it on a larger scale. Yields, after 4 years, can pass 2 t/ha with 0.9 to 6.9% (average about 2.5%) bixin covering the seeds in a sticky resin (Nicholson 1964, I. Guimaraes pers. commun.). Yields from seedling trees are very variable as the crop is cross pollinated. Variation in the exact composition of the colorants in the final extracted products limits marketability. Vegetative propagation is easy and should make rapid advances possible especially if the crop is selected for a combination of yield and bixin content. The relatively small market for colorants could quickly become saturated so there is interest in the potential of this rustic perennial crop as an alternative grain for growing on exhausted tropical soils. The high yield potential despite any scientific attempts at improvement, makes it a very promising crop.

CONCLUSIONS

The above species have been identified by a series of multidisciplinary criteria as some of the best Brazilian options for development into new crops. They are found in various stages of development from early germplasm collection to small commercial plantations. Attention is drawn to some of the missing data and problems that they face if they are to overcome the risks of early commercial plantations and make the large jump from botanical curiosities to useful crops. Appropriate research is now underway to collect the missing data and to resolve the problems, however it is bedeviled by a lack of continuity. Germplasm maintenance and work with tree crops, especially breeding, are very long term projects that funding bodies have failed to face so much research has been wasted in the past (Arkcoll and Clement 1989). Thought is needed on how one forms and keeps a multidisciplinary team together over many years in countries with wildly fluctuating economies and poor working conditions.

It is also well known that few crops have been successfully exploited on a large scale near their center of diversity because of indigenous pests and diseases, so that local research will probably benefit other regions of the globe. Thus, improvements in the exchange of germplasm are important if many new crops are to be fully evaluated and developed.

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Actinidia deliciosa, Actinidia arguta

Actinidiaceae

Kiwifruit, Chinese Gooseberry, Hardy Kiwifruit, *Yang tao*

We have information from several sources:

New Temperate Fruits: *Actinidia chinensis* and *Actinidia deliciosa*—A.R. Ferguson

Kiwifruit—Julia Morton, Fruits of warm climates

New Horticultural Crops in New Zealand—Errol W. Hewett

Temperate Berry Crops—Chad Finn

Outside links:

The Kiwifruit (*A. deliciosa*) from the California Rare Fruit Growers.

The Hardy Kiwifruit (*A. arguta*) from the California Rare Fruit Growers.

Kiwifruit Production from the Northwest Berry and Grape Information Network

Kiwifruit—from Mark Reiger, Dept of Horticulture, University of Georgia.

Kiwifruit Information from the University of California Fruit & Nut Research and Information Center

California Kiwifruit Commission

Vigna angularis (Willd.) Ohwi & Ohashi

syn: *Phaseolus angularis* (Willd.) W. F. Wight

Fabaceae

Azuki bean, Adzuki bean, Adanka bean

We have information from several sources:

Potential New Specialty Crops from Asia: Azuki Bean, Edamame Soybean, and Astragalus—Thomas A. Lumpkin, J.C. Konovsky, K.J. Larson, and D.C. McClary

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Plant Configuration and Population Effects on Yield of Azuki Bean in Washington State—An N. Hang, D.C. McClary, G.C. Gilliland, and T.A. Lumpkin

Herbicides for Azuki Production—Dean C. McClary, A.N. Hang, G.C. Gilliland, J.M. Babcock, T.A. Lumpkin, A.G. Ogg, and L.K. Tanigosh

Adzuki Bean: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

New Opportunities in Vigna—Richard L. Fery

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Aegle marmelos Correa

Rutaceae

Bael, bael tree, bel-fruit, Bengal quince, Indian bael, *marmelo*, Sirphal, Wood apple

We have information from several sources: FactSHEET contributed by K.K. Misra

Bael Fruit—Julia Morton, Fruits of warm climates

Horsechestnut

Aesculus hippocastanum L.

Other common names.—Hippocastanum, bongay, konker-tree

Habitat and range.—This tree is largely cultivated in this country as an ornamental shade tree and occasionally escapes from cultivation.

Description.—The horsechestnut is a rather large tree, usually reaching 40 feet or more in height. The large leaves are composed of five to seven leaflets from 4 to 8 inches long, pointed, and broader at the top than at the base. In June it produces handsome flower clusters sometimes a foot in length, consisting of large white flowers spotted with yellow and red. The fruit is round and prickly and contains a large shining brown nut.

Part used.—Horsechestnut bark is collected in autumn, and preference is given to the bark from the younger branches.

Figure 66.—Horsechestnut (*Aesculus hippocastanum*)

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Amomum melegueta Roskoe

syn.*Aframomum melegueta* [Roskoe] K. Schum.
[the genetic epithet "*Aframomum*" is a *nomen rej*. see: Monog. Scitam. t. 98.]

Grains of Paradise or Guinea Pepper

also known as **Guinea Grains, Melegueta Pepper, Atar** and **Aligator Pepper**. In pharmacy, ***Grana paradisi***.

Zingiberaceae, the Ginger family

NewCROP has information from the following sources:

A summarized description of the flavor of grains of paradise from "What peppercorns only dream of being" New York Times, May 3, 2000 by Ammanda Hesser.

Grains of Paradise — Iwu, M.W., A.R. Duncan, and C.O. Okunji. 1999. New antimicrobials of plant origin. p. 457-462. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Grains of Paradise from Magness *et al.* 1971. Food and feed crops of the United States.

Outside links to Grains of Paradise info:

Essential oil of grains of paradise.

Grains of paradise — from Gernot Katzer's Spice Pages.

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Cenchrus ciliaris L.

Syn.: *Pennisetum ciliare* (L.) Link
Pennisetum cenchroides Rich.

Poaceae

Buffelgrass, Anjangrass, African foxtail

We have information from several sources:

African Grasses—Glenn W. Burton

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update October 27, 1997

Cucumis metuliferus E. Mey. ex Naud or ex Schrad

Cucurbitaceae

Kiwano, African horned cucumber, African horned melon, English tomato, Hedged gourd, Horned melon, Jelly melon, Melano, *Metulon*

We have information from several sources:

FactSHEET contributed by: Aliza Benzioni

Germination, Fruit Development, Yield and Post Harvest Characteristics of *Cucumis metuliferus*—A. Benzioni, S. Mendlinger, M. Ventura, and S. Huyskens

Evaluation of *Cucumis metuliferus* as a Specialty Crop for Missouri—Dyremple B. Marsh

Eleusine coracana (L.) Gaertn.

Poaceae

African millet, Finger millet, *Ragi*

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside links:

Finger millet—*Eleusine coracana* from Lost Crops of Africa: Volume I: Grains

Elaeis guineensis Jacq.

Syn.: *Elaeis melanococca* J. Gaertn.

Arecaceae (Palmae)

African oil palm

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update August 23, 1996 by aw

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Mushroom

Agaricaceae *Agaricus* sp.

Source: Magness et al. 1971

The term mushroom applies to edible, fleshy fungi, either gathered from the wild or grown in cultivation. Under cultivation, mushrooms are grown mainly in the dark, in caves or light-tight buildings, with temperature, moisture and ventilation control. The "spawn" or mycelium is seeded in specially prepared compost in beds or suitable containers. After the mycelia have spread through the compost, a layer of soil or "casing" is applied. The mushrooms, the fruiting bodies of the fungi, first appear at the soil surface 6 or more weeks after seeding with spawn, and continue to appear. They are usually harvested by cutting off the cap with a small portion of the stem before the caps have become fully expanded. Beds produce the main crops in the first 50 days after fruiting starts, but may be retained with light production for several months.

Season, seeding spawn to first harvest: 6 to 8 weeks.

Production in U.S.: 100,000 tons.

Use: Food flavoring, soups, sometimes as pot vegetable, or raw in salads.

Part of plant consumed: Fruiting "cap" and stem.

Last update February 18, 1999 by ch

Sesbania grandiflora (L.) Pers.

Fabaceae
Agati, Corkwood tree, West Indian pea

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The tender leaves, green fruit, and flowers are eaten alone as a vegetable or mixed into curries or salads. Flowers may be dipped in batter and fried in butter. Tender portions serve as cattle fodder, (overeating is said to cause diarrhea). Ripe pods apparently are not eaten. The inner bark can serve as fiber and the white, soft wood not too durable, can be used for cork. The wood is used, like bamboo, in Asian construction. The tree is grown as an ornamental shade tree, and for reforestation. In Java, the tree is extensively used as a pulp source. A gum resembling kino (called katurai), fresh when red, nearly black after exposure, exudes from wounds. This astringent gum is partially soluble in water and in alcohol, but applied to fishing cord, it makes it more durable. Pepper vines (*Piper nigrum*) are sometimes grown on and in the shade of the agati. According to NAS (1980a), this small tree produces firewood, forage, pulp and paper, food, and green manure and appears to hold promise for reforesting eroded and grassy wastelands throughout the tropics. It combines well with agriculture (agroforestry) in areas where trees are not normally grown and becomes an important fuelwood source. Dried and powdered bark is used as a cosmetic in Java.

Allen and Allen enumerated three undesirable features (1) short lived (2) shallow-rooted and subject to wind throw, and (3) prolific seeder, the pods often considered a litter. An aqueous extract of bark is said to be toxic to cockroaches.

Folk Medicine

Resorted to be aperient, diuretic, emetic, emmenagogue, febrifuge, laxative, and tonic, agati is a folk remedy for bruises, catarrh, dysentery, eyes, fevers, headaches, smallpox, sores, sorethroat, and stomatitis (Duke and Wain, 1981). Bark, leaves, gums, and flowers are considered medicinal. The astringent bark was used in treating smallpox and other eruptive fevers. The juice from the flowers is used to treat headache, head congestion, or stuffy nose. As a snuff, the juice is supposed to clear the nasal sinuses. Leaves are poulticed onto bruises. Rheumatic swellings are poulticed or rubbed with aqueous decoctions of the powdered roots of the red-flowered variant. In India the flowers are sacred to Siva, representing both the male and female sex organs; still I find no mention of their use as aphrodisiacs. Ayurvedics, believing the fruits to be alexeteric, laxative, and intellectually stimulating, prescribe them for anemia, bronchitis, fever, pain, thirst, and tumors; the flowers, apertif and refrigerant, for biliousness, bronchitis, gout, nyctalopia, ozoena, and quartan fever; the root for inflammation, the bark as astringent; leaves, alexeteric, anthelmintic, for epilepsy, gout, itch, leprosy, nyctalopia, and ophthalmia. Yunani consider the tonic leaves useful in biliousness, fever, and nyctalopia. Indians apply the roots in rheumatism, the juice of the leaves and flowers for headache and nasal catarrh. Mixed with stramonium and pasted, the root is poulticed onto painful swellings. In Amboina, flower juice is squeezed into the eye to correct dim vision. The bark is used in infusions for smallpox. Cambodians consider the flowers emollient and laxative, the bark for diarrhea, dysentery, and paludism. Malayans apply crushed leaves to sprains and contusions. They gargle with the leaf juice to cleanse the mouth and throat. In small doses, the bark is used for dysentery and sprue, in large doses, laxative, in still larger doses, emetic. Pounded bark is applied to scabies. Philippines use the pounded bark for hemoptysis. The powdered bark is also recommended for ulcers of the mouth and alimentary canal. In Java, the bark is used for thrush and infantile disorders of the stomach. Leaves are chewed to disinfect the mouth and throat.

Chemistry

Per 100 g, the leaf is reported to contain 73.1 g H_2O, 8.4 g protein, 1.4 g fat, 11.8 g NFE, 2.2 g fiber, 3.1 g ash, 1,130 mg Ca, 80 mg P, 3.9 mg Fe, 9,000 IU vit. A, 0.21 mg thiamine, 0.09 mg riboflavin, 1.2 mg niacin, and 169 mg ascorbic acid. Leaves contain (ZMB) per 100 g, 321 calories, 36.3 g protein, 7.5 g fat, 47.1 g carbohydrate, 9.2 g fiber, 9.2 g ash, 1684 mg Ca, 258 mg P, 21 mg Na, 2,005 mg K, 25,679 μg β-carotene equivalent, 1.00 mg thiamine, 1.04 mg riboflavin, 9.17 mg niacin and 242 mg ascorbic acid. The flowers (ZMB) contain per 100 g, 345 calories, 14.5 g protein, 3.6 g fat, 77.3 g carbohydrate, 10.9 g fiber, 4.5 g ash, 145 mg Ca, 290 mg P, 5.4 mg Fe, 291 mg Na, 1,400 mg K, 636 μg β-carotene equivalent, 0.91 mg thiamine, 0.72 mg riboflavin, 14.54 mg niacin, and 473 mg ascorbic acid. Seeds (ZMB) contain 36.5% CP, 7.4% fat, 51.6% total carbohydrate, and 4.5% ash. The seed oil contains 12.3% palmitic, 5.2% stearic, 26.2% oleic, and 53.4% linoleic acids. The seed testa, which constitutes 20% of the seed, contains 5.2% moisture, 1.3% ash, 0.8% fat, 2.7% CF, 0.1% free reducing sugars, 1.4% sucrose, 2.8% nitrogen, 6.3%

pentosans, and 65.4% carbohydrates. Yields of 33% galactomannans are reported for alkali extraction of the testae. Seeds allowed to germinate (sprouts) for 120 hours increased vit. C content from 17–166 mg/100 g. Extracellular invertase of *Rhizobia japonicum* and its role in free sugar metabolism in the developing root nodules was studied. The enzyme hydrolyzed sucrose extracellularly, and its release was substrate inducible. 0.1 m β-mercaptoethanol released the cell-bound form of this enzyme. The production of invertase was low when glucose, galactose, mannose, fructose, and farrinose were used as carbon sources in the growth medium. In the developing nodules sucrose was the major sugar. The content of fructose was low in comparison with that of glucose, suggesting that in the nodules the fructose is converted to glucose prior to its entry into the bacterial cell. The content of glucose synchronized with the pattern of change in the activity of invertase in the nodules (Singh et al, 1980).

Description

A small erect quick-growing short-lived soft-wooded tree to 10 m tall, 25 cm DBH, sparsely branched. Bole straight and cylindrical, the wood white and soft. Bark light gray, corky, deeply furrowed. Leaves pinnate, 15–30 cm long, with 16–30 pairs of linear oblong leaflets. Racemes 2.5 cm long. Flowers 2–4, white to pink, pendulous the corolla 7–9 cm long. Pods 50–60 cm long.

Germplasm

Reported from the Indochina-Indonesia Center of Diversity, agati, or cvs thereof, is reported to tolerate drought, heavy soils, poor soil, and water-logging. Widely cultivated as ornamental or curio vegetable in tropical Asia. ($2n$ = 14, 24).

Distribution

Native to many Asian countries, e.g., India, Malaysia, Indonesia, and the Philippines from sea level to 800 m, agati commonly grows on dikes between rice paddies, along roadsides, and in backyard vegetable gardens. It has been widely distributed in southern Florida and the West Indies and from southern Mexico through most countries of Central America down to South America. Cultivated in Mauritius (NAS, 1980a).

Ecology

Apparently frost-sensitive, this species seems limited to the tropics. Ranging from Tropical Dry through Tropical Moist Forest Life Zones, agati is reported to tolerate annual precipitation of 4.8 to 22.5 dm (mean of 11 cases = 15.1), annual temperature of 24.3 to 26.7°C (mean of 8 cases = 25.6), and pH of 6.6 to 8.5.

Cultivation

Propagated readily by seeding or cuttings, requiring little maintenance. It has been aerially seeded, apparently with success. For reforestation, Mendoza (1980) recommends spacing cuttings ca 1 m long at 4 x 4 m. The saplings could serve as a nurse crop for mahogany, Banquet pine, etc. Cuttings should be set out at the beginning of the rainy season. When grown as shade plant for coconut seedlings, agati is sown in India in June and July, putting 3–4 seed per hole in a narrow channel, 30 cm x 30 cm, ca 1 m from the coconut seedlings.

Harvesting

When cultivated for fodder, agati is usually cut when ca 1 m tall. Indonesian foresters, growing the species for fuelwood, harvest on a 5-year rotation. One hectare can yield three m^3 of stacked fuelwood in a 2-year rotation. After the plant is harvested, shoots resprout with such vigor that they seem irrepressible. The tree's outstanding quality is its rapid growth rate, particularly during its first 3 or 4 years (NAS, 1980a).

Yields and Economics

Planted at 90 cm intervals, an agati plant yields 4.5–9.1 kg lvs/yr, which translates to ca 12,000 plants per hectare yielding 50–100 MT leaves per year per hectare (C.S.I.R., 1948–1976), about 75% of which is water, suggesting DM yields of 12–25 MTha. Javanese have obtained 55 MT green matter per ha in 6–7 months. On a black, poorly structured clay, pH 8.5, in Australia, agati outgrew all other species tested, attaining 4.3–5.5 (-8.3) m in one year's growth.

Energy

Long been used as firewood in Southeast Asia, has been planted in several areas in Indonesia to provide fuel and other products in "turinisation" projects (after turi, the indigenous name). However, the wood is white, soft, and has a rather low specific gravity of about 0.42, which is poor for fuelwood. Wood yields of 20–25 m^3 per ha per year are commonly achieved in plantations in Indonesia. Even when planted only along the edges of agricultural fields, as in Java, yields of 3 m^3 of stacked firewood per ha from 2-year rotation periods have been recorded. The wood weighs 512 kg m^3. Charcoal is used for gunpowder (C.S.I.R., 1948–1976). If 25 MT of dry leaves are available, then certainly there must be 5–10 MT stem as well, all of which could be diverted to energy.

Biotic Factors

Described as very susceptible to nematodes, agati is said to have been damaged by birds and grasshoppers in northern Australia. *Colletotrichum capsici* causes seedling blight, forming elongated or oblong cankers on the collar region of affected seedlings. The cankers, controlled with a Bordeaux spray, have black bristle-like tufts of setae. Nematodes include *Heterodera trifolii* and *Meloidogyne* sp. (Golden, p.c. 1984). *Cercospora sesbaniae* infects agathi. The Drosophilid fly *Protostegana lateralis* is a serious pest in Tamil Nadu. The maggots bore into the tender shoots of mature plants causing a gradual wilting of affected parts. The weevil *Alcidodes buko* causes serious damage to young crop both in adult and larval stage. It bites holes through leaves and bores the stem causing gall-like swellings DDT (0.05%) and BHC dust (5%) are cheap and effective; Product 1250 and Parathion are also effective against the grub. The larvae of *Azygophleps scalaris* tunnel through the stem and eat the contents leaving only the epidermis. The plant becomes weak and breaks off at the slightest jerk. Uprooting the stumps immediately after harvesting and burning them may prove effective means of control. *Otinotus oneratus*, the common 'tree hopper' infests agati from July to February (C.S.I.R., 1948–1976). *Sesbania* seedlings are highly receptive to infection by their homologous rhizobia, but different species have restricted susceptibility profiles. Sesbania rhizobia have a rather restricted host range. Rhizobia from alfalfa, clover, lupines, peas, soybeans failed to nodulate Sesbania species and vice versa.

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Ravetta, D. and A. Soriano. 1990. *Colliguaya integerrima* (Euphorbiaceae): A possible new crop for temperate deserts. p. 267. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Colliguaya integerrima (Euphorbiaceae): A Possible New Crop for Temperate Deserts

Damian Ravetta and Alberto Soriano

Patagonia, occupying more than one third of Argentina, has an and cold climate. Large areas have no more than 150 mm of annual precipitation and very short periods without frosts. These conditions make traditional crop production impossible. Wool and meat production by extensive sheep grazing is the only economic option at the present time. The development of crops adapted to these extreme conditions, could give an economic alternative to this and other regions with similar environment constrains.

Colliguaya integerrima Gill. et Hook. ex Hook. (Euphorbiaceae), a native shrub of Patagonia Argentina and Chile, produces seeds with high drying oil content and is being evaluated as a potential new crop for this region.

Natural populations of this species from three different locations in Patagonia, Argentina were studied in order to assess seed production, oil content and quality of different type of seeds. Plants producing 400 g of seeds were not difficult to find. Proximate analysis of the seed is: 35% oil, 40% chaff, and 25% of meal (containing 51% of protein, with a lysine value of $3.17_g/16_g$ N_2. This meal was not toxic when included in mice diet. Latex production and composition is another potentially useful characteristic of *Colliguaya*. The adaptation of this species to temperate semi-deserts, together with other features such as seed attachment to the mother plant, the ease with which dormancy can be broken by chilling or storage, and the possibility of asexual propagation by rhizome cuttings, increase the interest and possibilities of domestication and cultivation of the species.

McDaniel, R.G. 1990. Agave: A new crop for the desert southwest. p. 268. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Agave: A New Crop for the Desert Southwest

Robert G. McDaniel

A number of agave species have been cultivated throughout the world for some time. Notable among these are *Agave sisalana*, grown in plantations in Africa Asia and Brazil as a source of sisal fiber *Agave fourcroydes*, grown in Mexico and the Caribbean Islands, providing henequen fiber; *Agave tequilana* in Mexico for tequila liquor, and various species for production of hecogenin and smilagenin, pharmaceutical steroidal sapogenins.

Several multi-hectare agave plantations have been established in Southern Arizona since 1980 to evaluate growth potential of both native and introduced agave species under desert conditions. This is the first extensive evaluation of agave as a row crop in the United States. With one or two supplemental irrigations at the Marana Agricultural Center, several agave species achieved biomass accumulations greater than 100 kg over a three-year growth period. Infra-red thermal measurements indicated that all species showed CAM metabolism under periods of high temperature stress (in excess of 40°C) with adapted desert species responding more quickly to irrigation than introduced tropical species. Root and crown tissues of *A. americana,* the fastest growing species tested, contained 50% carbohydrate on a dry weight basis, which would qualify them as a viable botanical ethanol source. HPLC analyses of steroid content of these species are underway, as are fiber analyses. In summary, these data support agave as a potential multi-use crop for the and Southwest. Ability to grow with less than 30 cm rainfall per year makes agave a low input crop adaptable to large areas of this region presently not under cultivation.

Glumac, E. and J. Cowles. 1990. Chinese tallow: Multipurpose tree crop. p. 268. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Chinese Tallow: Multipurpose Tree Crop

Edward Glumac and Joe Cowles

The Chinese tallow tree, a naturalized species that thrives and proliferates in the heavy clay soils of the Gulf coastal region, could be exploited economically if harvesting techniques and markets are established. Rapid, pest free growth of 10 t/ha-yr of dry wood make it suitable for energy cropping under a short-rotation coppicing system. The tallow tree bears seed after 3 years with yields of up to 12 t/ha-yr from mature wild trees. The seeds contain a saturated solid fat, or tallow, on the outside and an unsaturated liquid inside the kernel. Commercial and industrial raw materials obtainable from the seed are fuel oil drying oil, surfactants, soaps, emulsifiers, cocoa butter, seed meal, confections, detergents, and bioactive extracts. Other economic benefits are as a forage crop for honey production, firewood, soil reclamation, and ornamental planting.

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Ming, L.C. 1999. *Ageratum conyzoides*: A tropical source of medicinal and agricultural products. p. 469–473. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Ageratum conyzoides: A Tropical Source of Medicinal and Agricultural Products

Lin Chau Ming

Ageratum conyzoides L., Asteraceae, is an annual herbaceous plant with a long history of traditional medicinal uses in several countries of the world and also has bioactivity with insecticidal and nematocidal acitivity. This tropical species appears to be a valuable agricultural resource.

BOTANY

Ageratum is derived from the Greek "*a geras*," meaning non-aging, referring to the longevity of the flowers or the whole plant. The specific epithet "*conyzoides*" is derived from "*kónyz*," the Greek name of *Inula helenium*, which it resembles (Kissmann and Groth 1993).

The synonyms of *A. conyzoides* include *A. album* Stend; *A. caeruleum* Hort. ex. Poir.; *A. coeruleum* Desf.; *A. cordifolium* Roxb.; *A. hirsutum* Lam.; *A. humile* Salisb.; *A. latifolium* Car.; *A. maritimum* H.B.K.; *A. mexicanum* Sims.; *A. obtusifolium* Lam.; *A. odoratum* Vilm. and *Cacalia mentrasto* Vell. (Jaccoud 1961). In Brazil, *A. conyzoides* has the following vernacular names: *catinga de bode*, *catinga de barrão, erva de são joão*, *maria preta, mentrasto, erva de são josé*, *picão roxo, erva de santa-lúcia, camará-opela, agerato, camará apeba, camará iapó, camará japê, erva de santa maria, macela de são joão, macela francesa, matruço* (Jaccoud 1961; Oliveira et al. 1993).

Ageratum ranges from Southeastern North America to Central America, but the center of origin is in Central America and the Caribbean. Most taxa are found in Mexico, Central America, the Caribbean, and Florida. *Ageratum conyzoides* now is found in several countries in tropical and sub-tropical regions, including Brazil (Baker 1965; Lorenzi 1982; Correa 1984; Cruz 1985).

Johnson (1971), classifies two subspecies, *latifolium* and *conyzoides*. Subspecies *latifolium* is found in all the Americas and subsp. *conyzoides* has a pantropical distribution. The basic chromosome number is $2n = 20$ but natural tetraploids are found. *A. conyzoides* subsp. *latifolium* is diploid and *A. conyzoides* subsp. *conyzoides* is tetraploid.

Ageratum conyzoides is an erect, herbaceous annual, 30 to 80 cm tall; stems are covered with fine white hairs, leaves are opposite, pubescent with long petioles and include glandular trichomes. The inflorescence contain 30 to 50 pink flowers arranged as a corymb and are self-incompatible (Jhansi and Ramanujam 1987; Kaul and Neelangini 1989; Ramanujam and Kalpana 1992; Kleinschimidt 1993). The fruit is an achene with an aristate pappus and is easily dispersed by wind. In some countries the species is considered a weed, and control is often difficult (Lorenzi 1982; Scheffer 1990; Kalia and Singh 1993; Lam et al. 1993, Paradkar et al. 1993; Waterhouse 1993; Kshatriya et al. 1994). Seeds are positively photoblastic, and viability is often lost within 12 months (Marlks and Nwachuku 1986; Ladeira et al. 1987). The optimum germination temperature ranges from 20 to 25°C (Sauerborn and Koch 1988). The species has great morphological variation, and appears highly adaptable to different ecological conditions.

PHYTOCHEMICAL CHARACTERISTICS

There is high variability in the secondary metabolities of *A. conzyoide* which include flavonoids, alkaloids, cumarins, essential oils, and tannins. Many of these are biologically active. Essential oil yield varies from 0.02% to 0.16% (Jaccoud 1961). Vyas and Mulchandani (1984) identified conyzorigum, a cromene. Borthakur and Baruah (1986) identified precocene I and precocene II, in a plant collected in India. These compounds have been shown to affect insect development, as antijuvenile hormones, resulting in sterile adults (Borthakur and Baruah 1987). Ekundayo et al. (1988) identified 51 terpenoid compounds, including precocene I and precocene II. Gonzales et al. (1991) found 11 cromenes in essential oils, including a new cromene, 6-angeloyloky-7-methoxy-2,2-dimethylcromen. Vera (1993), in Reunion, found ageratocromene, other cromenes, and beta cariophylene in its essential oil. Mensah et al. (1993) and Menut et al. (1993) reported similar yields of precocene I in the essential oil of plants collected in Ghana.

Vyas and Mulchandani (1986), in India, identified flavones, including some considered new such as *ageconyfavones* A, B, and C. Horrie et al. (1993) reported hexametoxyflavone. Ladeira et al. (1987) in Brazil, reported three cumarinic compounds, including 1-2 benzopirone. The species contains alkaloids, mainly the pirrolizidinic group, which suggest that it may be a good candidate for pharmacological studies. Trigo et al. (1988) found several alkaloids, including 1,2-desifropirrolizidinic and licopsamine which can have hepatotoxic activity. Alkaloids also were found by Weindenfeld and Roder (1991) in a hexane extract of *A. conyzoides* in Africa.

FOLK MEDICINAL USES AND PHARMACOLOGICAL STUDIES

A. conyzoides is widely utilized in traditional medicine by various cultures worldwide, although applications vary by region. In Central Africa it is used to treat pneumonia, but the most common use is to cure wounds and burns (Durodola 1977). Traditional communities in India use this species as a bacteriocide, antidysenteric, and antilithic (Borthakur and Baruah 1987), and in Asia, South America, and Africa, aqueous extract of this plant is used as a bacteriocide (Almagboul 1985; Ekundayo et al. 1988). In Cameroon and Congo, traditional use is to treat fever, rheumatism, headache, and colic (Menut et al. 1993; Bioka et al. 1993). In Reunion, the whole plant is used as an antidysenteric (Vera 1993). The use of this species in traditional medicine is extensive in Brazil. Aqueous extracts of leaves or whole plants have been used to treat colic, colds and fevers, diarrhea, rheumatism, spasms, or as a tonic (Penna 1921; Jaccoud 1961; Correa 1984; Cruz 1985; Marques et al. 1988; Negrelle et al. 1988; Oliveira et al. 1993). *A. conyzoides* has quick and effective action in burn wounds and is recommended by Brazilian Drugs Central as an antirheumatic (Brasil 1989).

Several pharmacological investigations have been conducted to determine efficacy. Duradola (1977) verified inhibitory activities of ether and chloroform extracts against in vitro development of *Staphylococus aureus*. Almagboul et al. (1985), using methanolic extract of the whole plant, verified inhibitory action in the development of *Staphylococus aureus*, *Bacillus subtilis*, *Eschericichia coli*, and *Pseudomonas aeruginosa*. Bioka et al. (1993) reported effective analgesic action in rats using aqueous extract of *A. conyzoides* leaves (100 to 400 mg/kg). Assays realized in Kenia, with aqueous extract of the whole plant, demonstrated muscle relaxing activities, confirming its popular use as an antispasmotic (Achola et al. 1994).

In Brazil, assays conducted by State University of Campinas and Paraiba Federal University) showed promising results. Marques Neto et al. (1988) in clinic trials with patients with arthrosis, administered aqueous extract of the whole plant, and reported analgesic effect in 66% of patients and improvement in articulation mobility in 24%, without side effect. Mattos (1988), using aqueous extract of the whole plant, verified effective clinical control of arthrosis, reporting a decrease in pain and inflammation or improvement in articulation mobility, after a week of treatment.

BIOACTIVITY

Ageratum conyzoides has bioactive activity that may have agricultural use, as shown by several research investigations in different countries. Pereira in 1929, cited by Jaccoud (1961), reported use of the leaves as an insect (moth) repellent. The insecticide activity may be the most important biological activity of this species. The terpenic compounds, mainly precocenes, with their antijuvenile hormonal activity are probably responsible for the insecticide effects.

Assays conducted in Colombia by Gonzalez et al. (1991) showed activity of this species against

Musca domestica larvae, using whole plant hexane extract. Vyas and Mulchandani (1980) reported the action of cromenes (precocenes I and II), isolated from *Ageratum* plants, which accelerate larval metamorphosis, resulted in juvenile forms or weak and small adults.

Ekundayo et al. (1987) also demonstrated the juvenilizing hormonal action of precocene I and II in insects, the most common effect being precocious metamorphosis, producing sterile or dying adults. Raja et al (1987), using *A. conyzoides* methanolic extract from fresh leaves (250 and 500 ppm) in the fourth instar of *Chilo partellus* (Lepidoptera, Pyralidae), a sorghum pest, observed the presence of a dark stain in the insects' cuticle and immature pupae formation, both symptoms of deficiency of juvenile hormone.

A. conyzoides also induces morphogenetic abnormalities in the formation of mosquitoes larvae (*Culex quinquefasciatus*, *Aedes aegypt*, and *Anopheles stephensi*). This has been verified using petroleum ether extracts (5 and 10 mg/L) of the whole plants. The larvae showed intermediary stages between larvae–pupae, discolored and longer pupae, as well as incompletely developed adults (Sujatha et al. 1988). Extracts of the flowers of this species showed activity against mosquitoes (*Anopheles stephensi*), in the last instar, showing DL 50 with 138 ppm (Kamal and Mehra 1991).

Cetonic extracts of the species produced significant effects against the mosquito, *Culex quinquefasciatus*, in India, when applied to fourth instar larvae and adult females. In larvae, the extracts produced altered individuals, intermediate between larvae and pupae, unmelaninized and with inhibition of development, as well as adults with deformed wings muscles. In female adults, there was loss of fecundity, lower eggs production, and production of defective eggs (Saxena et al. 1992). Similar results were observed in larvae *of Anopheles stephensi* and *Culex quinquefasciatus* in others essays, confirming the antijuvenile potential of *A. conyzoides* (Saxena and Saxena 1992; Saxena et al. 1994).

The species also has potential use in controlling other pests. Shabana et al. (1990), using aqueous extract of the whole plant, verified reduction of larvae emergence of *Meloidogyne incognita*. Pu et al. (1990) and Liang et al. (1994), verified that plants of *A. conyzoides* in *Citrus* orchards sheltered predators of the spider *Panonychus citri*, suggesting that its development in orchards is beneficial. Other *Citrus* spiders populations, *Phyllocoptruta oleivora* and *Brevipalpus phoenicis* were decreased with maintenance of *A. conyzoides* in the orchards and a reduction of leprosy virus was noted (Gravena et al. 1993)

The presence of *A. conyzoides* can also be used as an seed inhibitor, decreasing development of several herbaceous plants. Jha and Dhakal (1990) in Nepal, reported that an aqueous extract of the aerial part or roots of this species (15 g of aerial part or 3 g of roots in 100 ml of water, during 24 h) inhibited germination of wheat and rice seeds while Prasad and Srivastava (1991) in India, reported a lower germination index in peanut seeds with aqueous extract.

CULTURAL STUDIES

Magalhaes et al. (1989) in Brazil evaluated fertilizer studies and plant density on biomass production of *A. conzyzoides.* The higher the N level, the higher the biomass production (dry weight basis). Optimum spacing was 70 cm between rows and 50 cm between plants. Biomass yields was 1.3 t (dry weight)/ha.

Correa Jr. et al. (1991) obtained biomass yields of 3.3 to 5.3 t (fresh wt)/ha. Essential oil content was 0.02% (fresh wt) and 0.16 % (dry wt) in the preflowering state. Preliminary data of Ming (1998) indicated that essential oils, higher in leaves than in flowers, peaked during early-flowering.

FUTURE POTENTIAL

There are some small pharmaceutical companies in Brazil using *A. conyzoides* as a raw material for phytochemicals. The demand is increasing year by year and this situation warrants further scientific research to develop both agricultural and medical uses. Research on medicinal plants should be focused primarily on species whose pharmaceutical activities have already been demonstrated. Positive preliminary clinical assays of *A. conyzoides* clearly demonstrate that this species may be an important economic resource in several tropical countries. The use of this species as a natural biocide or agent for pest management particularly requires further investigation.

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Wheatgrasses

Gramineae, or Poaceae

Agropyron species (syn. *Thinopyrum* sp.)

Source: Magness et al. 1971

The wheatgrasses are hardy, mainly perennial, erect grasses, important especially in the Northern Great Plains. The seed heads resemble wheat heads, hence the name. They may form sods or grow in bunches. They are suitable feed for all classes of livestock. They produce growth early in the spring.

Around 150 species of *Agropyron* are known in the temperate regions of the world, about 30 in North America.

Last update September 22, 1997

Fairway wheatgrass

Gramineae, or Poaceae *Agropyron cristatum* (L.) Gaertn.

Source: Magness et al. 1971

Fairway is a bunch wheatgrass of Siberian origin more widely grown in Canada than in the United States. It generally resembles crested wheatgrass but is finer stemmed and shorter than crested and yields less forage. It is especially suited for dryland lawns and other turf planting because of its dense growth and relatively fine texture. It is also used extensively for pasture and hay in Western Canada and to a more limited extent in the Northern Great Plains and Intermountain Region in the United States.

Last update September 22, 1997

Thickspike wheatgrass

Gramineae, Poaceae *Agropyron dasystachym* (Hook.) Scribn

Source: Magness et al. 1971

This is a sod forming wheatgrass native from the Hudson Bay and Alaska south to Nevada and Colorado. Stems reach to 3 feet. The creeping rhizomes result in formation of fairly dense sod. It does well on light textured soils and is very hardy. Growth starts early and provides good pasturage while succulent, but becomes tough and wiry late in the season. It is rarely seeded but is an important native grass over a wide area.

Last update September 22, 1997

Crested wheatgrass

Gramineae *Agropyron desertorum* (Fisch. ex Link) Schult.

Source: Magness et al. 1971

This is a hardy perennial bunch grass, originally introduced from Russian Turkestan. Leaves are abundant, both at the base and along the stems. Leaves are 6 to 10 inches long, about 1/4 inch wide, flat, and slightly hairy on the upper surface. Stems are slender, 2 to 3 feet in height, growing in dense clumps. It is deep-rooted and drought resistant, well adapted to the Northern Plains and higher elevations in the Rocky Mountains. Growth starts early in spring. If cut early, hay of excellent quality is produced. This is a highly valuable grass in its area of adaptation. Stands once established will persist for many years. Propagation is by seeding.

Last update February 18, 1999 by ch

Agropyron elongatum (Host). Beauv.

Poaceae

Tall Wheatgrass

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

last update December 19, 1997

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Thinopyrum intermedium (Host) Barkworth & D.R. Dewey
Syn: *Agropyron intermedium* (Host) Beauvois

also: *Elytrigia intermedia* (Host) Nevski
Elymus hispidus (Opiz) Meldris
Agropyron glaucum (Desf. ex DC.) Roemer & Schultes

Family: Poaceae or Gramineae
Tribe: Triticeae

Wild Triga, Intermediate Wheatgrass

We have information from several sources:

FactSHEET contributed by Peggy Wagoner

Intermediate Wheatgrass as a Perennial Grain Crop.—Peggy Wagoner, and A. Schauer

Perennial Grain: A New Use for Intermediate Wheatgrass—Peggy Wagoner

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and Feed Crops of the United States.
Intermediate Wheatgrass - *Agropyrum intermedium*
Pubescent Wheatgrass - *Agropyrum intermedium* var. *trichophorum*
General information about Wheatgrasses *Agropyron* species

Around 150 species of *Agropyron* or *Thinopyrum* are known in the temperate regions of the world, about 30 in North America. The species most important in Agriculture in the United States follow:

- Crested wheatgrass *Agropyron desertorum*
- Western wheatgrass *Agropyron smithii*
- Bluebunch wheatgrass *Agropyron spicatum*
- Beardless bluebunch wheatgrass *Agropyron spicatum* f. *inerme*
- Slender wheatgrass *Agropyron trachycaulum*
- Thickspike wheatgrass *Agropyron dasystachyum*

- Fairway wheatgrass *Agropyron cristatum*
- Quackgrass *Agropyron repens*
- Streambank wheatgrass *Agropyron riparuim*
- Siberian wheatgrass *Agropyron sibiricum*
- Tall wheatgrass *Agropyron elongatum*

Last update October 30, 1997

Pubescent wheatgrass

Gramineae, Poaceae *Agropyron intermedium* var. *trichophorum* (Link) Halac.

Source: Magness et al. 1971

This is a sod-forming grass native to Europe and Asia Minor, closely related to Intermediate Wheatgrass and having the same range of adaptation. The heads and seeds of pubescent are covered with short, stiff hairs. A named variety of pubescent, Topar, is better adapted to low-fertility soils and is more drought resistant than intermediate. In palatability and general appearance pubescent is very similar to intermediate.

Last update September 22, 1997

Agropyron repens (L.) Beauv.

Gramineae, Poaceae

Quack grass

We have information from several sources:

The Herb Hunters Guide—.Sievers, A.F. 1930.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Wednesday, July 08, 1998 by aw

Streambank wheatgrass

Gramineae, Poaceae *Agropyron riparium* Scribn. & Smith

Source: Magness et al. 1971

This grass, native from Alberta and British Columbia in Canada south to Nevada and Colorado, resembles thickspike wheatgrass except that leaf blades are more narrow. It develops vigorous rhizomes, resulting in dense sods. It is drought tolerant and especially valuable for erosion control. Top growth is short and it produces less forage than some other wheatgrasses. Its greatest value is for sods on airports, roadbanks and irrigation canal banks.

Last update September 22, 1997.

Siberian wheatgrass

Gramineae, Poaceae *Agropyron sibiricum* (Willd.) Beauv.

Source: Magness et al. 1971

This is a drought-resistant bunchgrass introduced from Russia in 1934. It is generally similar to crested wheatgrass but appears to do better than crested on poor sites or under other adverse conditions. For this reason it is replacing crested in some areas. The stems are finer and heads more narrow than in crested. Nutritive value and palatability are similar to those of crested.

Last update September 22, 1997

Western wheatgrass

Gramineae, Poaceae *Agropyron smithii* Rydb.

Source: Magness et al. 1971

Western wheatgrass is a perennial and sod-forming grass, native to most parts of the United States except the humid southeast. It is a dominant species in the Central and Northern Great Plains. Plant growth is vigorous, reaching 2 to 3 feet in height. Leaves are up to 12 inches long, 0.25 inch wide, rather stiff and erect. The whole plant is covered with a grayish bloom. It thrives best on rather heavy soil, but is adapted to a wide range of soil types, including alkaline soil. Both as pasturage and when cut for hay while still succulent, it is relished by all classes of livestock. The plants are usually grown from seed, but spread from underground rhizomes to form dense sods. This is a very valuable grass, both for feed and for erosion control.

Last update June 27, 1996 bha

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Bluebunch wheatgrass

Gramineae *Agropyron spicatum* (Pursh) Scribn. and Smith

Beardless bluebunch wheatgrass

***A. spicatum* f. *inerme* (Scribn. & Smith) Beetle**

Source: Magness et al. 1971

Bluebunch wheatgrass is a drought-resistant bunchgrass native to the dry areas of the western states. It is a dominant species in the Pacific Northwest and Intermountain States. Both taxa are very similar, except the beardless lacks the awns, making the plants more palatable in late stages of growth. Plant growth is vigorous, starting early in spring. Plants may reach a height of 4 feet. Leaves are up to 10 inches long and 0.5 inch wide, flat and tending to droop. Leaves remain green throughout the summer and are palatable even when dry. Propagation is by seed.

Last update September, 1997

Slender wheatgrass

Gramineae, Poaceae *Agropyron trachycaulum* (Link) Maltex H. F. Lewis

Source: Magness et al. 1971

This is a native bunchgrass, generally distributed throughout the United States, except in the southeastern and southcentral regions. It is prevalent in the Northern Great Plains and the Rocky Mountain States. It grows to 3 feet, in dense leafy clumps or bunches, a foot or more in diameter. The flowering stems are erect and rather coarse. Most of the leaves are basal. They are up to a foot long and 0.5 inch wide. This grass furnishes abundant pasture, and a nutritious hay if harvested early. The forage also matures well on the ground, so furnishes winter grazing. Stands may easily be overgrazed, and are not as persistent as the sod-forming wheatgrasses. Propagation is by seeds.

Last update February 19, 1999 by ch

Redtop

Florin, Fine bentgrass

Gramineae, Poaceae *Agrostis alba* L.

Source: Magness et al. 1971

Redtop is a creeping perennial, related to the bentgrasses. It is now found over much of the northern United States, although originally from Europe. The stems are slender. Leaves are narrow, about 0.25 inch. The panicle is loose and pyramidal in shape, and reddish in color, which accounts for the name. Redtop is used in pasture mixes under humid conditions, also in lawns and golf greens in the Southeast. It is low in palatability, but grows and forms a sod quickly, and so protects from erosion until slower-growing grasses become established. It is rarely seeded alone.

Last update July 1, 1996 bha

Bentgrasses

Gramineae *Agrostis* sp.

Colonial bent. *A. tenuis* Sibth.
Creeping bent. *A. palustris* Huds.
Velvet bent. *A. canina* L.

Source: Magness et al. 1971

The bentgrasses are rather fine-leaved, creeping grasses, used mainly in lawns and golf putting greens over the northern half of the United States. These species were all introduced into this country from Europe. Colonial bent is most comonly used in lawns. Included here are the varieties Astoria bent and Highland bent. The creeping bents generally do not produce seed and are propagated by stolons. Seaside bent and Penncross varieties do produce seed and are propagated in that way. None of these bentgrasses is used for pasture or hay.

Last update February 18, 1999 by ch

Persia americana Mill., *P. schiedeana, P. nubigena* and hybrids.

Lauraceae

Avocado, *aguacate*, *abuacatl*, alligator pear, avocado pear, *avocat*, Bacon, Booth, butter pear, Fuerte, Guatemalan avocado, Hass, Lulu, Mexican avocado, *palta*, Waldin, West Indian avocado, Zuttano

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NewCROP has avocado information at:

Avocado—Julia Morton, Fruits of warm climates

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Magness J.R. et al. 1971. Food and feed crops of the United States.

and information about Avocado Oil

Outside links:

Avocado Crop Information from University of California Davis

AVOCADO "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

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Ailanthus altissima (Mill.) Swingle

Syn.: *Ailanthus glandulosa* Desf.
Simaroubaceae
Tree-of-heaven, China sumac

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

A tree that will grow in Brooklyn, Washington, and Peking, this "weed tree" can be a handsome "tropical-looking" ornamental with its compound leaves sometimes overtopped by reddish to yellowish clusters of winged fruits. It is used for erosion control, shade, and shelter where few other trees will thrive. Though little used, except in poorer countries, the wood is suitable for cabinetry, cellulose manufacture, furniture, lumber, pulp, and woodwork. It is difficult to split but easy to work and polish. The wood is locally used for charcoal and firewood. Leaves have been used as adulterants of belladonna and senna. Plant parts steeped in water and said to yield an insecticidal solution.

Folk Medicine

According to Hartwell (1967–1971), the tree is used in homeopathic "remedies" for cancer. Reported to be antiseptic, astringent, bactericidal, cardiac, cathartic, deobstruent, depressant, emetic, protisticidal, taenifuge, and vermifuge, tree-of-heaven is a folk remedy for asthma, cancer, diarrhea, dysentery, dysmenorrhea, dysuria, ejaculation (premature), epilepsy, eruption, fever, gonorrhea, hematochezia, leucorrhea, malaria, metrorrhagia, sores, spasms, spermatorrhea, stomachic, tumors of the breast (China), and wet dreams (Duke and Wain, 1981). From Manchuria to the Malay Peninsula, various parts of *Ailanthus altissima* are considered to be medicinal. The fruits are used for ophthalmic diseases. In Manchuria, the fruit is a remedy for dysentery. In China, it is bechic, emmenagogue, and used for hemorrhoids. In Korea, the root bark is used for cough, gastric and intestinal upsets. The vermifuge properties do not act on round worms or earthworms. Resin extracted from the roots and leaves is a revulsive or vesicant. The disagreeable odor of the plant may cause some people to feel sleepy. The leaves, bark of the trunk, and roots are put into a wash for parasitic ulcers, itch, and eruptions (Perry, 1980)

Chemistry

Per 100 g, the seed is reported to contain 27.5–27.6 g protein and 55.5–59.1 g fat (Duke and Atchley, 1983). The bark contains oleoresin, resin, some mucilage, ceryl alcohol, ailanthin, "quassiin," calcium oxalate crystals, and isoquercetin (quercitin 3-glycoside), tannin, phlobaphene, ceryl palmitate, saponin, quassin, and neoquassin (Perry, 1980; List and Horhammer, 1969–1979). Hager's Handbook (List and Horhammer (1969–1979) adds that the leaves contain 12% tannin, quercetin, as well as isoquercetin, and the alkaloid linuthine. Seeds contain quassiin.

Toxicity

Leaves are toxic to domestic animals (Perry, 1980). Gardeners who fell the tree may suffer rashes. Mitchell and Rook's observations are more violent than my own to sniffing the leaves, "The odour of the foliage is intensely disagreeable and can cause headache and nausea...rhinitis and conjunctivitis...The pollen can cause hay fever." (Mitchell and Rook, 1979).

Description

Deciduous tree, usually dioecious, 6–10(-30) m tall; trunk 30(-100) cm or more in diameter. Bark light brown or gray, smoothish, thin, becoming rough with long fissures and dark ridges. Leaves alternate, pinnately compound 30–60 cm long, hairy when young, crushed foliage with disagreeable odor but suggestive of peanuts. Leaflets 13–41, short-stalked, broadly lanceolate, 7.5–13 cm long, 1.5–5 cm wide, acuminate, with 2–5 teeth near Insided base. Panicles large, 15–25 cm long; flowers many, 6 mm long, greenish or greenish-yellow, with 5-lobed calyx, 5 narrow petals. Male flowers with 10 stamens and disagreeable odor. Female flowers with 2–5 nearly separate pistils united at base. Samaras many, 1–5 from a flower, 3–5 cm long, 1 cm wide, with reddish or purplish-brown, flat, slightly twisted wing. Seed 1 in middle, 6 mm long, elliptical, flattened (Little, 1983).

Germplasm

Reported from the China-Japan Center of Diversity, tree-of-heaven, or cvs thereof, is reported to tolerate alkalinity, disease, drought, frost, heat, high pH, hydrogen fluoride, insects, low pH, pollution, poor soil, SO_2 and waterlogging. ($2n= 80$)

Distribution

Native to China and Taiwan, it is only fitting that missionaries should introduce the "tree-of-heaven" to Europe in 1751 and to the US in 1784. It is listed as a serious weed in Australia and is widely spread, weedlike, in all temperate climates.

Ecology

Estimated to range from Subtropical Dry to Wet through Cool Temperate Dry to Wet Forest Life Zones, tree-of-heaven is estimated to tolerate annual precipitation of 3 to 25 dm (tolerating a dry season up to 8 months), annual temperature of 10° to 20°C, and pH of 5.5 to 8.0. Growing on the smallest of city plots and rubbish heaps, this species obviously can tolerate a wide array of soils, from acid to alkaline, sand to light clay, well-drained to swampy, poor to rich. It is said to do poorly on chalky soils or compact clay (Little, 1983).

Cultivation

A prolific seeder, spreading also by root suckers and coppicing readily, we might better study how to get rid of than to cultivate this "weed tree." Planting root cuttings of male trees would eliminate the seeding problem, however, augmenting the bad odor in the process. Root suckers can be problematic in fields as well as sidewalks and buildings. Seed stratified over winter should be spring sown, covered with ca 12–15 mm soil, one kg seed yielding 6,500 usable plants (Ag-Handbook 450).

Harvesting

Perhaps the branches should be lopped for fuel before the seeds mature, stored until winter to dry. One hundred kg fruits will yield 30–90 kg seed. Seeds should be stored in sealed containers, with low moisture content, at ca 1–3°C. Trees coppice readily.

Yields and Economics

I find no yield data, but suspect that it yields as well as Paulownia in our Maryland climate. NAS (1980a) reports that it can grow 3–4 m in height during a 5-month growing season. I would estimate that 20 m^3/ha is possible for this light wood.

Energy

Like most of our herbaceous and woody weeds, this too has been suggested as an energy candidate. The yellow wood, moderately hard and heavy is used for charcoal and firewood in many countries. I have heard no reports of toxicity from the smoke.

Biotic Factors

Agriculture Handbook 165 lists the following as affecting this species: *Armillaria mellea* (mushroom root rot), *Botryodiplodia ailanthi* var. *chromogena, Camarosporium berkeleyanum, Cercospora glandulosa* (leaf spot), *Colletotrichum tertium, Coniothyrium insitivum, Cytospora ailanthi, Daedalea unicolor* (butt rot), *Diaporthe medusaea, Dimerosporium robiniae* (black mildew), ?*Diplodia ailanthi* (twig blight), *D. natalensis* (twig blight), *Eutypella glandulosa, E. microcarpa, Fusarium lateritium* (twig blight), *Gloeosporium ailanthi* (leaf spot), *Guignardia ailanthi*, and *Haplosporella ailanthi*. Tent caterpillars are occasionally a problem in the US, completely defoliating, but rarely, if ever, killing the trees.

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Complete list of references for Duke, Handbook of Energy Crops

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Air potato

Dioscoreaceae *Dioscorea bulbifera* L.

Source: Magness et al. 1971

This relative of the yam is a tall-climbing, twining herb with alternate, heart-shaped leaves. It forms large tubers of variable size and shape in the axils of the leaves. These may attain several pounds in weight and are palatable and potato-like in flavor. The plant is native to South Asia and is cultivated to a limited extent in tropical and subtropical areas.

Last update February 18, 1999 by ch

Blighia sapida K. Konig

syn. *Cupania sapida* Voigt.

Sapindaceae

Akee

We have information from several sources:

Akee—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Albizia falcataria (L.) Fosberg

Syn.: *Albizia falcata* (L.) Backer.
Albizia moluccana Riq.
Mimosaceae
Molucca Albizia

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Timber tree, "one of the quickest-growing trees of Malaysia. It is highly regarded as shade tree, sometimes used for coffee shade. It has also been used to shade tea in Java, but its rapid growth may damage the tea during drought. It has been suggested as cover for mine spoil. The wood is described as soft but suitable for tea boxes. In Hawaii during the 1970's, about 1,000,000 board feet were rotary peeled and processed for core stock. It is used for matches, match boxes, packing cases, lightweight pallets, shelves and other general uses for certain grades of paper. It can substitute for pinewood as a pulping source. Pulp: The fiber averages 1.15 mm long with thin walls, giving it flexibility and good fiber to fiber bonding in paper. The soft, low-density wood is easy to chip and yields much pulp with relatively low chemical input. Because of its light color, only minimum bleaching is required to achieve a good white paper. The woods are nonsiliceous, usually light colored with some open pores, and produce a sawdust that may cause sneezing. The wide ranging roots are said to taint the water supply with their peculiar nauseous odor.

Folk Medicine

No data uncovered.

Chemistry

Mitchell and Rook (1979) report respiratory problems in people working with the wood.

Description

Tall deciduous tree to 30 m tall, 1 m in diameter. Leaves alternate, bipinnate, 23–30 cm long, rufose pubescent, the pinnae 20–24, 5–10 cm long, each with 30–40 paired leaflets, sessile, obliquely oblong, 6–12 mm long, 3–5 mm broad, shortly acute. Panicles large, 20–25 cm long, lateral, the numerous flowers sessile, white, ca 10–12 mm long; the calyx 5-toothed, corolla 5-lobate, ca 6 mm long; stamens filiform, more than 12 mm long; ovary narrow, the style filiform. Pods 10–13 cm long, 2 cm wide, flat, acute, green, turning brown, papyraceous, dehiscent. Seeds 15–20 per pod, reniform to oblong, ca 6 mm long, brown (Little, 1983). Seed ca 46,000/kg.

Germplasm

Reported from the Indochina-Indonesia Center of Diversity, Molucca albizia, or cvs thereof, is reported to tolerate poor soils. With a superficial root system, it is subject to windthrow (Duke, 1978).

Distribution

Native to the eastern islands of the Indonesian archipelago (Moluccas) and New Guinea, this species has been spread to Southeast Asia from Burma to the Philippines, and introduced locally in tropical Africa and America.

Ecology

Tree seems to thrive on many soils, alluvial soils, laterites, sandy mining soil, and white sands. Ranging from Subtropical Moist to Wet through Tropical Moist to Wet Forest Life Zones, probably tolerates annual precipitation of 20 to 45 dm annual temperature of 20 to 28°C. Flowering in Dec.–Jan. in Sri Lanka. NAS (1979) says it needs at least 15 rainy days during the driest 4 months.

Cultivation

The hard seeds may require scarification. Trees can be closely spaced at 1,000–2,000 trees/ha so that trunk grows straight and the crown closes quickly, shading out weeds.

Harvesting

Growing fast enough to be considered a cash crop, it is harvested in the Philippines after 7 or 8 years, then every 8 years from the coppice. The wood is soft, light-colored and has a specific gravity of 0.30–0.35.

Yields and Economics

Trees 2 years old may attain 10 m height, 15 cm DBH, while 10-year old trees may attain 30 m and 60 cm. Young plantations have yielded mean annual increment of 25–40 m^3/ha is more than 50 m^3 wood/yr. However, a mean annual increment of 40 m^3/yr is more likely in 8–12 yr rotations. Palit reports yield potential of 40 m^3/yr at 3–5 yrs in North Bengal, assuming 50% Survival and establishment at 2 x 2 m.

Energy

In a 9-year old stand, the above ground biomass was 102 MT/ha, the leaf biomass was 1.6 MT, leaf litter ca 5.2 MT making up ca 62% of the total litter. Annual net productivity was ca 20 MT/ha, productivity worthy of investigation for energy potential, especially if the tree has a high rate of N-fixation. These data derive from a Mindanao site with annual precipitation ca 45 dm, annual temperature ca 27°C, elevation 50–100 m on reddish brown ratozol over andesite. In a head-on study, the Albizia biomass compares with 18 MT for Gmelina plantation and 14 MT/ha for dipterocarp forest (Kawahara et al, 1981). Annual stem increment was maximum in three-year old plantations, tapering off thereafter. Nodules of N-fixing bacteria occur on the roots. Reported yields run from 2.6–55 m^3/ha/yr (Webb et al., 1980; Fenton et al., 1977).

Biotic Factors

On the Malayan Peninsula, the black lotong monkey (Semnopithecus) eats the shoot tips, sometimes to the extent of defoliating and killing the tree. The tree has been known to survive in the Asian weed, *Imperata*, but cannot be depended on to grow in thick lalang or kill out that grass. The tea pest, Helopeltis, can live on it. There have been frequent attacks by caterpillars, deer and monkey in Indonesian plantations adjacent to rainforests. Browne (1968), lists: Fungi. *Armillaria mellea, Calonectria theae, Corticium salmonicolor, Fomes noxius, Ganoderma lucidum, G. pseudoferreum, Helicobasidium compactum, Irpex subvinosus, Macrophomina phaseoli, Nectria pulcherrima, Physalospora rhodina, Pleiochaeta albiziae, Poria hypolateritia, Thanatephorus cucumeris, Ustulina deusta*. Acarina. *Tetranychus telarius*. Coleoptera. *Hypomeces squamosus,* *Xyleborus fornicatus, Xylosandrus morigerus, Xystrocera globosa*. Hemiptera *Ferrisia virgata, Parthenolecanium persicae*. Lepidoptera. *Achaea janata, Ericeia inangulata, Hypanartia blanda, H. hecabe, Indarbela quadrinotata, Rhesala moestalis, Semiothisa emersaria, Zeuzera coffeae*. Nematoda. *Meloidogyne* spp., *Pratylenchus coffeae*. Mammalia. *Callosciurus notatus, Tupaia glis*.

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Last update December 19, 1997

Albizia lebbek (L.) Benth.

Mimosaceae
East Indian Walnut, Siris Tree, Kokko

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

A fast growings nitrogen-fixing, heavy shade tree, recommended for reforestation and firewood plantations. Often planted as an avenue tree or as shade for coffee and tea. The wood is hard and strong, resembling walnut, and non siliceous. It produces a sawdust that may cause sneezing. Specific gravity 0.61; Air Dry Weight 39 lb/cu ft (ca 630 kg/cu m). The heartwood calorific value is 5,166 cals. Strong and elastic, the wood is used for cabinet wood, furniture and veneer, and serves well as firewood. The burr wood is prized for veneer. Bark has served for tanning. Foliage can be used as fodder. In the Sudan, goats eat fallen leaves and flowers. Bark containing saponin can be used in making soap, and containing tannin, can be used for tanning; used e.g. in Madras to tan fishing nets. It produces a gum which can be sold deceitfully as gum arabic. Host of the lac insect.

Folk Medicine

According to Hartwell (1967–1971), the tree is used in folk remedies for abdominal tumors, in bolmes, enemas, ghees or powders. Reported to be astringent, pectoral, rejuvenant, and tonic, the siris tree is a folk remedy for boils, cough, eye ailments, flu, and lung ailments. The seed oil is used for leprosy, the powdered seed to scrofulous swellings. Indians use the flowers for spermatorrhea.

Chemistry

According to Roskoski et al (1980), studying Mexican material, the seeds contain 9.47% humidity, 3.57% ash, 33.60% crude protein, 3.13% crude fat, 13.17% crude fiber, 35.30% carbohydrates with a 78.25% in vitro digestibility. The pods contain 6.99% humidity, 5.47% ash, 17.86% crude protein, 2.6% crude fat, 45.08% crude fiber, and 22.00% carbohydrates with a 76.56% in vitro digestibility. The foliage contains 3.57% humidity, 7.06% ash, 28.87% crtide protein, 5.42% crude fat, 31.75% crude fiber, 23.33% carbohydrates, and 83.55% in vitro digestibility. Prohibitive levels of toxic compounds were not detected in any of the plant parts analyzed. Gohl (1981) tabulates the following nutritive data:

Nutritive Data On *Albizia lebbek* (Gohl, 1981)

		As % of dry matter						
	DM	CP	CF	Ash	EE	NFE	Ca	P
Fresh leaves, India	39.6	18.1	26.5	8.0	4.7	42.7	2.02	0.14
Fresh leaves, Pakistan	31.7	22.0	26.5	7.0	10.0	34.5	1.84	0.20
Pods, Thailand	91.5	21.1	23.0	4.6	4.6	46.7		

		Digestibility (%)				
	Animal	CP	CF	EE	NFE	ME
Leaves	Zebu	64.5	62.2	44.6	37.6	1.84

Seeds have yielded 5.3–6.8% fixed oil or fat, the endosperm 11%. The oil contains 9.6% stearic, 10.9% arachidic, 39.3% oleic, and 32.9% linoleic acid (Watt and Breyer-Brandwijk, 1962). Bark contains 5–15% tannin (leaves contain ca 4%) and saponins. The saponin from the seed yields oleanolic acid and albizziagenin. Wood workers have reported upper respiratory problems following involvement with this species (Mitchell and Rook, 1979).

Description

Deciduous tree to 30 m tall, with a dense shade-producing crown. Bark smoothish, light whitish or greenish gray. Leaves alternate, twice compound, with 2–4 pairs of pinnate pinnae, each with 4–10 pairs of leaflets, the ultimate leaflets entire, arcuate, oblong. Flowers white, with greenish stamens, in clusters resembling a white powder puff. Pods flat, reddish brown, several seeds, often rattling in the breeze. In Puerto Rico, flowers April to September, fruiting year-round, the fruits more prominent probably in the dry season.

Germplasm

Siris tree, or cvs thereof, is reported to tolerate alkalinity, some drought, laterite, very light frost, saltspray, and sand ($2n = 26$).

Distribution

According to the NAS (1980) this is native to tropical Africa, Asia, and northern Australia, widely planted and naturalized throughout the tropics.

Ecology

Ranging from Tropical Thorn to Tropical Wet through Subtropical Thorn to Wet Forest Life Zones, siris tree is reported to tolerate annual precipitation of 4.8 to 23.4 dm (mean of 17 cases = 14.6) and annual temperature of 23.3 to 26.6°C (mean of 12 cases = 25.5) (EBL computer printout).

Cultivation

Immerse seed in boiling water, cool; soak for 24 hours, sowing in loam in wrapped pots 10 x 15 mm. Move seedlings to partial shade, watering and spraying as needed. Harden off for 2–3 months. Outplant at 3 x 3 or 4 x 4 m when at least 30 cm tall, at beginning of rainy season (Fabian, 1981).

Harvesting

Trees coppice well.

Yields and Economics

Studying Mexican material, Roskoski et al (1980) concluded that there were 8.60 (+/- 3.5) moles N_2 fixed per gram of nodule per hour, about 1/3 the hourly rate of *Acacia pennatula*, whose N_2 fixation rate was pegged at 34 kg/ha/yr.

Energy

Curtis and Duke (1982) report wood yields of 5 m^3/ha/yr, but Webb et al. (1980) report yields of 18–28 m^3. Krishnamurti (1974), suggesting the tree as a new alcohol source, notes that the ripe fruit has been found to contain 15% moisture, 17% reducing sugar, and 38% total reducing sugar as glucose. One hundred grams fruit crushed and fermented whole with addition of water and a pure culture of distillery yeast, gave a net yield of 20.5 cc of absolute alcohol, 82% of the theoretical yield, corresponding to about 170 liters alcohol per MT. With fruit yields of 10 MT possible, that suggests a renewable yield of 1,700 liters per hectare, or more than 10 barrels from the fruits alone.

Biotic Factors

Left standing or as logs, the timber is subject to borer and fungal attack (C.S.I.R., 1948–1976). Sapwood is liable to borer and termite attack, but is immune to dry rot (Watt and Breyer-Brandwijk, 1962). Browne (1968) lists: Viruses. Albizia Mosaic Virus. Fungi. *Ascochyta sacardiana, Camptomeris albizziae, Clitocybe tabescens, Fomes noxius, Fomes robiniae, Ganoderma lucidum, Helminthosporium albiziicolum, Irpex flavus, Nectria ditissima, Phellinus gilvus, Ravenelia sessilis, phaerophragmium acaciae, Uredo ngamboensis*. Angiospermae. *Cuscuta reflexa, Loranthus* sp. (?), *Tapinanthus* sp. Coleoptera. *Amblyrrhinus poricollis, Apate terebrans, Batocera rufomaculata, Bruchidius uberatus, Bruchus pisorum, Caryedon serratus, Trachys bali, Xystrocera globosa*. Hemiptera. *Drosicha stebbingi, Eurybachys tomentosa, Halys dentatus, Kerria lacca, Oxyrhachis tarandus, Parlatoreopsis chinensis, Parthenolecanium persicae, Rastrococcus iceryoides*. Lepidoptera. *Eriboea athamas, Hypanartia blanda, Orgyia postica, Pandesma quenavadi, Rhesala imparata, Rhesala moestalis, Sataspes infernalis, Stathmopoda basiplectra*. Mammalia. *Lepus nigricollis*. Nematoda. *Meloidogyne javanica, M*. sp., *Radopholus similes*.

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Albizia Procera (Roxb.) Benth

Mimosaceae
Tall Albizia

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Tree cultivated for shade and timber. Wood rather similar to *Albizia lebbeck* but lighter and softer (sp. gra. 0.60 air dry weight of sapwood ca 460 kg/m^3 of heartwood 640 kg/m^3). The heartwood is durable even in exposed situtations. It can be worked to a good surface that polishes well. Wood is used chiefly for construction, furniture, carts and carriages, cane crushers, carvings, boats and oars, rice pounders, and, of course, fuel. In Australia, the tree is reagarded as a good cattle feed and as a sign of good country for farming sugarcane. Leaves said to be insecticidal (Kirtikar and Basu, 1975). Bark used for fish poison. The tree yields a reddish-brown gum.

Folk Medicine

Leaves are poulticed onto ulcers in India. Bark considered useful in pregnancy and stomachache. Bark given with salt as a medicine for water buffalo.

Chemistry

Bark, leaf, and root contain saponin. Hydrolysis of the saponin yields machaerinic acid. Tree contains some HCN. Leaf and fruit have given positive tests for haemolysis. A new pentacyclic triterpenic acid, procera acid, was isolated from the seed (List & Horhammer, 1969–1979). The gum contains aldobiuronic acid and the disaccharide 3-0-D-galactopyranosyl-L-arabinose. Degraded gum from *Albizia procera* contains D-galactose, D-mannose, D-glucuronic acid, and 4-0-mehtyl-D-glucuronic acid. Complete methylation and subsequent hydrolysis of the product afford 2,4-di-0-methyl-D-galactose (3 moles), 3,4,6-tri-0-methyl-L-arabinose. Perceragenin $C_{30}H_{46}O_4$ is reported from the seed (List and Horhammer, 1969–1979).

Description

An erect, slightly pubescent or nearly glabrous tree, 10–25 m high. Leaves about 40 cm long; pinnae about 4–12, 15–20 cm long; leaflets 12–20, oblong-elliptic, rounded or retuse, 2–5 cm long, oblique. Panicles terminal or in the upper axils, up to 20 cm long, diffuse; flowers 1–1.5 across. Pod long, thin, smooth, flattened, 10–15 cm long, 2–2.4 cm broad, containing 8–10 seeds (Li, 1963).

Germplasm

Reported from the Indochina-Indonesia and Hindustani Centers of Diversity, tall albizia, or cvs thereof, is reported to tolerate drought, and stony, dry, and shallow soils. ($2n = 26$)

Distribution

Native to tropical Asia and Australia, now widely cultivated in the tropics.

Ecology

Ranging from Tropical Very Dry through Tropical Moist Forest Life Zones, tall albizia is reported to tolerate annual precipitation of 8.8 to 29 dm (mean of 25 cases = 16.8) and annual temperature of 24.7 to 26.3°C (mean of 12 cases 25.3).

Cultivation

Soak seed a few seconds in boiling water (removed from source of heat) and soak overnight. Directly sow seed in prepared pots (in 10–15 mm polyethylene bags) using 50:50 sandy loam:potting soil. Spray insecticides twice a month for two months and as often as necessary thereafter. Place seedlings in shade, watering at least every other day. Harden off after 3–4 months. Regulate exposure to sun and water until seedlings are hardened. Space at 3 x 3 m, marking with Stakes. Set out in early morning and/or late afternoon at beginning of rainy season, when seedlings are about 4–7 months old (Canopy, 1981). Trees are easily propagated, using seedlings or stumps (NAS, 1979).

Harvesting

Tree is cut as needed for fuel, timber, or charcoal.

Yields and Economics

Should yield about like *Albizia lebbeck*. In Java, annual wood production of 10 m3/ha is recorded. Trees may attain 1 m DBH at 12 years, 2 m at 30 years.

Energy

Pods and fallen leaves may be considered as undesirable litter or as potential energy sources. It seems probable that if *Albizia lebbeck* fruits can yield 10 barrels of ethanol per hectare, this species could do as well. The species was increased in Puerto Rico during the 1940's because it seemed "a promising rapid-growing fuelwood species for the coastal and lower mountain regions."

Biotic Factors

Wood is relatively resistant to attack by dry-wood termites. Most of the Puerto Rican introductions have suffered severely from a fungus disease which causes disback or death (Little and Wadsworth, 1964). Browne (1968) lists: Fungi. *Ganoderma applanatum, Ganoderma lucidum, Nectria haematococca, Phellinus gilvus, Polyporus anebus, Ravenelia clemensiae, Ravenelia indica, Ravenelia sessiles, Sphaerophragmium acaciae*. Coleoptera. *Apate terebrans, Bruchidius uberatus, Sinoxylon anale, Xystrocera globosa*. Hemiptera. *Arytaina ramakrishni, Kerria lacca, Oxyrhachis mangiferana*. Isoptera. *Ancistrotermes amphidon, Coptotermes curvignathus*. Lepidoptera. *Archips micaceanus, Ascotis selenaria, Cusiala raptaria, Heliothis zea, Hypanartia hecabe, Hyposidra successaria, Indarbela quadrinotata, Platypeplus aprobola, Polydesma umbricola, Rhesala imparata, Rhesala inconcinnalis, Rhesala moestalis, Semiothisa emersaria, Semiothisa pluviata, triglina scitaria*. Orthoptera. *Schistocera gregaria*.

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Last update December 19, 1997

Aletris

Aletris farinosa L.


Figure 1.—Aletris (*Aletris farinosa*)

Other common names.—Stargrass, blazing star, mealy starwort, starwort unicorn root, true unicorn root, unicornplant, unicorn's-horn, colicroot, devil's-bit, ague grass, ague root, aloeroot, crow corn, huskwort. Some of the common names are also used in connection with Helonias (*Chamaelirium luteum* (L.) A. Gray), which causes much confusion, although the two plants do not bear any close resemblance. It is best, therefore, to designate it as Aletris, under which name it is best known in the drug trade.

Habitat and range.—Aletris occurs in dry, generally sandy soil, from Maine to Minnesota, Florida, and Tennessee.

Description.—This plant is an erect slender herb 1 1/2, to 3 foot tall with leaves only at the base. These are grasslike, of a yellowish green color, and from 2 to 6 inches long. They surround the base of the stem in the form of a star, in this respect differing distinctly from starwort (*Chamaelirium luteum*), with which it is sometimes confused, as stated. The erect, flowering spike produced from May to July bears white urn-shaped flowers sometimes tinged with yellow.

Other species.—Three other species of Aletris, namely, *Aletris aurea* Walt., *A. lutea* Small. and *A. obovata* Nash, bear much resemblance to *A. farinosa* and are for this reason no doubt frequently collected with the latter.

Part used.—The rootstock, which should be collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Monday, March 12, 1998 by aw

Aleurites fordii Hemsl.

Euphorbiaceae
Tung-Oil Tree

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Tung trees are cultivated for their seeds, the endosperm of which supplies a superior quick-drying oil, utilized in the manufacture of lacquers, varnishes, paints, linoleum, oilcloth, resins, artificial leather, felt-base floor coverings, and greases, brake-linings and in clearing and polishing compounds. Tung oil products are used to coat containers for food, beverages, and medicines; for insulating wires and other metallic surfaces, as in radios, radar, telephone and telegraph instruments.

Folk Medicine

No data available.

Chemistry

The fruit contains 14–20%; the kernel, 53–60%; and the nut, 30–40% oil. It contains 75–80% α-elaeo stearic, 15% oleic-, ca 4% palmitic-, and ca 1% stearic-acids. Tannins, phytosterols, and a poisonous saponin are also reported (List and Horhammer, 1969–1979).

Description

Trees up to 12 m tall and wide, bark smooth, wood soft; leaves dark green, up to 15 cm wide, heart-shaped, sometimes lobed, appearing usually just after, but sometimes just before flowering; flowers in clusters, whitish, rosethroated, produced in early spring from terminal buds of shoots of the previous season; monoecious, male and female flowers in same inflorescence, usually with the pistillate flowers surrounded by several staminate flowers; fruits spherical, pear-shaped or top shaped, green to purple at maturity, with 4–5 carpets each with one seed; seeds usually 4–5, but may vary from 1 to 15, 2–3.2 cm long, 1.3– 2.5 cm wide, consisting of a hard outer shell and a kernel from which the oil is obtained. Fl. Feb.–Mar.; fr. late Sept. to early Nov.

Germplasm

High-yielding cultivars continue to be developed. Some of the best varieties released by the USDA for growing in southern, United States are the following:

'Folsom': low-heading, high productivity; fruits large, late maturing, turning purplish when mature, containing 21% oil; highest resistance to low temperature in fall.

'Cahl': low-heading, productive; fruits large, 20% oil content; matures early, somewhat resistant to cold in fall.

'Isabel': low-heading, high productive; fruits large, maturing early, 22% oil content.

'La Crosser: High-heading, exceptional productivity; fruits small, late maturing, tending to break segments if not harvested promptly, 21–14% oil content; a very popular variety.

'Lampton': outyields all other varieties; very low-heading; fruits large, early maturing; 22% oil content.

Several other species of *Aleurites* are used to produce tung-oil, usually of low quality. *Aleurites cordata*, Japanese wood-oil tree; *A. moluccana*, Candlenut or lumbang tree; *A. trisperma*, Soft Lumbang tree; none of which can be grown commercially in the United States. *Aleurites montana*, Mu-tree, is the prevailing commercial species in South China and could be grown in Florida. ($2n$ = 22)

Distribution

Native to central and western China, where seedlings have been planted for thousands of years; planted in southern United States from Florida to eastern Texas.

Ecology

Ranging from Subtropical Dry to Moist through Tropical Very Dry to Dry Forest Life Zones, this species is reported to tolerate annual precipitation of 6.4–17.3 (mean of 8 cases = 12.,3), temperature of 18.7–26.2°C (mean of 8 cases 22.5), pH of 5.4–7.1 (mean of 4 cases = 6.4) (Duke, 1978, 1979). Tung trees are very exacting in climatic and soil requirements. They require long, hot summers with abundant moisture, with usually at least 112 cm of rainfall rather evenly distributed through the year. Trees require 350–400 hours in winter with temperatures 7.2°C or lower; without this cold requirement, trees tend to produce suckers from the main branches. Vigorous but not succulent growth is most cold resistant; trees are susceptible to cold injury when in active growth. Production of tung is best where day and night temperatures are uniformly warm. Much variation reduces tree growth and fruit size. Trees grow best if planted on hilltops or slopes, as good air-drainage reduces losses from spring frosts. Contour-planting on high rolling land escapes frost damage. Tung makes its best growth on virgin land. Soils must be well-drained, deep aerated, and have a high moisture-holding capacity to be easily penetrated by the roots. Green manure crops and fertilizers may be needed. Dolomitic lime may be used to correct excessive acidity; pH 6.0–6.5 is best; liming is beneficial to most soils in the Tung Belt, the more acid soils requiring greater amounts of lime.

Cultivation

Tung trees may be propagated by seed or by budding. Seedlings generally vary considerably from parent plants in growth and fruiting characters. Seedlings which have been self-pollinated for several generations give rather uniform plants. Only 1 out of 100 selected 'mother' tung trees will produce seedlings sufficiently uniform for commercial planting. However, a `mother' tree proven worthy by progeny testing may be propagated by budding. The budded trees, which are genetically identical with the original tree, will provide an adequate supply of seed satisfactory for planting. Seedlings are used for the root system for budded trees. Buds from 'mother' trees are inserted in stems of 1-year old seedlings, 5–7.5 cm above surface of the soil. Later, original seedling top is cut off and a new top grown for p the transplanted bud, making the tops of budded trees parts of the parent tree. Usually seedling trees outgrow budded trees, but budded trees produce larger crops and are more uniform in production, oil content and date of fruit maturity. Tung seed are normally short-lived and must be planted during the season following harvest. Seeds are best hulled before planting, as hulls retard germination. Hulled seed may be planted dry, but soaking in water for 5–7 days hastens germination. Stratification, cold treatment or chemical treatment of seeds brings about more rapid and uniform germination. Dry-stored seed should be planted no later than February; stratified seed by mid-March; coldtreated and chemical treated seed by early April. Seed may be planted either by hand or with a modified corn-planter, the seed spaced 15–20 cm apart, about 5 cm, in rows 1.6 m apart, depending on the equipment to be used for cultivation and for digging the trees. Seeds germinate in 60 days or more, hence weed and grass control may be a serious problem. As soon as seedlings emerge, a side-dressing of fertilizer (5–10–5) with commercial zinc sulfate should be applied. Fertilizer is applied at rate of 600 kg/ha, in bands along each side of row, 20 cm from seedlings and 5–7.5 cm deep. Other fertilizers may be needed depending on the soil. Most successful budding is done in late August, by the simple shield method, requiring piece of budstock bark, including a bud, that will fit into a cut in the rootstock bar, a T-shaped cut is made in bark of rootstock at point 5–7.5 cm above ground level, the flaps of bark loosened, shield-bud slipped inside flaps and the flaps tied tightly over the transplanted bud with rubber budding stripe, 12 cm long, 0.6 cm wide, 0.002 thick. After about 7 days, rubber stripe is cut to prevent binding. As newly set buds are susceptible to cold injury, soil is mounded over them for winter. When growth starts in spring, soil is pulled back and each stock cut back to within 3.5 cm of the dormant bud. Later, care consists of keeping all suckers removed and the trees well-cultivated. Trees are transplanted to the orchard late the following winter. Spring budding is done only as a last resort if necessary trees are not propagated the previous fall. Trees may be planted 125–750 ha. When trees are small, close planting in rows greatly increases the bearing surface, but at maturity the bearing surface of a crowded row is about the same as that of a row with trees farther apart. However, it is well to leave enough space between row for orchard operations. In contourplanting, distances between rows and total number of trees per hectare vary; rows 10–12 m apart, trees spaced 3.3–4 m apart in rows, 250–350 trees/ha. Tops of nursery trees must be pruned back to 20–25 cm at planting. As growth starts, all buds are rubbed off except the one strongest growing and best placed on the tree. A bud 5 cm or more below top of stump is preferred over one closer to top.

Harvesting

Tung trees usually begin bearing fruit the third year after planting, and are usually in commercial production by the fourth or fifth year, attaining maximum production in 10–12 years. Average life of trees in United States is 30 years. Fruits mature and drop to ground in late September to early November. At this time they contain about 60% moisture. Fruits must be dried to 15% moisture before processing. Fruits should be left on ground 3–4 weeks until hulls are dead and dry, and the moisture content has dropped below 30%. Fruits are gathered by hand into baskets or sacks. Fruits do not deteriorate on ground until they germinate in spring.

Yields and Economics

Trees yield 4.5–5 MT/ha fruits. An average picker can gather 60–80 bushels of fruits per day, depending on conditions of the orchard. Fruits may be gathered all through the winter season when other crops do not need care. Because all fruits do not fall at the same time, 2 or more harvestings may be desirable to get the maximum yield. Fruits are usually sacked, placed in crotch of tree and allowed to dry 2–3 weeks before delivery to the mill. Additional drying may be done at the mill, but wet fruits contain less oil percentage-wise and prices will be lower. Prices for tung oil depend on price supports, domestic production, imports and industrial demands. World production in 1969 was 107,000 MT of tung nuts; in 1970, 143,000; and projected for 1980, 199,000. Wholesale prices are about \$0.276/kg; European import prices, \$0.335/kg. Growers receive about \$51.10/ton of fruit of 18.5% oil content to about $63.10/ton for fruits of 22% oil content. Major producing countries are mainland China and South America (Argentina and Paraguay); United States and Africa much less than the others. U.S. Bureau of Census figures 1,587,000 pounds of tung oil were consumed during February of 1982, representing a 1,307,000 pound drop from January. The largest application for the oil is paint and varnish, which accounted for 566,000 pounds of total consumption in February (CMR, April 26, 1982).

Energy

During World War II, the Chinese used tung oil for motor fuel. It tended to gum up the engines, so they processed it to make it compatible with gasoline. The mixture worked fine (Page, 1981).

Biotic Factors

Bees are needed to transfer pollen from anthers to pistil. When staminate and pistillate flowers are on separate trees, one staminate tree for 20 pistillate trees should be planted in the orchard. Pollination can occur over several days. Tung trees are relatively free of insects and diseases, only a few causing losses serious enough to justify control measures: as *Botroyosphaeria ribis, Clitocybe tabescens, Mycosphaerella aleuritidis, Pellicularia koleroga, Physalospora rhodina* and the bacterium, *Pseudomonas aleuritidis*. Other bacteria and fungi reported on tung trees are: *Armillaria mellea, Botryodiplodia theobromae, Cephaleures virescens, Cercospora aleuritidis, Colletotrichum gloeosporioides, Corticium koleroga, Fomes lamaoensis, F. lignosus, Fusarium heterosporum* forma *aleuritidis, F. oxysporum, F. scirpi, F. solani, Ganoderma pseudoferreum, Cloeosporium aleuriticum, Glomerella clngulata, Pestalotia dichaeta, Phyllosticta microspore, Phytomonas syringas, Phytophthora omnivora, Ph. cinnamomi, Poria hypolateritia, Pythium aphanidermatum, Rhizoctonia solani, Septobasidium aleuritidis, S. pseudopedicellatum, Sphaerostilbe repens, Uncinula miyabei*, var. *aleuritis, Ustilina maxima, U. zonata*. Insect pests are not a serious problem, since fruit and leaves of tung trees are toxic to most animal life. Nematodes *Meloidogyne* spp. have been reported (Golden, p.c. , 1984).

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Aleurites moluccana (L.) Willd.

Syn.: *Aleurites triloba* Forst.
Croton moluccanus L.
Euphorbiaceae
Candlenut oil tree, Candleberry, Varnish tree, Indian or Belgaum walnut

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Seed yields 57–80% of inedible, semi-drying oil, liquid at ordinary temperatures, solidifying at -15°C, containing oleostearic acid. Oil, quicker drying than linseed oil, is used as a wood preservative, for varnishes and paint oil, as an illuminant, for soap making, waterproofing paper, rubber substitutes and insulating material. Seeds are moderately poisonous and press cake is used as fertilizer. Kernels when roasted and cooked are considered edible; may be strung as candlenuts. Oil is painted on bottoms of small crafts to .protect against marine borers. Tung oil, applied to cotton bolls, stops boil weevils from eating them. Also prevents feeding by striped cucumber beetle.

Folk Medicine

Bark used on tumors in Japan. The oil is purgative and sometimes used like castor oil. Kernels are laxative stimulant, and sudorific. The irritant oil is rubbed on scalp as a hair stimulant. In Sumatra, pounded seeds, burned with charcoal,are applied around the navel forcositiveness. In Malaya, the pulped kernel enters poultices for headache, fevers, ulcers, and swollen joints. In Java, the bark is used for bloody diarrhea or dysentery. Bark juice with coconut milk is used for sprue. Malayans apply boiled leaves to the temples for headache and to the pubes for gonnorhea

Chemistry

The oil cake, containing ca 46.2% protein, 4.4% P_2O_5, and 2.0% K_2O, is said to be poisonous. A toxalbumin and HCN have been suggested. Bark contains ca 4–6% tannin. Oil also contains glycerides of linolenic, oleic and various linoleic acids. Per 100 g, the seed is reported to contain 626 calories, 7.0 g H_2O, 19.0 g protein, 63.0 g fat, 8.0 g total carbohydrate, 3.0 g ash, 80 mg Ca, 200 mg P, 2.0 mg Fe, 0 mg beta-carotene equivalent, 0.06 mg thiamine, and 0 mg ascorbic acid.

Description

Medium-sized tree, up to 20 m tall, ornamental, with widespreading or pendulous branches; leaves simple, variable in shape, young leaves large, up to 30 cm long, palmate, with 3–7 acuminate lobes, shining, while leaves on mature trees are ovate, entire, and acuminate, long-petioled, whitish above when young, becoming green with age, with rusty stellate pubescence beneath when young, and perisiting on veins and petiole; flowers in rusty-pubescent panicled cymes 10–15 cm long; petals 5, dingy white or creamy, oblong, up to 1.3 cm long; ovary 2-celled; fruit an indehiscent drupe, roundish, 5 cm or more in diameter, with thick rough hard shell making up 64–68% of fruit, difficult to separate from kernels; containing 1 or 2 seeds. Fl. Apr.–May (Sri Lanka).

Germplasm

Reported from the Indochina-Indonesia Center of Diversity, *Aleurites moluccana* or cvs thereof is reported to tolerate high pH, low pH, poor soil, and slope (Duke, 1978) ($2n$ = 44, 22)

Distribution

Native to Malaysia, Polynesia, Malay Peninsula, Philippines and South Seas Islands; now widely distributed in tropics. Naturalized or cultivated in Malagasy, Sri Lanka, southern India, Bangladesh, Brazil, West Indies, and Gulf Coast of United States.

Ecology

Candlenut trees thrive in moist tropical regions, up to 1,200 m altitude. Ranging from Subtropical Dry to Wet through Tropical Very Dry to Wet Forest Life Zones, *Aleurites moluccana* is reported to tolerate annual precipitation of 6.4 to 42.9 dm (mean of 14 cases = 19.4) annual temperature of 18.7 to 27.4°C (mean of 14 cases = 24.6) and pH of 5.0 to 8.0 (mean of 7 cases = 6–4). (Duke,1978, 1979)

Cultivation

Usually propagated from seed, requiring 3–4 months to germinate. Seedlings planted 300/ha. Once established, trees require little to no attention.

Harvesting

Bears two heavy crops each year, harvested when mature. Kernels adhere to sides of shell and are difficult to separate.

Yields and Economics

In plantations yields are estimated at 5–20 MT/ha nuts, each tree producing 30–80 kg. Oil production varies from 15 to 20% of nut weight. Most oil produced in India, Sri Lanka and other tropical regions is used locally and does not figure into international trade. In the past, oil has sold for 12–14 pounds per ton in England. According to the Chemical Marketing Reporter (June 8, 1981), tung oil prices (then ca 0.65/lb.) are likely to rise in the near future if demand remains adequate and Argentinean and Parguayan suppliers pressure the U.S. market by charging high prices for replacement oil. U.S. imports for the first quarter of 1981 were 58% higher than 1980, despite the absence of Chinese tung from the market.

Energy

Nut yields at 80 kg/tree, spaced at 200 trees per hectare, would suggest 16 MT/ha/yr, about 20% of which (3 MT) would be oil, suitable, with modification, for diesel uses, the residues for conversion to alcohol or pyrolysis. Fruit yields may range from 4–20 MT/ha/yr. Commercial production of oil yields 12–18% of the weight of the dry unhulled fruits, the fruits being air-dried to ca 12–15% moisture before pressing (Univ. Fla. Bul. 221, 1935). Oil yields as high as 3, 100 kg/ha have been reported. The pomace contains 4.5–5% oil. This suggests that the "chaff factor" might be ca 0.8. As of June 15, tung oil was $0.65/lb, compared to $0.38 for peanut oil, $1.39 for poppyseed oil, $0.33 for linseed oil, $0.275 for coconut oil, $0.265 for cottonseed oil, $0.232 for corn oil, and $0.21 for soybean oil (Chemical Marketing Reporter, June 15, 1981). At $2.00 per gallon, gasoline is roughly $0.25/lb.

Biotic Factors

Following fungi are known to attack candlenut-oil tree: *Cephalosporium* sp., *Clitocybe tabescens, Fomes hawaiensis, Gloeosporium aleuriticum, Physalospora rhodina, Polyporus gilvus, Pythium ultimum, Sclerotium rolfsii, Sphaeronema reinkingii, Trametes corrugata, Xylaria curta, Ustulina deusta*. Nematodes include *Meloidogyne* sp. (Golden, p.c. 1984).

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Aleurites montana (Lour.) Wils.

Anacardiaceae
Wood-oil tree, Mu-oil tree

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Kernels yield a valuable drying oil, largely used in paints, varnishes and linoleums. Also used locally for illumination and lacquer-work. Varnish made from this plant possess a high degree of water-resistance, gloss and durability. There are only slight differences between the oils of *A. montana* and *A. fordii*.

Folk Medicine

The oil is applied to furuncles and ulcers.

Chemistry

The oil content of the seed is ca 50–60%. Oil consists chiefly of glycerides of beta-elaeostearic and oleic acids, and probably a little linoleic acid. Oil cake residue is poisonous and is only fit for manuring.

Description

A small tree about 5 m tall, much-branched, partially deciduous, dioecious; leaves simple, ovate or more or less cordate, apex cuspidate, about 12 cm long, 10 cm broad, sometimes larger and 3-lobed; leaf-blade with 2 large, conspicuous glands at base, petiole up to 24 cm long; flowers monoecious, petals large, white, up to 3 cm long; fruits egg-shaped, 3-lobed, wrinkled, about 5 cm in diameter, pointed at summit, flattened at base, generally with 3 or 4 oneseeded segments, the outer surface with wavy transverse ridges, the pericarp thick, hard and weedy. Fl. and fr. March.

Germplasm

($2n = 22$)

Distribution

Native to South China and in some of the S. Shan States (Burma). Introduced and cultivated successfully in Indochina where it has replaced *A. fordii*; Malawi, and in cooler parts of Florida, and other tropical regions.

Ecology

Ranging from Warm Temperate Moist to Tropical Dry to Moist Forest Life Zones, the mu-oil tree tolerates annual rainfall of 8.7–20.2 dm (mean of 7 cases = 14.5), annual temperatures of 14.8–26.5 (mean of 7 cases = 22.1°C), and pH of 5.5–8.0 (mean of 4 cases = 6.4). Adapted to subtropical regions and high elevations with moderate rainfall. Mainly a hillside species, but can thrive ded the area is well-drained. Maximum temperature 35.5°C, minimum temperature 6°C. It is frost-tender, and does not require a low temperature (below 3°C) as tung-oil trees (*A. fordii*) do, so can be grown in warmer regions. In Assam, grown where rainfall is 175–275 cm annually; in Mysore at elevations of 800–1,000 m with annual rainfall of 150 cm. Grows well in alluvial soils and is not very exacting in its soil requirements, but in richer soils the growth is more vigorous. A slightly acid soil is preferable.

Cultivation

Trees are propagated from seeds or by budding. In Malawi, propagation is by budding from high yielding clones. Seeds are usually planted in nursery and may take from 2 to 3 months to germinate. When seedlings are about I year old, they are planted out, spaced 6.6 x 6.6 m or more. Cultural practices are similar to those for *A. fordii*. As soon as the seedlings emerge, a sidedressing of fertilizer (5-10-5) of nitrogen and phosphorus along with commercial zinc sulfate should be applied. Fertilizer is applied at rate of 600 kg/ha, in bands along each side of row, 20 cm from seedlings and 5–7.5 cm deep. Other fertilizers may be needed depending on the soil. According to Spurling and Spurling (1974), N is the most important nutrient for tung in Malawi, irrespective of climate or soil. Most successful budding is done in late August, by the simple shield method, requiring a piece of budstick bark, including a bud, that will fit into a cut in the rootstock bark. A T-shaped cut is made in bark of rootstock at point 5–7.5 cm above ground level, the flaps of bark loosened, shield-bud slipped inside flaps and the flaps tied tightly over the transplanted bud with rubber budding strip 12 cm long and 0.6 cm wide. After about 7 days, rubber strip is cut to prevent binding. As newly set buds are susceptible to cold injury, soil is mounded over them for winter. When growth starts in spring, soil is pulled back and each stock cut back to within 3.5 cm of the dormant bud. Later care consists of keeping all suckers removed and the trees well-cultivated. Trees may be planted 125–750/ha. When trees are small, close planting in rows greatly increases the bearing surface, but at maturity the bearing surface of a crowded row is about the same as for a row with trees further apart. However, it is well to leave enough space between rows for orchard operations. In contour-planting, distances between rows and total number of trees per hectare vary; rows 10–12 m apart, trees spaced 3.3–4 m apart in rows, 250–350 trees/ha. Tops of trees must be pruned back to 20–25 cm at planting. As growth starts, all buds are rubbed off except the one strongest growing and best placed on the tree. A bud 5 cm or more below top of stump is preferred over one closer to top.

Harvesting

Trees begin bearing 2–5 years after transplanting with maximum production reached in 8 years and continuing for 40 years. In northern Burma, it has been observed to be more vigorous and disease-resistant than *A. fordii*. In Indochina, it has been successfully planted and its oil is now being produced on commercial scale, replacing that of *A. fordii*. Fruits mature and drop to ground in late September to early November. They are gathered and dried to 15% moisture before processing. Fruits should be left on ground 3–4 weeks until hulls are dead and dry, and the moisture content has dropped below 30%; fresh they are about 60% moisture. Fruits are gathered by hand into baskets or sacks.

Yields and Economics

A. montana is reported to give much higher yields of fruits than *A. fordii*. The percentage of kernels in the seeds is about 56%, and of oil in the kernels, about 59.3%. Major producers of the oil from *A. montana* are Burma, Indochina (Vietnam, Cambodia, Laos), Malawi, Congo, East Africa, South Africa, Malagasy Republic, India, and U.S.S.R. It has been considered for introduction in Florida.

Energy

Yields of oil per tree in China is reckoned to be about 3.2 kg; in Florida, 4.5–9 kg. Trees yield about 45–68 kg nuts/year, these yielding about 35–40% oil. In one Malawi trial, N treatments gave an increase of 519 kg/ha dry seed over a trial mean of 1070 kg/ha. With tung cake and ammonium sulphate, air dry tung seed yields of 12–17 year old trees was 2013 to 2367 kg/ha, of 6–9 year olds 766–1546 kg/ha (Spurling and Spurling, 1974).

Biotic Factors

Fungi reported on *A. montana* include the following: *Armillaria mellea, Botryodiplodia theobromae, Botryosphaeria ribis, Cephaleuros mycoidea, C. virescens, Cercospora aleuritidis, Colletotrichum gloeosporioides* var. *aleuritidis, Corticium oleroga, C. solani (Rhizoctonia solani), Corynespora cassiicola, Diplodia theobromae, Fusarium arthrosporioides, F. lateritium, Glomerella cingulata, Haplosporella aleurites, Mycosphaerella aleuritidis, Periconia byssoides, Pestalotiopsis disseminata, P. glandicola, P. japonica, P. versicolor, Pestalotia dichaeta, Phyllosticta microspora, Pseudocampion fasciculatum, Rhizoctonia lanellifera, Schizophyllum commune, Thyronectria pseudotrichia, Trametes occidentalis, Ustilin zonata*.

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Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 303-332

Neglected horticultural crops

The authors of this chapter are F. Nuez (Department of Biotechnology, ETSIA, Valencia, Spain) and J.E. Hernández Bermejo (Córdoba Botanical Garden, Córdoba, Spain).

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In the chapter on the processes and causes of the marginalization of Iberian crops, more than 20 horticultural crops are mentioned which could be considered to be in this situation. The authors have selected eight which will be dealt with in detail. Selection was based on a stricter identification of their marginalized nature and choosing from various taxonomic groups that would allow a detailed view of the problem.

Rocket (*Eruca sativa*), garden cress (*Lepidium sativum*), purslane (*Portulaca oleracea*), borage (*Borago officinalis*), alexanders (*Smyrnium olusatrum*), scorzonera or black salsify (*Scorzonera hispanica*), spotted golden thistle (*Scolymus maculatus*) and Spanish salsify or Spanish oyster plant (*Scolymus hispanicus*) are the eight species selected.

Rocket

(*Eruca saliva*)

Botanical name: *Eruca sativa* Miller

Family: Brassicaceae = Cruciferae

Common names. English: rocket, salad rocket, garden rocket; Spanish: oruga, oruga común, eruca, roqueta común; Catalan: ruqueta; Basque: bekarki; Portuguese: eruca, rúcula, fedorenta, pinchão (Brazil); French: roquette

Origin of the name

The semantic origin of this plant's name alludes to the oldest crops of the Near East. The Persian *girgir* and Acadian *gingiru* gave the Aramaic, Hebrew and Syrian *gargira*, and from these the Arabic *yiryir* and Latin *eruca*, from which, through Spanish, the words "roqueta" and "oruga" of present-day Spanish appeared.

Properties and uses

This plant is considered to be an excellent stomachic, stimulant and aphrodisiac, and is also used as a diuretic and antiscorbutic. The leaves have a bitter flavour which is made milder by cooking or frying. The seeds are hot, although rather less so than mustard seeds. It contains glucosides, such as allyl sulphocyanate, mineral salts and vitamin C. The oil of the seed contains erucic acid.

Rocket was always considered to be a potent aphrodisiac. In classic antiquity, it was consecrated to Priapus and was planted at the foot of the statue of this deity dedicated to the procreative potential of males. Dioscorides warns that, eaten raw, it stimulates lust and that the seeds have the same power. Columela also refers to its sexually stimulating effect, but is also very well acquainted with its cultivation technique: "...and rocket and basil also remain in the place where they have been sown and require no other care than manuring and weeding. Moreover, they can be sown not only in autumn, but also in spring...." The Hispano-Romans also compared the aphrodisiac power of rocket precisely with the anaphrodisiac power of lettuce. In Hispano-Visigoth culture, Isidoro de Sevilla supports the use and knowledge of this plant's powers: "... rocket is, so to speak, inflammatory, since it has burning properties and, if consumed frequently in the diet. arouses the sexual appetite. There are two species. one of which is in habitual use while the other is wild with a more bitter taste. Both stimulate sexual appetite."

Irrespective of these effects, rocket has been eaten basically as a vegetable (leaves) and as a spice (leaves and seeds). It is thus an ingredient of misticanza" (mixed salad), a speciality eaten in Rome since the very foundation of that city. Hispano-Arab agronomists also mention its cultivation. for instance Ibn Hayyay (eleventh century). Ibn Wafid (eleventh and twelfth century) and. of course, Ibn al-Awwam (twelfth century). The latter author mentions the plant's use as a flavouring for musts and syrups, the seed being ground and scattered over the surface of the earthenware jars containing the syrup. He also mentions its flowers being used in a similar way. In the sixteenth century, Alonso de Herrera's *Tratado de agricultura* contains no mention of rocket.

It is used to make sauces in which the leaves are mixed with sugar or honey, vinegar and toasted bread (rocket sauce). In Italy, it is eaten boiled with spaghetti, and then seasoned with garlic and oil. In Spain, it is traditionally used in La Roda and Montealegre del Castillo (Al bacete) in the preparation of *gazpachos* of La Mancha, an ancestral dish which includes the meat of partridge and rabbit and unleavened bread (*gazpacho*), with lightly fried rocket. Some authors relate this tradition to primitive fertility rituals.

Nowadays it still remains very much appreciated in various countries of the Mediterranean area. including Italy, Greece and Turkey, where it is eaten mainly in salads and as a garnish for meat. It goes very well with lettuce, chicory, valerian and tomato. Another recipe is potato and rocket salad. In India, it is cultivated to obtain a semi-drying oil from the seeds. At present, most of the rocket grown is for this purpose, and it is considered mainly as a potential oilseed product.

This plant's marginalization as a vegetable in Spain may have been very much connected with its condemnation because of its aphrodisiac properties.

Botanical description

Rocket is an annual herbaceous plant, growing up to 80 cm. The basal leaves occur in a rosette and are lyrate-pinnatifid (those normally eaten in salads); the caulinar leaves are lobulate or dentate. The flowers have white or light yellow petals. The siliquae measure up to 40 mm, are erect, attached to the stem, with a subcylindrical valvar portion and an ensiform face as long as the valves. The seeds measure 1.5 to 2.5 mm and are brown.

The wild form flowers from February to June and the cultivated form right into mid-summer. It is allogamous with a complex system of self-incompatibility, mainly gametophytic, but with some alleles acting sporophytically. The existence of genie male sterility has been verified. The chromosome pattern is $2n = 2x = 22$.

Figure 37. Horticultural crops: A) rocket (*Eruca saliva*), detail of fruit in the silicle; B) garden cress (*Lepidium sativum*), detail of fruit in the silicle; C) purslane (*Portulaca oleracea*)

Ecology and phytogeography

Rocket grows spontaneously in places modified by humans: abandoned gardens, waysides, tips and among rubble. It prefers hot, dry climates.

It is distributed all around the Mediterranean, extending to central Europe in the north and as far as Afghanistan and northern India in the east. It has reverted to the wild state in North America, South Africa and Australia. Vavilov described it in central Asia, the Near East and the Mediterranean, the latter being considered its main centre of origin.

It is cultivated mainly in India, and is grown more rarely in Turkey and Greece. It is also cultivated in Italy. In countries such as Spain, France and Great Britain, cultivation is rare.

Genetic diversity

The biggest collections of rocket germplasm are to be found at the Institute of Germplasm in Bari, Italy, at the NBPGR in New Delhi, India, at the Haryana Agricultural University in India and at the VIR in St Petersburg.

There are also smaller collections in Kabul in Afghanistan, Saskatoon in Canada, Gaersleben and Braunschweig in Germany, Tapioszele in Hungary, Islamabad in Pakistan, Blonie in Poland and Alnarp in Sweden. A small collection of species of *Eruca*, including *E. sativa*, is to be found at the Universidad Politécnica de Madrid and there is also germplasm from wild populations of the genus at the Córdoba Botanical Garden.

Collecting expeditions have continued. In 1985, 25 samples of indigenous germplasm of *E. sativa* were collected in the northeastern Sudan.

In an analysis using the D^2 statistic of Mahalanobis, out of 99 lines of rocket no correlation was found between genetic diversity for 12 characters associated with production and geographical origin.

There is wide variability as regards the characters of the siliqua and its stability, and a strong interaction with the cultivation conditions. Similarly, there is wide genetic variability for seed production per plant and related characters.

An important group of studies is attempting to use *E. sativa* as a genetic resource for improving other crucifers. In this way, intergeneric hybrids have been obtained with *Raphanus sativus, Brassica campestris* and *B. oleracea*. Somatic hybrids have been obtained through the fusion of protoplasts with *B. napus* and *B. juncea*.

There are lines of rocket (T27) known which are resistant to mustard aphid and tolerant of several stress conditions as well as *Fusarium oxysporum*. Such lines may also be a source of genes that are transferable to species of *Brassica*.

Cultivation practices

Rocket is a very hardy plant which requires little care. It is generally sown direct in late winter or early spring, in shallow furrows. To encourage emergence, it is advisable to cover with light sieved soil. It requires little irrigation and manuring. It is usually hoed by hand.

The young leaves are harvested in spring.

Prospects for improvement

The use of rocket as a vegetable, salad or spice has been marginalized, possibly for moral or religious reasons, and its recovery is limited by local gastronomic tradition, which is not always able to appreciate its characteristic bitter flavour. This is due to glucosinolates and the high content of mineral salts.

The development of cultivars with a low allyl sulphocyanate content does not appear to be an improvement objective since, even though the plant would be rendered innocuous, it would lose its individual identity.

In fact, a wide variability has been observed as regards both erucic acid content and glucosinolate content in 128 rocket specimens from Pakistan. Rocket already has a low content of these constituents, and the local inhabitants clearly distinguish this species from other more bitter crucifers. Its use can be increased only through the promotion of the traditional dishes in which it appears.

The use of agronomic techniques such as nitrogen fertilization and shading would enable younger, more juicy rosettes to be obtained which have a milder taste and are more palatable.

The work on genetic improvement for the use of "rocket" as a vegetable is very limited, if we exclude the development of in vitro cultivation, which has made it possible to regenerate normal diploid plants from isolated protoplasts of leaf mesophyll.

Garden Cress

(*Lepidium sativum*)

Botanical name: *Lepidium sativum* L.

Family: Brassicaceae = Cruciferae

Common names. English: cress, common cress, garden cress, land cress, pepper cress; Spanish: mastuerzo, mastuerzo hortense, lepidio, berro de jardín (Spain), berro de tierra, berro hortense (Argentina), escobilla (Costa Rica); Catalan: morritort, morrisá, Portuguese and Galician: masturco, mastruco, agrião-mouro, herba do esforzo; Portuguese: mastruco do Sul, agrião (Brazil); Basque: buminka, beatzecrexu

Origin of the name

Cultivation of this species, which is native to Southwest Asia (perhaps Persia) and which spread many centuries ago to western Europe, is very old, as is shown by the philological trace of its names in different Indo-European languages. These include the Persian word *turehtezuk*, the Greek *kardamon*, the Latin nasturtium and Arabic *tuffa'* and *hurf*. In some languages there is a degree of confusion with watercress. It seems that the meaning of the word nasturtium (*nasum torcere*, because its smell causes the nose to turn up) must have been applied initially to garden cress, as both Pliny and Isidoro de Sevilla explain. The confusion remains with the terms used by the Hispano-Arabs. The word *hurf* is applied without distinction to watercress and garden cress (several species certainly of up to three different genera: *Nasturtium*, *Lepidium* and *Cardaria*). Thus the medieval agronomists of Andalusia went as far as differentiating between several *hurf*, such as *hurf abyod*, *hurf babili*, *hurf madani*....

Properties, uses and cultivation

Xenophon (400 BC) mentions that the Persians used to eat this plant even before bread was known. It was also familiar to the Egyptians and was very much appreciated by the Greeks and Romans, who were very fond of banquets rich in spices and spicy salads. Columela (first century) makes direct reference to the cultivation of garden cress. In *Los doce libros de Agricultura*, he writes: " ...immediately after the calends of January, garden cress is sown out... when you have transplanted it before the calends of March, you will be able to harvest it like chives, but less often... it must not be cut after the calends of November because it dies from frosts, but can resist for two years if it is hoed and manured carefully... there are also many sites where it lives for up to ten years" (Book XI). The latter statements seem to indicate that he is also speaking of the perennial species *L. latifolium*, as *L. sativum* is an annual.

Almost all of the Andalusian agronomists of the Middle Ages (Ibn Hayyay, Ibn Wafid, Ibn alBaytar, Ibn Luyun, Ibn al-Awwam) and many of the doctors, such as Maimonides, mention garden cress. Ibn al-Awwam also includes references from Abu al-Jair, Abu Abdalah as well as from Nabataean agriculture and, among other comments, he says: "Garden cress is sown between February and April (in January in Seville). It has small seeds which are mixed with earth for sowing to prevent the wind carrying them away.... It is harvested in May and is grown between ridges, in combination/conjunction with flax cultivation."

Many of the authors of the old oriental and Mediterranean cultures emphasized the medicinal properties of cress, especially as an antiscorbutic, depurative and stimulant. Columela notes its vermifugal powers. Ibn al-Awwam refers to certain apparently antihistaminic properties, since it was used against insect bites and also as an insect repellent, in the form of a fumigant. It was perhaps Ibn al-Baytar, an Andalusian botanist (eighth century), who collected most information on its properties, summarizing the opinions of other authors such as El Farcy, who says that it incites coitus and stimulates the appetite; Ibn Massa, according to whom it dissipates colic and gets rid of tapeworms and other intestinal worms: or Ibn Massouih, who mentions that it eliminates viscous humours. Ibn al-Baytar also says that it is administered against leprosy, is useful for renal "cooling" and that, if hair is washed with garden cress water, it is "purified" and any loss is arrested.

In Iran and Morocco, the seeds are used as an aphrodisiac. In former Abyssinia, an edible oil was obtained from the seeds. In Eritrea, it was used as a dyestuff plant. Some Arab scholars have attributed garden cress's reputation among Muslims to the fact that it was directly recommended by the Prophet.

Garden cress's main use was always as an aromatic and slightly pungent plant. Not only in antiquity but also in the Middle Ages it enjoyed considerable prestige on royal tables. The young leaves were used for salads. The ancient Spartans ate them with bread. This use still continues and they are also eaten with bread and butter or with bread to which lemon, vinegar or sugar is added. However. it is mainly used nowadays in the seedling stage. the succulent hypocotyls being added to salads and as a garnish and decoration for dishes.

The roots, seeds and leaves have been used as a spicy condiment. Columela explains how *oxygala*, a type of curd cheese with herbs, was prepared: 'Some people, after collecting cultivated or even wild garden cress, dry it in the shade and then. after removing the stem, add its leaves to brine. squeezing them and placing them in milk without any other seasoning, and adding the amount of salt they consider sufficient.... Others mix fresh leaves of cultivated cress with sweetened milk in a pot… ".

L latifolium L. stands out for its horticultural interest; although it grows spontaneously on the edges of rivers and lakes, it is also occasionally grown in the same way as *L. sativum*. Its young leaves can be used for salads; the ancient Greeks and Romans used to grow it for this purpose. Its leaves and seeds were also used as a spicy condiment. Several sauces are prepared with its leaves, including in particular the bitter sauce of the paschal lamb of the Jews. The seeds of this species were known in England as the poor people's pepper. The roots have been used on occasion as a substitute for radish.

In the fifteenth century, we know through Alonso de Herrera that garden cress was one of the vegetables most widely eaten in Castile. During the sixteenth century, obstinate attempts were made to introduce it into America. Right up to the beginning of the nineteenth century, its cultivation in Spain continued to be important, since Boutelou and Boutelou (1801) deal specifically with this crop in their *Tratado de la huerta*, commenting on the existence of several cultivars At present, the cultivation of cress is very occasional in countries such as Spain and France. Water cress, in competition with garden cress, has eclipsed the cultivation of the latter. However, this is not the case in other central European countries or the United Kingdom, where its use is normal and the system of cultivation has changed substantially.

Botanical description

Cress is an annual, erect herbaceous plant, growing up to 50 cm. The basal leaves have long petioles and are lyrate-pinnatipartite; the caulinar leaves are laciniate-pinnate while the upper leaves are entire. The inflorescences are in dense racemes. The flowers have white or slightly pink petals, measuring 2 mm. The siliquae measure 5 to 6 x 4 mm, are elliptical, elate from the upper half, and glabrous. Cress flowers in the wild state between March and June.

It is an allogamous plant with self-compatible and self-incompatible forms and with various degrees of tolerance to prolonged autogamy. There are diploid forms, $2n = 2x = 16$, and tetraploid forms, $2n = 4x = 32$. A degree of variability is noted in the character of the basal leaves which are cleft or split to a greater or lesser degree. a character which is controlled by a single incompletely dominant gene.

Ecology and phytogeography

Cress is a plant that is well suited to all soils and climates, although it does not tolerate frosts. In temperate conditions, it has a very rapid growth rate. It grows subspontaneously in areas transformed by humans, close to crops or human settlements. It appears in this way on the Iberian peninsula. mainly in the eastern regions.

Wild cress extends from the Sudan to the Himalayas. Most authors consider it to be a native of western Asia, whence it passed very quickly to Europe and the rest of Asia as a secondary crop, probably associated with cultivars of flax. Vavilov considers its main centre to be Ethiopia, where he found the widest variability: the Near East, central Asia and the Mediterranean are considered secondary centres. It is now naturalized in numerous parts of Europe, including the British Isles.

Genetic diversity

The genus *Lepidium* is made up of about 150 species, distributed throughout almost all temperate and subtropical regions of the world. On the Iberian peninsula and the Balearic Islands, at least 20 species or subspecies exist among the autochthonous and allochthonous taxa, some genetically close to *L. sativum*. Seven of them are exclusively endemic to the peninsula or, at the very most, are common with North Africa. Other close species are *L. campestre* (L.) R. Br. and *L. ruderale* L. which also have edible leaves. The leaves of *L. campestre* are used to prepare excellent sauces for fish.

Common cress (*L. sativum* L.), with regard to the anatomy of the leaf, stem and root, has been divided into three botanical varieties: *vulgare*, *crispum* and *latifolium*. The latter is the most mesomorphic, *crispum* the most xeromorphic and *vulgare* intermediate.

At present, most of the studies on the variability and development of new cultivars are being carried out in liaison with the VIR of St Petersburg, where there is a good collection of material. Of the 350 forms of garden cress studied in the Ukraine, Uzkolistnyti 3 was the best, being highly productive and of good quality. It is being used as the basis of improvement programmes, as it appreciably surpasses the best Soviet varieties in production and quality. Other cultivars well suited to European Russia are Tuikers Grootbladige (broad-leaved) and the lines Mestnyi k137, k106 and k115. Of the types most cultivated in Europe, Early European, Eastern, Dagestan and Entire Leaved stand out, being distinguished by the length and shape of the leaf, earliness and susceptibility to cold. In Western Europe, one broad-leaved type is especially appreciated (Broad Leaved French) as are curly types (Curly Leaved), the latter being used extensively to garnish dishes. In Africa, there are red, white and black varieties.

This crop is also arousing interest in Japan, and collecting expeditions to Nepal have been organized. Some specimens collected during an expedition to Iraq in 1986 are now stored in Abu Ghraib and in Gratersleben, Germany. There are also small collections of *L. sativum* in the PGRC in Addis Ababa (Ethiopia), at the ARARI of Izmir in Turkey and in Bari, Italy. At the Universidad Politécnica de Madrid there are accessions of 20 species of *Lepidium*, while the BGV of the Córdoba Botanical Garden keeps germplasm of the southern Iberian species of the genus.

Cultivation practices

Cress is an easily grown plant with few requirements. It can be broadcast after the winter frosts or throughout the year in temperate climates. However, Boutelou and Boutelou (1801) were already recommending sowing in shallow furrows, which enables surplus plants to be thinned out and facilitates hoeing. Sowing has to be repeated every 15 to 20 days so that there is no shortage of young shoots and new leaves for salads—the leaves of earlier sowings begin to get tough and are no longer usable. The seed sprouts four or six days after sowing, depending on the season, and the leaves are ready for consumption after two or three weeks.

The usual form of cultivation continues to be as described, with 15 to 20 cm between rows and the use of irrigation in the summer, since they are lightly rooted seedlings which can dry up in a few days. Its growth is very rapid and harvesting can begin in the same month as sowing, with yields reaching 6 tonnes per hectare.

Prospects for improvement

Most of the genetic improvement work on garden cress is being carried out in the CIS, with little or no work being done at present in the countries of western Europe. Mainly early cultivars with a prolonged production period and better cold tolerance are being developed.

Cress can be grown and used like white mustard. It geminates more slowly at low temperatures, the emergence period being three or four days longer. Shortening this period is an interesting improvement objective.

However, cress's recovery and its greater presence on markets mainly depends on a modification of cultivation and marketing techniques. In counties such as the United Kingdom, where this vegetable is nominally to be found at the markets. cultivation takes place in greenhouses throughout the year. The whole succulent hypocotyls of the very young seedlings are eaten. The seed is placed on the soil surface on soft, level beds. It is finely sprinkled with water and then covered with sackcloth which has been steam-sterilized and moistened. The latter is frequently wetted to maintain moisture and is removed when the seedlings reach 4 to 5 cm in height (after approximately seven days in spring and autumn and ten days in winter). The yellowish leaves turn green after two to three days.

The cress is harvested when the first pair of cotyledon leaves have developed and it is marketed in small bags or trays, sometimes together with seedlings of white mustard.

Garden cress and white pepper are sometimes sown in the plastic trays or bags in which they will be sold, generally in peat with a nutrient solution.

Purslane

(*Portulaca oleracea*)

Botanical name: *Portulaca oleracea* L.

Family: Portulacaceae

Common names. English: purslane, purslave, pursley, pusley; Spanish and Catalan: verdolaga, verdalaga, buglosa, hierba grasa, porcelana, tarfela, peplide (Spain), colchón de niño (El Salvador), flor de las once (Colombia), flor de un día, lega (Argentina); Portuguese and Galician: beldroega, bredo-femea, baldroaga; Basque: ketozki, ketorki, getozca; French: pourpier, portulache

Origin of the name

The diversity of names and meanings already gives an idea of the age and geographical dispersion of purslane's cultivation or use. On the basis of historical, archaeological and linguistic documentation, De Candolle thought that this species was cultivated more than 4000 years ago. Its common names come from different roots: *lonica* or *louina* (Sanskrit), *koursa* (Hindustani), *kholza* and *perpehen* (Persian), *adrajne* *agria* (Greek), *portulaca* (Latin, which means "little door", because of the way its capsule opens). The Arabs in the Middle Ages called it *baqla hamqa'*, which means "mad" or "crazy vegetable" because of the fact that its branches spread over the ground without any control. The Hispano-Arabs of Al-Andalus (from the tenth to fifteenth century) used the name *riyla*, which means "foot", most certainly because of its dactyliform leaves, and also *furfir*, *farfan, farfag*, *farfagin*, derived from the Persian *perpehen*. They also called it *missita*, which means "mixed", because it is sometimes found growing in gardens and sometimes growing wild. In Spanish, names such as verdilacas, yerba aurato and yerba orate are known (which again mean "crazy herb").

Properties, uses and cultivation

As a medicinal plant, it is considered to have antiscorbutic, diuretic and cooling properties. Being rich in mineral salts and with a high water content (95 percent) and mucilage content, it has emollient and soothing properties for irritations of the bladder and urinary tract. It is also used to regulate the bowels. Dioscorides already recognized its medicinal powers: these were anti-inflammatory (eyes) and analgesic (headache), emollient and soothing, antifebrifuge (in juice) and anthelmintic. He also says that "it reduces the desire to fornicate". In the latter sense, other authors also mention its anaphrodisiac powers (1837 Codex of the Spanish Pharmacopoeia), including this plant among the "four cold seeds", together with chicory, endive and lettuce. The anaphrodisiac effect is perhaps due to the presence of norepinephrin, a precursor of adrenalin, which causes a reduction in the blood flow through constriction of the main arteries. It is also mentioned by Maimonides. In the Middle Ages, the pharmacists of Cairo used to sell purslane seed for various uses, recommending it in particular as a vermifuge. Laguna and Leclerc also recognized its different medicinal properties, especially the anti-inflammatory ones, in mixtures prepared with plantain, violets and gourds. Its magical powers have also been mentioned, as a charm against evil spirits and for dispelling nightmares if placed in the bed.

However, in addition to its medicinal powers, it is also a vegetable, a weed and a food for pigs.

Columela writes in his poem on the garden: "Already the juicy purslane covers the dry beds"; and in *Los doce libros de agricultura*: "Leafy purslane appeases the plot's thirst" (Book X); and in Book XI he gives a recipe for preserving it in vinegar and salt. Paladio refers to it exclusively because of its mucilaginous, medicinal and veterinary properties. Similar references are found in Kastos, taking up the Byzantine tradition. Isidoro de Sevilla mentions it without giving any information on its cultivation. In short, such a summary reference to the Hispano-Roman and Hispano-Visigoth tradition regarding purslane is surprising.

It is the writers of oriental and Arabic treatises who concerned themselves most with this vegetable. Ibn Wahsiyya describes its cultivation in the Near East, presenting it as a summer crop. Most of the Hispano-Arab agronomists deal with this plant. Arib (tenth century) mentions it in his *Calendario agrícola*. Al Zahrawi and Ibn Hayyay (eleventh century) also mention it. Ibn Bassal (eleventh century) deals extensively with its cultivation, already recognizing a certain intraspecific variability (he distinguishes early and late varieties), setting out its temperature and water requirements (summer cultivation and irrigation or vegetable garden), drawing up a sowing calendar which extends from March to August and demonstrating the practice of two basic cultivation periods, depending on whether the aim is to produce seed or to produce for human consumption. Sowing quantities and manuring and irrigation requirements also appear and are dealt with in great detail by the author. Ibn Wafid (Hispano-Arab agronomist of the eleventh and twelfth centuries) mentions it under the names *haqla hamqa'* and *missita*. Ibn al-Awwam, in his *Kitab al-Filaha*, recalls that it is mentioned by almost all the Arab authors and refers to different varieties. He uses the adjectives "mild", "vain" and "blessed".

After the sixteenth century, cultivation of purslane was gradually lost in Spain. Alonso de Herrera (sixteenth century), for example, makes no reference to it while Boutelou and Boutelou (1801) say that "purslane, which is not at all appreciated in Spain, is one of the crops which, in England and other countries further north, need to be cultivated in frames and hotbeds in order to bring forward their vegetation artificially"; and further on: "on this land, it is not usual to cultivate purslane other than using those that have grown at random among other plants cultivated with more care". In spite of Spanish disregard for this plant, it is still valued in many Latin American countries where it was introduced.

Purslane has been eaten as a vegetable, particularly fresh. In England in the seventeenth century. the cooks of Charles II used to add its leaves to all salads, perhaps to satisfy the king's taste or else for its digestive properties. In this recipe, the chopped young leaves were mixed with double the amount of leaves of lettuce, chervil, borage flowers and marigold petals, the mixture being dressed with oil and lemon juice. The recipe resembles that mentioned by Tirso de Molina: "I will have green coriander, garden cress, purslane, borage and mint added to it."

Not only the leaves, but also the stems and rootless plantlets can be eaten raw and fresh. Columela mentions their being eaten pickled with salt and vinegar. Purslane has a pleasant acidic flavour and is very juicy. In Spain, it is usually eaten at a more advanced stage of growth, after cooking. It is also delicious boiled and in omelettes. Sauteed in butter or fried, it is used in soups, broths, salads and sauces. Together with sorrel, it forms part of the French soup *bonne femme*. Recipes are also known for purslane and pea soups.

To complete the range of its applications, one could mention its use as an insecticide, in which case its juice is poured on to anthills, and also its ornamental use in Roman and medieval gardens.

At present in Spain, it is basically a volunteer species (weed) among summer irrigated crops, and its consumption is gradually declining; this is also the case with individuals collected from wild populations.

Botanical description

Purslane is an annual, herbaceous plant, with branched, decumbent or fairly ascending stems of up to 50 cm, and which are reddish, fleshy and glabrous. The leaves measure 0.5 to 3.3 x 0.2 to 1.5 cm, are obovate, entire and fairly papillose. The flowers are yellow and solitary or in axillary groups of two or three. The fruit is in a capsule (pyxidium) of up to 7 mm. The seeds measure 0.6 to 1 mm; they are reniform, black, and maintain their germinating capacity for eight to ten years. Of orthodox behaviour in germination, their viability is maintained much more if they are stored dry at a low temperature.

Ecology and phytogeography

Purslane was one of the most widespread horticultural plants in the Old World since distant times. It was taken to America where it was naturalized, as in Europe, in gardens, among rubble and at waysides. It originates from the region extending from the western Himalayas to southern Russia and Greece. In eastern Asia it does not seem to be spontaneous. In Greece it is spontaneous and cultivated. Vavilov (1951) categorizes it in the Mediterranean countries of the Near East and central Asia as a weed and vegetable.

Nowadays it is distributed over the hot temperate zones of a great part of the world. Together with other species of the genus it occurs as a weed in the majority of tropical and subtropical countries.

It is cultivated in the United Kingdom, the Netherlands and other European countries. It is a popular winter vegetable in northern India. In Spain. it very frequently occurs as a volunteer, but it is very rare as a crop.

Genetic diversity

Little work has been done on the management of purslane's extraspecific variability. Apparently, without any aim at improvement, protoplast fusion of the genera *Portulaca* and *Nicotiana* has been attempted, and heterokaryons and the first division have been observed, but it is not clear whether multiple divisions occurred.

Nevertheless, there is an enormous intrageneric variability. The genus *Portulaca* is cosmopolitan and many species are grown as a vegetable. Thus, *P. afra* Jacq., *P. pilosa* L. and *P. tuberosa* Roxb. in southern Africa and *P. quadrifida* L. in tropical Africa; *P. retusa* Engelm. in North America and *P. pilosa* L. in South America; *P. napiformis* Muell. in Australia; and *P. lutea* Forst in Polynesia. *P. quadrifida* L. is cultivated in many tropical regions.

Within *P. oleracea* and in its wild populations, Danin and Baker distinguish five subspecies (*oleracea, papillato-stellulata, stellata, granulato-stellulata* and *nitida*), on the basis of the seed size and structure of the testa. Recognition of these subspecies is somewhat questionable, especially if we take into account their sympatric character. Generally speaking, the existence of a single *P. oleracea* complex with several varieties is accepted; it includes: var. *oleracea*, which is widespread as a weed; and var. *sativa* (Haw.) Celak, which is cultivated as a vegetable and has a bigger and erect habit.

In a chemotaxonomic study comparing proteins and free amino acids, Prabhakar and Ramayya (1988) found that, within the complex *P. oleracea*, the var. *ophemera* is distinct from the var. *oleracea* and *sativa*.

In the var. *sativa*, it is usual to distinguish two types which can be differentiated by their colouring: green purslane and golden purslane. However, it seems that colour depends basically on exposure to the sun and is more an environmental than a genetic characteristic. Some markets, such as the French market, appreciate red in particular.

In the commercial catalogues of seed firms, cultivars of this horticultural plant are not usually offered.

Girenko (1980) has described the intraspecific diversity and composition of cultivars in various climatic zones of the CIS, along with another set of data of agricultural interest.[1]

Extensive work also has to be done on the recovery and conservation of purslane germplasm. In 1985, as part of a joint project with the IBPGR, a mission of the Agricultural Research Corporation collected indigenous germplasm of *P. oleracea* in the northeastern region of the Sudan. At ARARI in Izmir, Turkey, some accessions of *P. oleracea* are conserved.

[1]This article, published in 1988, has not been translated from Russian.

Cultivation practices

This is a vegetable which develops rapidly in hot environments. Cultivation is very simple, entailing the necessary hoeing and irrigation on light, rich soils which encourage emergence.

It can be grown in greenhouses and may be broadcast or sown by burying the seeds with light pressure. A first and second irrigation are essential and must be carried out either by sprinkler or by hand. In order to ensure moisture during emergence, the plots are sometimes covered with wet sackcloth. The seeds germinate quickly and have to be raised up to accelerate emergence and development. The plantlets are harvested when four or five leaves have formed which, with suitable temperatures, is achieved in about 20 days. It is possible to cover a long production period by staggered sowing.

In temperate areas in central Europe around April, when the frosts are over, cultivation also takes place in the open air with direct broadcasting (10 g per m^2). Moisture must be ensured during emergence. Later, when the seedlings have reached the mid-point in their growth, they tolerate water shortages well. In this type of cultivation, the plant is normally allowed to develop and the stalks are harvested throughout the summer. If the plant is not pulled up, it sprouts again.

The crop's biggest enemies are low temperatures and weeds, which require as many hoeings as necessary. Pests and diseases do not appear to constitute important limitations.

Prospects for improvement

Cultivation does not present any technical difficulty preventing restoration of this vegetable's use. In experimental tests carried out by the authors on the southeastern coast of Spain, uniform production of seedlings of between 6 and 8 cm was obtainable after a month or so during the winter and spring in an unheated polyethylene greenhouse.

This type of cultivation is the one which may be most readily acceptable on western markets, provided clean rootless seedlings are offered, appropriately packaged in trays covered with plastic film. Under these conditions, they keep well at low temperatures for a couple of weeks.

This type of product is practically unknown to the consumer and yet it is the most suitable for salads. If plants or shoots of plants developed under high temperature conditions are used, they may have excessive mucilage and an unpleasant texture. The plantlets have a milder flavour and texture which make them more appetizing.

Where plant material is concerned, practically everything remains to be done, since very little improvement work has been carried out recently.

Borage

(*Borago officinalis*)

Botanical name: *Borago officinalis* L.

Family: Boraginaceae

Common names. English: borage, cool tankard; Spanish: borraja, borraja común, borraga, borracha, bora, corrago, alcohelo, flores cordiales; Catalan: borratja, borraina, pa-i-pexet; Basque: borrai, borroin, murrum, assunasa, porraiña; Portuguese and Galician: borrage, borragem, erva borragem, borraxa

Properties, uses and cultivation

Borage is attributed with sudorific (flowers), diuretic (leaves and petioles) and emollient properties (cataplasms of leaves). It contains substantial mucilage, tannin, potassium and magnesium salts and traces of essence. The seeds contain up to 23 percent linoleic acid.

Pharmacologists in past times used to include borage within the "four pectoral flowers", and it was also strongly recommended in cases of rheumatism, in which case the fresh leaves were applied as a poultice, since they lose their properties when dry. The flowers and seeds had a reputation as euphoriants and were added to wine for this purpose. Some authors think that borage is the plant which the Greeks called *eafrosinon* and which, according to Pliny, "made men joyous and happy". One Greek proverb used to say: "I, borage, always give courage." In sixteenth-century Spain, it was still attributed with this property.

Thus, Alonso de Herrera (1981 [1513]) states that borages "are healthier than any other vegetable and. in truth, it can be said that in many cases they are not appreciated because these powers, which are many, are unknown". He also mentions some of these: "When raw, they engender a very singular blood, and more so when cooked with a good mutton or capons, and for this reason they are very good for old people... and if their seed is drunk in wine, it cheers the heart greatly...". The question arises as to whether the vegetable's virtues might not be due to the other ingredient which accompanied it.

In actual fact, its effects cannot be very obvious. since "in many cases they are not appreciated". The mildness of its action perhaps explains the well-known Spanish expression "it is borage water" to indicate that something has come to nothing. For example, Boutelou and Boutelou (1801) explained: "In ancient times it was very often used in medicine, but nowadays it is practically forgotten since it does not produce the effects for which it was applied in those days."

As a food vegetable, the origin of its cultivation has not been pinpointed. Although it is unclear whether the Greeks and Romans made medicinal use of this plant, it is more certain that they did not cultivate it, since none of the writers of treatises such as Columela or Paladio referred to it, although some authors attribute a Latin etymology to *borago* (derived from *borra* = rigid hair, because of the characteristic hairiness of the whole plant). Other authors support an Arabic etymology, from *abu* = father and *rash* = sweat, because of the sudorific property of its flowers. Some historians even thought that the plant came from Africa during the Middle Ages. However, there is no doubt that the plant is native to Spain and that, around the twelfth century, the Andalusian Muslims were not growing it. Indeed, in his *Kitab al-Filaha*, Ibn al-Awwam makes a single reference to it, treating it as a wild plant which could be used in times of famine. Other Andalusian agronomists and doctors such as Ibn Hayyay (tenth century), Ibn Wafid (eleventh to twelfth centuries) and Maimonides (tenth century) seem to mention it, but there is a degree of confusion regarding its name, *lisan al-lawr* (ox tongue), which may refer to both *Borago officinalis* and *Anchusa officinalis* or *A. italica*.

Consequently, borage must not have been cultivated until after the twelfth century. It is known to have been grown in Castile in the fifteenth century and, in 1539, Alonso de Herrera gave an extensive description of its cultivation and properties. It was one of the first vegetables taken to America by the Spanish; as early as 1494 it was being grown in the gardens of La Isabela, the first city founded on American soil. In the seventeenth century, Cobo (1953 [1662]) also stated that borage had adapted to Latin America. In the eighteenth century, it was frequently grown but had already lost importance.

Borage is grown for its leaves and stalks which are eaten as a vegetable. The young leaves can be eaten raw in salad dressed with olive oil, giving an aroma and flavour similar to cucumber. They should be chopped, since they are not very appealing whole because of their hairiness. They are used cooked in soups, as a garnish for meats and also in olla, a kind of stew. The leaves cooked in batter and served with hot or grated cheese are delicious. Similarly, borage dumplings can be made, while its finely chopped leaves can be cooked with almond milk to make an exquisite soup or used to make an excellent borage omelette.

However, nowadays leaf petioles are the part of the plant most used and lend themselves to most of the uses stated.

The flowers are used to garnish dishes and prepare an exquisite dessert. Genders (1988) suggests a recipe for borage tart. In some regions, a dessert is also prepared by frying the leaves, to which sugar or honey is added, in the same way as the *paparajotes* of Murcia, but using borage instead of lemon leaves. In Majorca, according to Font Quer (1990) the leaves are used to make fritters by preparing a mixture with beaten eggs and wheat flour and then frying the leaves thus coated in hot oil and sprinkling them with sugar and cinnamon.

Borage is also a honey-producing plant, the flowers and roots produce dye, while the active synthesis of linoleic acid—of pharmacological and cosmetic interest—occurs in the ovary, which explains the high content of linoleic acid in the seeds.

Botanical description

Borage is a sturdy, annual herbaceous plant. Almost all the plant is covered with stiff hairs. It has a taproot and erect, sturdy stems which reach 20 to 100 cm and are sometimes branched. It has ovate or lanceolate, petiolate basal leaves in a rosette which grow up to 25 cm. The upper caulinar leaves surrounding the stem are sessile. The flowers are a bright celestial blue on branched tops. Flowering occurs from spring to autumn. The fruit contains four oblongo-ovoid nucules measuring 4 x 2.5 mm.

Borage is an allogamous plant, which has hermaphrodite flowers with exserted stamens. It has a self-incompatibility system controlled by numerous genes. Pollination is predominantly entomophilous (bees).

The plant is propagated from seed. Seed collection is laborious, since the seeds drop easily. Sixty-five seeds weigh 1 g; 1 litre of seeds weighs around 430 g. In commercial storage conditions, germination capacity remains high for eight to ten years. Its behaviour is orthodox in storage.

The seed germinates very quickly, without any dormancy problems. The chromosome pattern is 2n = 2x = 16.

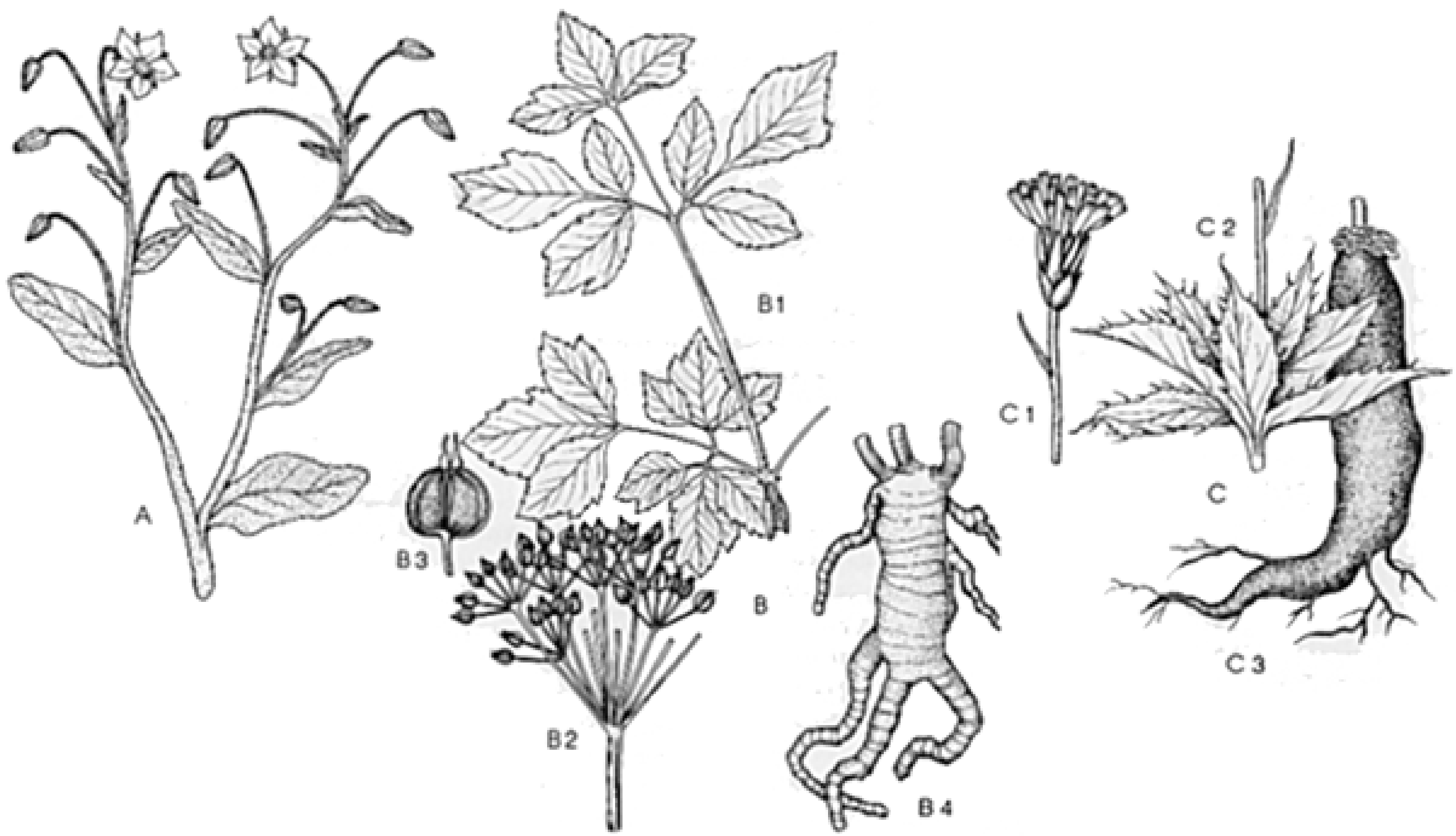

Figure 38. Horticultural crops: A) borage (*Borago officinalis*); B) alexanders (*Smyrnium olusatrum*); B1) leaves; B2) inflorescences in the umbel; B) fruit; B4) root; C) scorzonera (*Scorzonera hispanica*); C1) capitulum; C2) basal rosette of leaves: C3) root

Ecology and phytogeography

In its spontaneous or subspontaneous form, borage grows on uncultivated land, embankments, fallow land, wasteland, garden edges, waysides and among ruins.

It is native to the Mediterranean region but has been naturalized in the hot zones of western, central and eastern Europe, sometimes with unstable escapes northwards. It is also found in Southwest Asia, Macronesia and North America.

Cultivation of borage as a vegetable is limited to certain regions of the Netherlands, France, Spain and Latin America, being unknown in the rest of the world.

In Spain, it is grown mainly in the Ebro valley, in the provinces of Zaragoza, Logroño and Navarra. The total cultivated area in 1987 was 303 ha and production 7818 tonnes.

In recent years, some expansion of cultivation towards Andalusia has been noted, particularly in Almería. Sheltered cultivation is beginning to be carried out, with excellent results.

Genetic diversity

The genus *Borago* has only two Mediterranean species. In humid areas of Corsica and Sardinia, *B. pygmaea* (DC.) Chater & W. Greuter, a perennial with decumbent stems, is found.

Borago officinalis L. is a very variable species. There are varieties characterized by the flower colour. Although they are generally bright blue, there are also types with white and pink flowers. However, these are very heterogeneous populations with a great diversity in habit, vigour and development of the plant, shape, colour and size of the limb and leaf petiole, flowering, etc.

The cultivar Flor Blanca, which is marketed in Spain, has leaves with petioles of 40 to 50 cm in length and 1.5 cm in width. The plant grows to a height of around 50 to 60 cm.

In the gene bank of the SIA at the Diputación General de Aragón (Zaragoza), there is a small collection of accessions of this vegetable.

Cultivation practices

Borage is a very hardy plant which is suited to all types of soil. although it grows best on clayey-muddy soils. It prefers land that is rich in organic matter. It tolerates low temperatures, down to -50°C, and starts to sprout again when the temperature rises.

In Spain, direct sowing is used. The ground should be prepared with a basal dressing using about 50 tonnes of manure per hectare, if it has not been incorporated into the previous crop, and 90 to 120 units per hectare of nitrogen, phosphorus and potassium. The soil must be well broken up with deep ploughing and a couple of harrowings. In Aragon, staggered sowings are carried out in the open air from mid-August to January, in rows or individual drill holes with 25 to 30 cm between plants.

Cultivation presents no particular problems; the plants must be irrigated and, in the event of intensive cultivation, after thinning out top-dressing must be supplemented by 150 units per hectare of easily assimilated nitrogen.

The vegetative cycle takes between 50 and 120 days and harvesting can begin in mid-October, ending in May since, when high temperatures come with spring, the plant goes into flower and loses its value. Harvesting is done by hand. Each plant has two or three rosettes with five to seven leaves each. with a weight of 500 to 1000 g per plant.

Production levels of around 60 to 100 tonnes per hectare are obtained. According to data in the Spanish Government's *Anuario de Estadística Agraria*, average yields are 25 tonnes per hectare in the case of open-air irrigation and 36 tonnes per hectare in sheltered cultivation, Navarra being foremost with yields of 40 tonnes per hectare using both methods of cultivation.

Recently, sheltered cultivation under plastic has been gaining in importance. Under these conditions, much longer and fleshier leaf stalks are obtained and the stalk/plant yield rises to 60 percent, as against the 40 percent obtained with open-air cultivation. Production levels are also usually better.

The crop's main enemies are virus diseases (cucumber mosaic virus), soil fungi (*Fusarium* sp.), soil grubs, caterpillars and aphids.

The plant is usually marketed in 15 to 20 kg "bundles", amounting to 15 to 30 clumps, or in 10 to 12 kg boxes as complete plants, with part of the leaf removed. However, the consumer prefers borage to be completely stripped and packed in trays protected with plastic film.

Borage is subject to the technical regulations on the control and certification of horticultural plant seeds. The requirements for seeds of the basic, certified and standard category are 97 percent specific purity, 65 percent germination of pure seeds, with a maximum tolerance of 0.5 percent of seeds of other species. According to INSPV data, in 1989 2567 kg of borage seed were marketed, 2 489 kg of which were homegrown. Only the white variety was grown.

Another method of cultivation carried out in the Netherlands uses plantlets. After direct sowing, these are allowed to grow to a height of 10 to 15 cm and the complete plantlets are harvested. After washing and root removal, these can be marketed in trays covered with plastic film.

Prospects for improvement

Most improvement work has been carried out using white flower types. Breeding by growers has created forms with more succulent, longer and wider leaf stalks, with little pigmentation and less hair than the wild forms.

One of the main problems of cultivation is its ease of bolting, including the formation of flowers, which lowers the value of production. This process is caused by high temperatures and light intensity and reduced humidity. Breeding for resistance to bolting is a priority improvement objective, and a very high response to breeding is observed.

Although this plant has traditionally been cultivated in the open air, excellent results are now being obtained under plastic, in which case growth improves. A quality product, with long, tender leaf stalks and less hair can be obtained for a good part of the year in a greenhouse. The plant tolerates low winter temperatures and high humidity well. In the area around Zaragoza, borage has been converted into the most profitable crop under plastic.

The expansion of sheltered cultivation may encourage the recovery of this marginalized vegetable. The first tests in this connection have been carried out in Almería. If they prove positive, they would contribute to the diversification of production and to improving the supply in this region. which has great agricultural importance and yet depends on a very small number of crops.

As far as the consumer is concerned, in the case of regions that do not have a tradition of using this plant, borage must be presented stripped and properly packed, so that the work of culinary preparation is reduced. The plant's coarse, hairy appearance may cause some degree of rejection, which is avoided with appropriate cleaning and presentation.

With sights set on possible external markets which are even more demanding than the Spanish market, the high nitrate content of leaves and leaf stalks will need to be reduced. This can be achieved without great difficulty, as breeding to obtain a low nitrate content has been effective in other cases. Breeding to obtain individuals with a low content of lasiocarpine, a pyrrolizidinic alkaloid, would also be advisable, although its content is not excessively high.

As regards the plant's pharmacological use, in vitro cultivation of embryos is being developed; this is a technique whereby the active synthesis of linoleic acid takes place. In vitro propagation techniques of borage have also been developed.

Alexanders

(*Smyrnium olusatrum*)

Botanical name: *Smyrnium olusatrum* L.

Family: Apiaceae = Umbelliferae

Common names. English: alexanders, alisander, maceron; Spanish: apio caballar, apio equino, apio macedónico, perejil macedónico, esmirnio, olosatro, cañarejo; Portuguese and Galician: salsa de cavalo, cegudes, apio dos cavalos, roses de pé de piolho; Catalan: api cavallar, abil de siquia, julivert de moro, cugul, aleixandri

Origin of the name

This is the *hipposelinon* of the Greeks, a word which means parsley or "horse celery". In Arabic, during the Andalusian period, it was called *karafs barri*, one of the various *karafs* (celeries) known by Hispano-Arab agronomists, different from cultivated celery (*Apium graveolens*), aquatic celery (*A. nudiflorum*) and mountain or rock celery (the Greek and Latin *petroselinum* or *oreoselinon*). Alexanders has always been identified as oriental or Macedonian, very possibly as a reference to its geographical origin and its allochthonous character.

Properties, uses and cultivation

Its use as a medicinal plant is very old. The Greek botanist Theophrastus (fourth century BC) made reference to the plant. Dioscorides (first century) also included it in his *Materia medica*, commenting that its roots and leaves were edible. According to this author, its seed, taken with wine, is an emmenagogue. However, Galen said that it was less active than celery. In the Cordoba of the caliphs, Maimonides also spoke of its powers. During the Middle Ages, it was constantly considered as a plant with diuretic, depurative and aperient properties, particularly through its root. However, its most outstanding quality was perhaps as an antiscorbutic because of its high vitamin C content. The fruit has carminative and stomachic properties. In the eighteenth century, it continued to maintain its reputation as a medicinal plant. as the *Flore économique des plantes qui croissent aux environs de Paris* described it in 1799.

The plant, and especially the leaves, have a smell and flavour similar to myrrh. Hence the origin of the word *smyrnion*, its generic name. Columela (first century) refers to the plant as "myrrh of Achaea", because it was grown in Greece. which the Romans called Achaica or Achaea. It is also because of its characteristic flavour and smell that it is used as a condiment; it is used to season food in a similar way to parsley, giving flavour to soups and stews, and to prepare sauces accompanying meat and fish. However. its commonest use has been as a fresh vegetable, with a preference being shown for its leaves, young shoots and leaf stalks, which impart a pleasant flavour similar to celery, although somewhat sharper. It has also been eaten cooked. The Latin word olusatrum, which means "black vegetable". reflects these uses. The roots were used preserved in a sweet-and-sour pickle. The fruit contains an essential oil, cuminal, which is reminiscent of cumin.

The history of its cultivation is surprising. Of all the Umbelliferae used as vegetables, alexanders has been one of the commonest in gardens for many centuries, although in the nineteenth century it was almost completely forgotten. It was probably being gathered before the Neolithic period and was already being grown as early as the Iron Age. It became very popular during the time of Alexander the Great (fourth century BC) and was widely grown by the Romans, who certainly introduced it into western and central Europe, including the British Isles. It is now naturalized in these regions and on the Iberian Peninsula.

Columela elaborates on its cultivation and methods of consumption: "Before alexanders puts out stems, pull up its root in January or February and, after shaking it gently to remove any soil, place it in vinegar and salt; after 30 days, take it out and peel off its skin; otherwise, place its chopped pith into a new glass container or jar and add juice to it as described below. Take some mint, raisins and a small dry onion and grind them together with toasted wheat and a little honey; when all this is well ground, mix with it two parts of syrup and one of vinegar and put it like this into the aforementioned jar and, after covering it with a lid, place a skin over it; later, when you wish to use it, remove the pieces of root with their own juice and add oil to them."

Isidorode Sevilla (sixth century [1982]) seems to attach less importance to alexanders.

In France, it was an important vegetable, and was grown on the estates of the Carolingian kings. Thus, in the *Capitular de Villis*, promulgated by Louis the Pious, son of Charlemagne (around AD 795), alexanders appears among the plants which should be cultivated. In the eighteenth century, in Versailles, it was used blanched to accompany winter salads. In the early nineteenth century, Rozier, in his *Dictionnaire universel d'agriculture pratique*, writes: "The leaves of alexanders can appear among cooking condiments, like parsley. Its roots and young shoots are still eaten in England after blanching in the same way as celery."

There is documentation on its cultivation in Belgium in the fifteenth century and on its abundance in English gardens in the sixteenth century. The Italians also traditionally used this plant. However, by about the eighteenth century its cultivation was only very occasional or had fallen into disuse. In Spain, Font Quer (eighteenth century [1990]) says that its root was eaten in many countries as a salad, raw and cooked, as were the stems and young leaves. By the nineteenth century, Spanish agronomists were no longer making any reference to it. Thus, Boutelou and Boutelou (1801) do not mention it, an omission which contrasts with the 13 pages devoted to celery cultivation.

Alexanders was falling into disuse as from the seventeenth century. in direct competition with the celery of the Italians", an improved form of wild celery (*Apium graveolens*). This is a case of marginalization in which one plant, doubtless widely used since prehistory, is replaced by another one improved later.

Botanical description

Alexanders is a biennial herbaceous plant with a thick elongated root. The stems grow up to 150 cm and hollow on fruiting. It has large, pinnatisect, basal leaves, with ovate to subrhombic terminal segments; the caulinar leaves are pinnatisect. The umbels have seven to 22 rays, with black. didymous fruit measuring 5.5 to 7.5 x 4 to 7.5 mm. Alexanders flowers from April to June and propagates well from seed. Its chromosome structure is $2n = 2x = 22$.

Ecology and phytogeography

Wild populations of alexanders grow abundantly in salt-marshes and uncultivated land near the sea. normally in lime soils. It is also found in hedges. woods and on waysides.

It is spontaneous throughout southern Europe, North Africa (Algeria) and in the Near East. In former times it was very abundant in the area around Alexandria. Vavilov (1951) places this crop in the Mediterranean gene centre.

It also occurs on the Canary Islands and in the rest of the Macronesian region.

Genetic diversity

Perfoliate alexanders (*Smyrnium perfoliatum* L.) has smaller fruit (3.5 mm long) and is distributed through central and southern Europe and southwest Asia. The blanched stems and leaves are used in salads. Its cultivation is documented in the sixteenth century. According to Mathon (1986), this species is of superior quality.

Nowadays it is very difficult to find cultivars of alexanders. However, several cultivated varieties must have existed. For example, in England in 1570, Petrus Pena and Mathius Lobel wrote: "...the cultivated form is far better than the wild plant...". It seems that the plant is still occasionally grown in Great Britain.

Accessions of this species are kept only in the gene bank of the Córdoba Botanical Garden. They are from wild populations in Andalusia.

Cultivation practices

According to Columela, "alexanders must be grown from seed in ground dug out with a *pastino*, particularly close to walls because it likes shade and thrives on any kind of ground: so once you have sown it, if you do not uproot it fully but leave its stems for seed instead, it lasts forever and requires only light hoeing. It is sown from the feast day of Vulcan (August) until the calends of September, but also in January...".

Nowadays, since cultivation has been relegated to a few family gardens, similar practices are frequently seen. The stem is left to seed, and sowing and spontaneous cultivation takes place. Something like this usually occurs with chard: weeds are removed and a little fertilizer is applied.

Modernization of this crop will depend on techniques similar to those used for celery, including blanching, taking into account the fact that alexanders requires less soil and water.

Prospects for improvement

Celery was also known from antiquity but was considered to be an inedible plant of ill omen. The Greeks, who called it *apion*, used it in funeral ceremonies. It appears to have been grown early in our era by the Latins. Columela refers to it: ...after the ides of May, nothing must be put in the earth when summer approaches, except for celery seed, which must nevertheless be watered, since in this way it does very well...". Paladio also mentions it, probably basing himself on the earlier source. Likewise, in the *Capitular de Villis* (eighth century) reference is made to both *apium* and *olisatum*. Throughout this period, cultivation of alexanders seems to be predominant.

Around the seventeenth century, types of celery appeared which were derived through breeding to obtain a better size and improved succulence of the leaf stalks (var. *dulce* (Mill.) Gaud.-Beaup.) or fuller leaf development (var. *secalinum* Mill.) and which were clearly differentiated from the wild plant. These types are actually different vegetables requiring specific cultivation practices. Thus sweet-leaved celery ("celery of the Italians") is well suited to "blanching", which enables a milder, more tender product to be obtained.

The marginalization or disuse of many vegetables used since ancient times in Europe may be connected with the changing tastes in the Western world. The trend has been away from dishes rich in spices and hot ingredients towards milder dishes, which respect the flavour of the food itself or enhance it. This is perhaps the case with celery *vis-à-vis* alexanders. Alexanders is more bitter and pungent and not as tender as sweet celery.

It is significant in this respect that the last agronomic references to the cultivation of alexanders mention the introduction of the blanching technique. It appears thus in the reports by Versailles and Abbot Rozier: "...after they have been blanched in the same way as celery..."; and Barral and Sagnier, in *Diccionario de agricultura* (1889), write: "...in Turkey the cultivation of this plant is still an honour. The leaf is eaten after it has been blanched...". The blanching technique also used to be employed in North America. It is obvious that the smaller plant, celery, had asserted itself and now served as a reference, making it necessary to adopt the same cultivation practice for alexanders, evidently with little success.

While cultivation of alexanders is waning, cultivation of celery is by contrast on the increase, as is its importance in cool subtropical and tropical areas of Latin America and the Far East. Petiolate cultivate with big leaves are chiefly used.

The recovery of alexanders would be achieved via the derivation of plant materials with a specific typology, for specific uses, and the development of associated agronomic techniques; this seems very unlikely.

Scorzonera

(*Scorzonera hispanica*)

Botanical name: *Scorzonera hispanica* L.

Family: Asteraceae

Common names. English: scorzonera, Spanish salsify, black oyster plant, viper's grass; Spanish: escorzonera, escorcionera, escurzo, yerba viperina, salsifí negro, salsifí hispánico, churrimana, tetas de vaca; Catalan: escurçonera; Basque: sendaposei, astobe-harri; Portuguese and Galician: escorcioneira, escorzoneira

Properties, uses and cultivation

Scorzonera has diuretic and depurative properties. The root has restorative and sudorific properties and is an ingredient of many infusions. It is very rich in carbohydrates (18 to 20 percent in fresh weight), with a high proportion of inulin and laevulin, which makes it very suitable for a diabetic diet. It also contains conopherin (glucoside), asparagine, arginine, histidine and choline.

In upper Aragon, the latex is added to milk as a cure for colds. Its ground, fresh leaves are used against viper bites to soothe the pain. Its peeled root, fresh or cooked, acts as a tonic for the stomach and fortifies the body.

It is considered to be an antidote to the bite of poisonous animals, for which reason in Spanish it is called "escorzonera", i.e. herb against *escuerzo* [toad]. The *Diccionario de la lengua española* of the Real Academia Española mentions that the name derives from the Latin "black root" because of its external colour. In Italian, too, *scorza* means "root" and *nera* "black". However, as documented in Mattioli's *Epistolarium medicinalium libri quinque*, published in 1561, the first interpretation seems correct.

Cultivation of this plant is thought to be recent. No Roman or Arab agronomist mentions it. In Spain, its cultivation is not dealt with either by Andalusian agronomists (tenth to fourteenth centuries) or Castilian writers of treatises in the sixteenth century. The same applies in other countries. In France, it is not mentioned in the *Capitular de Villis* of the Carolingian kings, nor does Olivier de Serves, Henry IV's minister, mention it. It was from the sixteenth century onwards that botanists began to concern themselves with this species, describing it as wild, although sometimes introduced into botanical gardens. It is not quoted as a cultivated plant until up to one century later. In time, it was to become fashionable in several countries. Thus Louis XIV of France was very fond of it.

Although scorzonera was perhaps first cultivated in Spain, its cultivation has never been very important in the country. Boutelou and Boutelou (1801) commented: "Scorzonera is usually sown on the edges of unoccupied beds, the empty spaces being profitably used by this tasty root", thereby demonstrating a marginal rather than a main crop.

On the other hand, it is curious that these same authors visualized a greater agricultural importance for white salsify than scorzonera, contrary to what actually happened. Thus, they thought that "...sometimes the roots of scorzonera can begin to be used the first year after sowing, but they are so thin that there is no point in wasting them so young. They require two or sometimes three years for their root to form. Salsify, which has the same taste and properties and which forms in one year, should be preferred because it requires less time in the ground and its product is much more plentiful." The main improvement activity on this crop has enabled some good cultivars to be obtained, with a greater growth rate and better yields than salsify in annual cultivation.

The part of the plant most used is the tender, fleshy root. It is peeled and then cut into pieces and placed in water with lemon to prevent it from turning black. It can then be eaten in a wide variety of exquisite dishes: raw in a salad; dressed with vinaigrette or with other sauces, steamed and served with Béarnaise or Béchamel sauce or with whole milk cream and toast; sautéed in butter with parsley or other herbs; boiled as an accompaniment for meat; grated with cheese; baked with tomato and roast mutton or pork, fried with oil or butter after being lightly cooked and served with lemon; scrambled with eggs or in omelettes; and preserved in sugar.

It is recommended that, once cooked, the roots should be peeled so that they do not lose their flavour.

The leaves can also be eaten, especially the young ones after boiling. The "beards"—young, fresh and tender leaves—can also be eaten raw. The young shoots are used in the same way as asparagus.

The flowers are added to salads as a flavouring. They have an aroma reminiscent of cocoa. For this purpose, the flowers of other species such as *S. mollis* and *S. undulata* are also used. The flower buds can be used too. Recipes exist for scorzonera flower omelette.

Botanical description

Scorzonera is a perennial plant with a long, fragile taproot, which is blackish on the outside and white and milky inside, and which increases in size each year. The stems are solitary or few in number, usually branched on the upper part and between 30 and 120 cm long. The leaves are broad, long, fleshy and spatulate. The yellowish flowers are in capitula at the end of the stems. Flowering is in spring and summer (April-June).

Propagation is from seed. The achenes are 10 to 20 mm long, cylindrical, whitish and rough, with a pappus that has several rows of hairs. The weight of 75 to 90 seeds is I g, the weight of one litre of them is around

580 g. Under ordinary storage conditions they maintain a high germination capacity for two to three years.

It has a diploid chromosome number: 2n = 14. In the var. *crispatula*, some polyploids have been detected: 2n = 4x = 28.

Ecology and phytogeography

Scorzonera grows on dry pasture. rocky areas, in thickets and on limy or marry soils of temperate zones.

It is distributed over central and southern Europe and the south of the CIS, although it is not found in Sicily or Greece or in northwestern Africa or southwest Asia. It probably originates from the Mediterranean region and is native to Spain.

The plant is little cultivated outside Europe. Most cultivation takes place in the gardens of amateurs, with the plant being cultivated in professional gardens on a very small scale. Some estimates put cultivation at only a few dozen hectares. The countries with the biggest cultivated area of scorzonera are Belgium, Poland and members of the CIS.

At present, its cultivation is practically unknown in Spain. Although it is subject to the Technical Regulations on the Control and Certification of Agricultural Seeds and Plants, there is no evidence of the seed being marketed in Spain in recent years.

Genetic diversity

The modern *Scorzonera* genus, which is very close to *Tragopogon*, only includes three sections (*Podospermum*, *Scorzonera* and *Lasiospora*) with some 28 species in Europe. The majority of them are perennial diploid plants with 2n = 2x = 14. Cytotypes also exist with 2n = 2x = 12, x = 6 being derived from the earlier type through translocation.

In Spain, some 13 species are to he found. The majority of them prefer dry soils. This is the case with *S. angustifolia* L., *S. transtagana* Coutinho, *S. hirsuta* L., *S. crispatula* (Boiss.) Boiss. and *S. brevicaulis* Vahl. *S. parviflora* Jacq. is found predominantly on saline soils; *S. laciniata* L. on alkaline soils; *S. aristata* Ramond ex DC. is calcicolous and is found only in meadows and other grassy places of the Pyrenees, the Alps and Apennines; *S. fistulosa* Brot. del W. in Portugal and southwestern Spain. *S. humilis* L., dwarf scorzonera, grows very widely in Europe, while *S. baetica* (Boiss.) Boiss., *S. albicans* Cosson and *S. reverchonii* Deveaux ex Hervier are found only in southern Spain.

Scorzonera (*S. hispanica* L.) is extremely variable, especially in its leaf shape. The botanical varieties recognized are *crispatula* Boiss. (*S. crispatula* (Boiss.) Boiss.), which is very widespread, and *pinnatifida* (Rouy) Díaz de la Guardia & Blanca, which is relatively rare; they are basically distinguishable through their leaf morphology.

Numerous commercial cultivars already exist, and there are generally populations with open pollination:

- **Gigante de Rusia**, with a regular cylindrical, very long and smooth root and a very black skin. Various selections derive from it, such as Gigante negra de Rusia, Gigante anual, Annual Giant Bomba, Russisk Kaempe, etc.
- **Lange Jan**, which is of good quality.
- **Elite Stamm**, which is productive, stable, with a high yield of superior size roots.
- **Schwarze Pfahl**, which is similar to Elite Stamm.
- **Pronora**, which has well-formed roots, a smooth skin and, when canned, a good colour and flavour. It is especially suitable for industrial processing.

- **Vulcan, Duplex** and **Pilotis**, which are suitable for the frozen foods industry.
- **Hoffman 83, Flandria, Nero, Duro** and **Habil** are also good cultivars.

There are collections of local races and old cultivars at the Rijksstation voor Plantenveredling de Merelbeke (Belgium), at the Nordic Gene Bank in Alnarp (Sweden) and at the Vavilov Institute of Industrial Plants, St Petersburg.

Cultivation practices

Scorzonera is a vegetable that resists drought well when the plant has already developed.

It has similar cultivation requirements to white salsify. It is a typically winter vegetable which, although perennial, is grown as an annual.

It is usually sown direct in early spring, in shallow furrows, with 25 to 35 cm x 12 to 15 cm spacing. Care must be taken to provide protection from birds, which are very fond of these seeds.

About 12 kg of seed per hectare is required. Deep, fresh, loose soil is needed; it must be rich in decomposed organic matter and free from stones or gravel, which cause root deformation. The basal dressing recommended is 30 tonnes per hectare of rotted manure, 50 units of N, 100 units of P_2O_5 and 200 to 250 units of K_2O).

Attention must be paid to the first irrigations and hoeings, which can be controlled chemically, both at pre-emergence and post-emergence, with CIPC. It prefers sunny soils and the presence of easily assimilable nitrogen of which an additional 50 units can be applied as a top-dressing.

Harvesting takes place from November to March and requires perhaps more care than the harvesting of white salsify, since the roots are very fragile. This means furrows of about 40 cm have to be opened parallel to the rows of roots. Storage is good, both on the actual cultivation land and in cold stores at between 0 and -1°C, possibly for two to three months, or frozen, with light industrial processing to clean, peel, cut and scald the vegetables to prevent oxidation.

Yields of around 20 to 30 tonnes per hectare have been obtained.

The most important diseases are mycosis, white rust, oidiopsis and strangulation and splitting of the roots, the aetiology of which is unknown.

Prospects for improvement

Although it is thought that this vegetable is very little cultivated in Spain, because it has not been introduced into Iberian cooking, it should be recognized that serious cultivation problems still exist.

Although scorzonera is more productive than salsify and its cultivation more frequent, the two crops have many problems in common:

- a prolonged cultivation cycle, with garden space being occupied for an excessively long time;
- susceptibility to bolting, even during the first year of cultivation—although this does not hollow the root or impair its quality, it does affect yield, making systematic cuts of the flower stems necessary;
- poor seed storage;
- slow emergence and the need for a constant level of moisture;
- very laborious harvesting, since deep trenches have to be opened because the roots are very long and fragile;

- high nitrate content.

Some of these problems have already been tackled or are on the way to being solved. Thus, Schwarze Pfahl is more resistant to bolting than Elite Stamm.

Einjährige Riesen is particularly resistant to bolting and produces a low percentage of roots with cavities. However, it does not attain the yields of the former. Since genetic variability in respect of the character exists within commercial cultivars, rapid progress in improving this cultivar may be expected.

In Belgium, material is being selected which is especially suited to mechanical sowing and harvesting. Lange Jan, Hoffman 83 and Flandria were the ones which contributed the best product qualities among the cultivars tested.

In Poland, work is being done on the development of cultivars suited to industrial processing (both canning and freezing); some cultivars display a good behaviour in this respect.

Insofar as these improvement objectives are achieved. scorzonera may be expected to begin acquiring greater economic importance. It should not be forgotten that it is a vegetable with a very delicate flavour; its glucide composition is rich in inulin, very unlike other tubers and roots rich in carbohydrates, for instance the potato which has a high starch content. This property may be the reason for the increase in demand and price.

Spotted Golden Thistle

(*Scolymus maculatus*)

Botanical name: *Scolymus maculatus* L.

Family: Asteraceae = Compositae

Common names. English: spotted golden thistle; Spanish: tagarnina, diente de porro; Portuguese: escólimo-malhado

Origin of the name and properties

The generic name derives from the Greek, *skolos*, meaning spines, a characteristic shared with many other Compositae. In ancient Greece, a thistle with an edible root was known by the name skolymos. Diuretic and antisudorific properties were attributed to these plants.

Spotted golden thistle has occasionally been cultivated, but generally the wild plant has been used, with harvesting being limited to the leaves only in spring. At present, its cultivation is very restricted and is tending to disappear.

Cervantes did not seem to set great store by this plant: "...1 do not have a stomach made for spotted golden thistle, nor for *piruétanos*, nor for roots of the forests." However, the fleshy parts of the young leaves, like those of Spanish oyster plant, constitute a delicious vegetable which can be used in soups, stews and scrambled eggs or as an accompaniment for meat. Baked au gratin, they make an excellent dish.

Botanical description

Spotted golden thistle is an annual, glabrescent plant with latex. The stems are 20 to 130 cm long, broadly wing-shaped, irregularly dentate and spiny. The leaves, bracts and wings of the stem have a white and continuous cartilaginous edge. The basal leaves are oblong-lanceolate, smooth and pinnatifid, with few spines. The pinnatifid caulinar leaves are sinuate, more or less oval and spiny. The bracts are lanceolate, involucral and are more than five in number. The capitula are golden yellow, solitary or in clusters of two to four and flower from May to June. The achenes are of 3 to 4 mm and without a pappus. The chromosome number is 2n = 2x = 20.

The plant is propagated from seed. Its behaviour is orthodox in storage and its germination capacity is maintained for a long time. Dormancy phenomena are not very pronounced.

Ecology and phytogeography

Spotted golden thistle is found on uncultivated land, in abandoned fields and ditches and along paths and waysides. It prefers clayey soils and temperate climates.

It is distributed through southern Europe, Southeast Asia, North Africa and the Macronesian region. It is a native plant of the Mediterranean region. In Spain, it grows very widely throughout the country, including the Canary Islands.

It is occasionally cultivated in some areas of the Maghreb, southern Italy and Greece. In Spain. cultivation has practically disappeared.

Genetic diversity

The genus *Scolymus* L. includes another two Mediterranean species with a use similar to that of the spotted golden thistle, the Spanish salsify or Spanish oyster plant (*S. hispanicus* L.), with a wide Mediterranean distribution, and *S. grandiflorus* Desf, with a more restricted distribution in the eastern Mediterranean. These are very close species which differ in the leaf margin and wings of the stem and in the involucral bracts. among other characters. Unlike the spotted golden thistle, these Spanish salsify oyster plants are biennial or perennial.

A great morphological variability is observed, but no collections of material are known.

Cultivation practices

The spotted golden thistle is a very hardy plant which prefers clayey soils, although it grows spontaneously in a wide variety of environments. It tolerates cold and drought.

The method of cultivation is similar to that of Spanish salsify, although the latter thrives better on looser soils. Sowing is direct into the soil ready for cultivation, in late winter, with furrows 30 cm apart. After thinning, the plants are spaced 30 cm apart. It is preferable to apply organic fertilizer beforehand. The usual cultivation practices are very simple, being limited to removing weeds.

With hot temperatures, the plant grows very rapidly, with the basal rosette forming quickly, at which time the leaves have to be harvested.

Prospects for improvement

Spotted golden thistles, like Spanish salsify or oyster plants, are practically unknown vegetables on the market. However, they are appreciated in many Spanish regions on account of their very pleasant flavour. As in the case of so many other crops, its revival will have to be accompanied by a marketing system which creates demand. This means publicity campaigns, utilization standards, recipes for traditional dishes, etc., as well as a product of sufficient quality being available on the markets. The fleshy leaf parts would have to be offered peeled and clean and suitably packaged.

From the point of view of improvement, one of the most serious problems of the spotted golden thistle is the ease with which it goes into flower, encouraged by long-day spring conditions and high temperatures. Selection for resistance to this process would increase the cultivation period and make it possible to improve yields of the basal rosette. The plant's general spininess is another problem.

Undoubtedly, the most urgent task is to carry out collecting expeditions in the Mediterranean basin, including the Maghreb, and to characterize the material collected as a starting point for improvement. At the present time it is already very difficult to find traditional cultigens.

This problem is not limited to the spotted golden thistle and Spanish salsify, or even to the genus *Scolymus*, but affects many other Compositae. For example, the tribe *Carduaceae* contains 80 genera with over 2650 species, 227 of which are found in Spain and 150 of which are endemic in the country. Many of these plants have agricultural value and have occasionally been cultivated. In the majority of cases, cultivation is on the decline, even though it is being maintained. The recovery of these genetic resources, the characterization of the materials and the initiation of improvement programmes could contribute towards diversification, both of production and supply, thus helping to make Spanish agriculture more competitive.

Spanish Salsify

(*Scolymus hispanicus*)

Botanical name: *Scolymus hispanicus* L.

Family: Asteraceae = Compositae

Common names. English: Spanish salsify, Spanish oyster plant, common golden thistle; Spanish: cardillo, cardillo de comer, cardillo de olla, cardillo bravío, cardo lechar, cardón lechar, cardón lechal, lechocino, cardo zafranero; Catalan: cardet, cardelina; Basque: kardaberaiakca; Portuguese: cardo de ouro, cangarinha

Properties and uses

The Spanish salsify plant has been recognized as having antisudorific and diuretic properties. The Greeks knew it and it is mentioned by Theophrastus. Pliny makes reference to it and considers it an antiperspirant. However, it is barely mentioned by Andalusian agronomists. The translator of an anonymous Hispano-Arab document of the eleventh and twelfth century interprets that *silyan* and *adaliq*, spiny plants which people collect among wild vegetables, are indeed Spanish salsify, *Scolymus hispanicus*.

Although it has been cultivated occasionally, at present it is clearly in recession. Most of the Spanish salsify that is eaten comes simply from collecting the wild plant.

Several parts of the plant have a fairly delicate flavour. The young basal leaves are eaten as a vegetable in salads, boiled, in soups, stews, omelettes, etc. The most pleasant part of the leaf is the central rib, a white fleshy part which is obtained by peeling the leaf, with a scraping movement with one hand from the base to the apex, while the other hand holds the base. The young stems are used in a similar way. Font Quer (1990) mentioned that this plant is appreciated in almost all of Spain's provinces and "...is used widely in stew during the spring". In the sixteenth century in Salamanca, the washed young plants used to be eaten with their root, either raw or in stews with meat. In soup, its roots are prepared with milk, butter and flour.

Botanical description

Spanish salsify is a biennial or perennial plant, which is erect, contains latex and is very spiny. The stems are between 5 and 250 cm long, branched at the top, with discontinuous spiny, dentate wings. The basal leaves are oblong-lanceolate, smooth, pinnatisect, with few spines, and a long petiole. The caulinar leaves are rigid, coriaceous and spiny. The capitula have one to three golden-yellow, enveloping leaves; they are about 3 cm long, in a lateral or terminal arrangement and surrounded by an involucre of spiny bracts. The achenes are 2 to 3 mm with a pappus that has a short corona. It flowers from May to July. The plant is propagated from seed, which has a very good germination capacity for several years and does not exhibit any marked dormancy phenomena. It is a diploid plant: $2n = 2x = 20$.

Ecology and phytogeography

Spanish salsify is found on waste ground and uncultivated land, among rubble, in ditches and along paths; it is most frequently found in sandy places in temperate zones.

Distributed through southern Europe and North Africa, it extends to northwestern France. Vavilov (1951) pinpoints its origin as the Mediterranean region. In Spain, it grows wild in most of the country but shuns high mountains; it is less common in the north. It is also found in the Canary Islands.

It is occasionally cultivated in Mediterranean countries such as Spain, Greece and the Maghreb; it is practically unknown in the United States.

Genetic diversity

There is considerable variability in the morphological characteristics of Spanish salsify such as hainness, leaf morphology and involucral bracts, receptacular scales, spininess, etc.

No definite cultivars exist; it is still possible to obtain a few cultigens, although there is a serious risk of losing these materials.

There has been no significant activity in collecting or conserving genetic resources of this species.

Cultivation practices

Spanish salsify is a very hardy plant, is resistant to cold and thrives on all kinds of soil, although it prefers light-textured soils that are rich in organic matter. Its cultivation requires very little care.

Sowing is direct and is carried out in late winter or in spring. A light, well-drained, manured soil should be used. It can be sown in furrows, 30 cm apart with a distance of 30 cm between plants after thinning.

The young white shoots can be pulled up when they reach 20 cm or so in height. The fleshy parts of the leaves need the basal rosette to be well formed. The roots are usually harvested around the end of October or during the winter. If the plant is left until the following year, it goes into flower and develops a sturdy stem, while the basal leaves lose their quality because of toughening. Therefore, although the plant can be kept for several years, it should be cultivated as an annual.

There are no serious phytopathological problems.

Prospects for improvement

The considerably spiny nature of the Spanish salsify plant, and especially of the caulinar leaves which have big, tough spines, is a serious drawback to its handling and deters attempts to cultivate it. The breeding of less spiny forms would facilitate the plant's handling.

As far as the most widely used portion is concerned—i.e. the fleshy part of the leaves—forms will need to be bred that have thick, tender and juicy ribs. Wide collections of material must be made, especially of the old cultigens which can still be recovered, so as to characterize and select them. The areas of greatest interest are the Maghreb, southern Greece and non-horticultural Spanish regions.

If the intention is to use the roots, harvesting should be carried out until the end of the winter. Resistance to flowering will enable root yield to be improved by encouraging rapid root growth at the time of hot weather.

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last update Tuesday, June 16, 1998 by aw

Medicago sativa L., & other *Medicago* species

Fabaceae

Alfalfa, Bur Clover, Lucerne, Medic, Sativa

We have information from several sources:

New Uses for Alfalfa and Other "Old" Forage Legumes— Joe H. Bouton

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Alfalfa From: J.R. Magness et al., 1971. Food and Feed Crops of the United States.

Bur-Clovers - *Medicago polymorpha* and *M. arabica*. From: J.R. Magness et al., 1971. Food and Feed Crops of the United States.

See: Annual Medics In: Winter Survival of Austrian Winter Pea and Annual Medic on the Western High Plains. Krall, J., R.W. Groose, and J. Sobels. 1996.

Annual Medics: An Annual Forage Legume for Indiana. (Article from the New Crops News, 1993)

Special Purpose Forage Legumes —Melvin D. Rumbaugh

Alfalfa Stems: Potential Biofuel for Woodstoves—A. Gray, C. Anderson, E. Koppelman, B. Bjornsen, K. Frank, and M. Siedell

New Crops for Canadian Agriculture—Ernest Small

Prosopis pallida H.B.K.

Syn.: *Prosopis limensis* Benth.
Mimosaceae
Kiawe (Hawaii), Algarroba

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Very valuable for ornament, shelter in arid conditions, and for timber, fuel, and forage (fruits). Highly esteemed by foresters in Hawaii. Its cultivation might be encouraged in other warm and dry countries (Burkart, 1976). Leaves and pods, fed to cattle, donkeys, and other livestock, are eaten by wildlife. Pods sweeter than those of most other Prosopis species. In its native habitat they are made into a sweet syrup used to prepare various drinks. A potentially important species for plantations in hot, dry regions, especially where salinity makes the cultivation of other species difficult (NAS, 1980a).

Folk Medicine

No data available.

Chemistry

No data available.

Description

Tree (or shrub on sterile soils) 8–20 m high, trunk to 60 cm in diameter, unarmed or spiny, with short axillary, uninodal, geminate, divergent spines less than 4 cm long. Leaves medium to small in size, pallid grayish-green when dry, (1–)2–4 jugate, pubescent, ciliolate to subglabrous; petiole short, with the rachis 0.8–4.5 cm long, pubescent; pinnae 1.5–6 cm long, with a sessile, cuplike gland at their junction; leaflets green or gray when dry, 6 to 15 pairs per pinna, approximate without touching or a little distant, pubescent or at least ciliolate, oblong-elliptic to ovate, obtuse or mucronate, firm, pinnatinerved below, 2.5–8.3 mm long x 1.4–4 mm broad. Racemes spiciform, much (2 to 3 times) longer than the leaves; rachis and the short peduncle pubescent, together 8–15 cm long; florets dense (200 to 250 per raceme), short-pedicelled, greenish-yellow; calyx ciliolate, 0.5–1.5 mm long; petals 2.5–3 mm long, free, villous within; stamens 5–7 mm long; ovary stipitate, villous. Legume straight or subfalcate, very similar to that of *P. juliflora* (Sw.) DC., but thicker, straw-yellow when ripe, with parallel margins, fleshy, sweet, edible, subcompressed, long or short stipitate with rounded base, and acuminate, sometimes nearly subquadrate-rectangular in transection, (6-)10–25 cm long 1.5 cm broad 5–9 mm thick; endocarp segments to 30, broader than long; seeds oblong, brown, 6.5 mm long (Burkart, 1976).

Germplasm

Reported from the South American Center of Diversity, kiawe, or cvs thereof, is reported to tolerate drought, lava, salt, and sand. Shallow-rooted, the species is subject to windthrow. Said to hybridize with *P. juliflora* in Ecuador. The tree may become an invader, forming annoying thickets (Burkart, 1976).

Distribution

Native to Peru, Colombia, and Ecuador in the drier parts and along the Pacific coast. It has been naturalized in Puerto Rico and the Hawaiian Islands, and perhaps elsewhere (Brazil); introduced for cultivation in India and Australia (NAS, 1980a; Burkart, 1976).

Ecology

Probably ranging from Tropical Thorn to Moist through Subtropical Thorn to Moist Forest Life Zones, this species is estimated to tolerate annual precipitation of 2 to 13 dm and annual temperatures of 18 to 26°C. Ranges in soil adaptation from old lava flows to coastal sands.

Cultivation

Seed sown in new locations may require rhizobial inoculation. Can be irrigated with water half as salty as sea water. According to Felker et al (1981), *P. pallida*, *P. articulata*, and *P. tamarugo* grew well on an N-free medium equivalent to 1/2 seawater and grew slightly in full seawater.

Harvesting

No data available.

Yields and Economics

In the 1940's, nearly 181 MT honey were produced annually from the kiawe, once appraised as "the most valuable of all the introduced trees in the Hawaiian Islands. Prior to 1948, ca 500,000 bags of pods were collected annually as fodder in Hawaii (Neal, 1948).

Energy

Largely used for charcoal, the wood has a high calorific value.

Biotic Factors

Apparently attractive to termites and wood boring beetles like *Clytus cornis*. Psyllids feed on the shoots and leaf tips of this species, apparently more than others. Felker et al (1981) review the pest infestations of their *Prosopis* plantings with suggestions for their control.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Thursday, January 8, 1998 by aw

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Prosopis alba Grisebach

Mimosaceae
Algarrobo Blanco, Ibope, Igope, Tacu

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

All information, especially early information, on *Prosopis* spp. is only tentatively assigned to one or the other species of *Prosopis.* Taxonomic identities were extremely confused until Burkart's monograph. Much of the early chemical, ecological, and ethnobotanical data may be masquerading under the wrong name. Burkart (1943) describes several beverages made from the fruits, including a coffee substitute made from toasted pods. A very important tree in arid lands, similar in value to *Prosopis chilensis, P. nigra,* or *P. pallida*. In northeastern Argentina, native people frequently call it "el arbol", the tree, because of its usefulness and abundance. It is cultivated to a limited extent. In the Chaco it furnishes timber of high value for construction, doors, premanufactured houses, etc. Trees with straight trunks 8 to 10 m occur, but these are becoming extremely rare, from being cut in preference to the other shorter ones. Thus a negative, artificial selection is taking place, which should be counteracted by genetic up-building of the best lines in experimental plots (Burkart, 1976). According to NAS (1980a) this valuable food tree is also used for fodder, roadside planting, timber, and windbreaks. Streets of Buenos Aires are lined with these trees in the belief that they subdue vehicular noises (Burkart, 1943). The fruit is milled into a baking flour for human consumption. Though difficult to work, the wood is used for flooring, paving blocks, shoe lasts, and wine casks. Sawdust, like the fruits is used for tanning.

Folk Medicine

Reported to be astringent, lithontriptic, and tonic, the white algarrobo is a folk remedy for ophthalmia.

Chemistry

Per 100 g, the pericarp only (of *P. alba* and *P. velutina*) is reported to contain 4 g H_2O, 10 g protein, 40 g sugar, and 19 g fiber. "Patay" is the sweet floury paste of the pods, ground up and dried, serving as the basis for many popular Argentine dishes. Patay contains 9.6% water, 6.7% ash, 43.9% sugar, 10.4% starch, 5.9% cellulose (we need it), 4.3% protein, 1.2% fats, and 3.5% pentosans. While high in calories, the patay is deficient in certain proteins, vitamin A, C, and D (Burkart, 1943). Like *P. chilensis*, this species contains apigenin 8-glucoside, apigenin 6-glucoside, quercitin 3-glucoside, quercitin 3-rhamnoside, quercitin 3-rutinoside, and traces of myricetin 3-rhamnoside, luteolin, kaempferol-3-OMe quercetin, and quercitin 3-OMe (Simpson, 1977). Pipecolic and 4-hydroxy pipecolic acid also occur in both, but varying concentrations of pipecolic acid and proline are interpreted as reflecting a plastic response to changing environmental conditions. The consistent patterns of flavonoid distributions in several species groups, on the other hand, apparently reflects genetic fixation independent of known environmental factors (Simpson, 1977). Pods contain ca 7–11% protein, 25–28% sugar (Simpson, l977; Burkart, 1943).

Description

Tree 5–15 m tall, in age the short trunk possibly reaching 1 m in diameter; treetop rounded; branchlets drooping; spines scarce and small, only on strong shoots, 2–4 cm long, geminate. Leaves large, uni- to trijugate, glabrous; petiole (including the rachis) 0.5–8 cm long; pinnae 6–14 cm long, with 25 to 50 pairs of leaflets, these linear, acute or subacute, in some forms nearly obtuse, 0.5–1.7 cm long x 1–2 mm broad, scarcely nerved below, approximate, 1.5–6 mm between pairs. Racemes spikelike as in similar species, 7–11 cm long; florets greenish-white to yellowish, small; calyx 1 mm long, puberulous; corolla 3–3.2 mm; stamens 4.5 mm; pistil 5 mm long. Legume falcate to ring-shaped (ring ca 7 cm in diameter), linear, compresses with parallel margins, straw-yellow, stipitate and acuminate, 12–25 cm long x 11–20 mm broad x 4–5 mm thick, with 12 to 30 subquadrate endocarp segments broader than long, ca 0.6 x 1 cm (Burkart, 1976).

Germplasm

Reported from the South American Center of Diversity, white algarrobo, or cvs thereof, is reported to tolerate drought, salt, and sand, but it will withstand only a few hours of mild frost, prolonged cold (-6°C) killing most seedlings. Said to hybridize with *P. flexuosa, P. nigra*, and *P. ruscifolia*. In terms of chromosome number and morphology, there seem to be few genetic or chromosomal barriers to hybridization between various species of *Prosopis*. Sympatry, partial overlap of flowering time, and little specific discrimination by pollinating insects also facilitate hybridization ($2n = 28$) (Simpson, 1977).

Distribution

Plains of subtropical Argentina to Uruguay, Parguay, southern Brazil to Peru (Burkart, 1976).

Ecology

Our computer entries for *Prosopis* spp. are unreliable partly due to past taxonomic confusion. I estimate that the species ranges from Tropical Thorn to Moist through Subtropical Thorn to Moist Forest Life Zones. It will probably tolerate annual precipitation of 1 to 20 dm, annual temperature of 18 to 28°C, and pH of 6 to 8.5. Felker et al. (1981) cite studies suggesting that the annual minimum temperature isotherm of minus 20.5°C defines the northern limit for *Prosopis* distribution generically.

Cultivation

Tree can be seeded directly but is best sown in a nursery and outplanted when 2–3 months old. For quick germination (3–4 days), high temperatures (night 26°C; day 32°C) are best. Running the pods through a coarse sausage grinder both helps to separate and scarify the seed. Felker et al. (1981) found that a coffee mill produced fewer broken seed than the other devices they tested. Felker et al (1981) report water requirements of 478.3 cm /g DM, making this one of the more water efficient species. Felker et al. (1981) report the first successful rootings of mesquite cuttings. Seed need to be inoculated with mesquite rhizobia. Competes well with grasses and shrubs.

Harvesting

This species, like *P. nigra*, has good coppicing qualities. Felker et al (1981) project costs of $23.36 per dry ton (on the stump from tissue cultured seedlings) for the first harvest and only $5.00 per dry ton for subsequent coppice regrowth harvests. Firewood harvested as needed.

Yields and Economics

The three *Prosopis* accessions with greatest potential for woody biomass production in semi-arid southwestern US are *P. alba*, *P. chilensis*, and *P. articulata*. *P. alba* (#0166) had highest biomass production of the three selections, had good coppicing characteristics, and low psyllid insect damage. It has been successfully rooted from cuttings. Thorn free selections have been observed. One tree survives where a 5 mm salt layer covers the ground and a mature tree survived a -9°C (16°F) frost. It may prove more frost hardy than either *P. articulata* (#0016) or *P. chilensis* (#0009). Felker et al (1981) feel that progeny of *Prosopis* alba accessions used for ornamentals are most promising for woody biomass production in arid lands despite impressive biomass production by *Leucaena* and *Parkinsonia*. They report yields of 50 MT DM/ha in 3 years or nearly 17 MT/ha/yr, a yield sufficiently high to make effective use of harvesting and transportation equipment. Felker et al. (1981) give detailed economic projections in their table, *Projected Costs for Mesquite Pod Production.* Perhaps even more important, they talk about total use of the pods, fractionating for mesquite pod gum, protein, and sugar to realize their full economic potential. Galactomannan gums, estimated to constitute 25% of the seeds of some *Prosopis* species have many cosmetic, chemurgic, and food uses. The gum is fairly similar to carob gum, which commanded $0.62–1.11/kg in 1970. Way back in the 40's, the mildly intoxicant beverage, aloja, was made from fruits sold in the market for 30 Argentine centavos/kg. The fermented aloja was further distilled into aguardiente or ethanol. To produce a liter of absolute alcohol requires 1.7 kg fermentable sugar, which constitute about 3/4 of the fruit's weight (Burkart, 1943).

Energy

Burkart (1943) suggests that a ton of fruit could yield 27.2 liters of absolute alcohol. Felker et al (1981) state that the land area required for a small commercial ethanol production plant (1,000 barrels/day) could be contained in a circle with radius of 10.9 km assuming conversion rate of 2.6 gallons ethanol per 55 pounds pods (much higher than Burkart's assumptions) and yields of 4,000 lb/acre. Ca 12% of the land would provide firewood for distillation. Ten year old Argentinean plantations spaced at 2 x 2 m produced 7 m /ha/yr (NAS, 1980a). Felker et al (1981) report yields from 9.8–19.2 MT/ha/yr in the Imperial Valley.

Biotic Factors

Bruchids associated with this species include *Rhipibruchus*, *Pectinibruchus*, and *Scutobruchus*. Spraying cuttings with dithane suspensions has markedly reduced problems with the fungus Alternaria (Felker et al., 1981). Felker et al. (1981) review the pest infestations of their *Prosopis* plantings with suggestions for their control.

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- N.A.S. 1980a. Firewood crops. Shrub and tree species for energy production. National Academy of Sciences, Washington, DC.
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Complete list of references for Duke, Handbook of Energy Crops

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Last update Jaunary 8, 1998 by aw

Alkali sacaton

Gramineae, Poaceae *Sporobolus airoides* (Torr.) Torr.

Sacaton

***S. wrightii* Munro ex. Scribn.**

Source: Magness et al. 1971

Alkali sacaton is a native bunchgrass found from South Dakota west to Washington and south into Mexico. It is densely-tufted and long-lived, with erect, solid stems about 3 feet tall. Basal foliage is abundant, the leaves being up to 18 inches long and 0.25 inch wide. Roots are fibrous and deep-penetrating. The grass will grow on moist, alkaline soils, hence the name, but also occurs on other soil types. It is palatable while succulent but becomes tough and unpalatable when ripe. Hay is of fair quality if cut early. Propagation is by seed, which is usually harvested from native stands.

Sacaton is a more robust grower than alkali sacaton and is more southern in its range, being native from West Texas to Arizona and south into Mexico. The stems reach to 6 feet and are firm and bard. It is less drought resistant than alkali sacaton. It furnishes useful grazing both while succulent and in winter, and is useful for hay if cut while young. It is rarely planted but is a useful grass in its native range.

Last update July 1, 1996 bha

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Allium ameloprasum L.

Leeks and Great-headed Garlic
Amaryllidaceae

We have information from several sources:

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Onions and its Relatives—production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Elephant garlic
Leek

Outside Links

Allium spp.—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 18—Link to the publication on the International Plant Genetic Resources Institute web site

Allium cepa L.

Amaryllidaceae

Bermuda onion, California Italian Red onion, Common onion, Green onion, Italian red onion, Maui onion, Onion, Pearl onion, Purple onion, Red onion, Salad onion, Scallion, Spanish onion, Spring onion, Sweet onion, Vidalia onion, Walla Walla onion, White onion, Wild onion, Yellow onion

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Midwest Vegetable Production Guide for Commercial Growers 1998

Onions and its Relatives production links

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Advances in New Alliums—Michael J. Havey

Onions and Their Relatives—HO-67 Purdue University Cooperative Extension Service

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Onion—*Allium cepa* L. (Common onion group)
Onion [cv. Beltsville Bunching]—*Allium cepa* L. x *Allium fistulosum* L., 4N
Potato Onion—*Allium cepa* L. (Aggregatum group)
Shallot—*Allium cepa* L. (Aggregatum group)

Outside Links

Allium spp.—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 18—Link to the publication on the International Plant Genetic Resources Institute web site

Rakkyo

Ch'iao t'ou

Amaryllidaceae *Allium chinense* G. Don

Source: Magness et al. 1971

Rakkyo is an onion relative. It is an important vegetable in the Orient and in this country is grown and used mainly by Orientals. The plants do not produce seeds and are propagated by bulb division. In mild climates, bulbs are planted in late summer, and the crop is harvested in midsummer of the following year. Several small bulbs are obtained from each bulb planted. Rakkyo bulbs are mainly pickled, some are canned. Also, they are used as a cooked vegetable. The leaves have hollow blades. Culture and exposure of plant parts is similar to that of bulb-set onions.

Season, planting to harvest: About 10 months.

Production in U.S.: No data. Grown to limited extent by Oriental gardeners.

Use: Mainly pickles, some canned and some used as fresh cooked vegetable.

Part of plant consumed: Bulbs.

Onion, Welsh

Japanese bunching, Negi, Cibal, Spring onion, Nebuka, Cebollin

Amaryllidaceae *Allium fistulosum* L.

Source: Magness et al. 1971 This is the principal onion of Japan and China, but of limited importance in the U.S. Leaves are rigid and tubular and inflated or swollen in appearance. The bulbs become only slightly enlarged. Plants multiply by tillers from a mother plant, so clusters of plants result from planting a single one. They may also be grown from seed. In the Orient the leaves and leaf bases are often blanched by covering with soil. There, and in the U.S., they are also marketed as green onions. The thick, swollen leaves and leaf bases are harvested.

Season, seed to first harvest: 4 to 5 months for green onions, a year or more for blanched.

Production in U.S.: No separate data. Total green onions 12,071 acres, 1959 census.

Use: As pot herbs, flavoring in culinary cookery, salads.

Part of plant consumed: Thick leaves and leaf bases.

Last update June 27, 1996 bha

Allium tuberosum Rottler ex Sprengel

A. odorum

Amaryllidaceae

Chinese chives, Chinese garlic, Chinese leeks, Flowering chives, Garlic chives, Oriental garlic, Yellow chives

We have information from several sources:

Asian Vegetables: Selected Fruit and Leafy Types—Marita Cantwell, Xunli Nie, Ru Jing Zong, and Mas Yamaguchi

Greenhouse Production of Garlic Chives and Cilantro—Robert G. Anderson and Wenwei Jia

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Onions and its Relatives—production links

Outside Links

Allium spp.—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 18—Link to the publication on the International Plant Genetic Resources Institute web site

Allium sativum L.

Amaryllidaceae

Garlic, American field garlic, American wild garlic, British field garlic, British wild garlic, Elephant garlic, Field garlic, *Rocambole*, Sand leek, Wild garlic

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Advances in New Alliums—Michael J. Havey

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Onions and its Relatives—production links

Outside Links

Allium spp.—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 18—Link to the publication on the International Plant Genetic Resources Institute web site

Allium schoenoprasum L.

Amaryllidaceae

Chives, Chinese garlic, Chinese onion, Oriental garlic

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Onions and its Relatives—production links

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Allium spp.—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 18—Link to the publication on the International Plant Genetic Resources Institute web site

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Allium tricoccum Ait.

syn: *Allium tricoccum* var. burdickii

Amaryllidaceae

Ramps, wild leek

We have information from several sources:

Cultivating Ramps: Wild Leeks of Appalachia—Jeanine M. Davis and Jacqulyn Greenfield

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Allspice

Pimento, Jamaica pepper, Pimienta

Myrtaceae *Pimenta dioica* (L.) Merr.

Source: Magness et al. 1971

Allspice is the dried, unripe berries of a large evergreen tree, native to the Caribbean area. The leaves are large and leathery, about 8 inches long by 2 inches wide. The fruits are about 0.33 inch diameter, near globose, produced in clusters of a dozen or more at or near the terminals of branches. The fruit is harvested while immature, as it is then most strongly flavored. It is a drupe, with 1 or 2 seeds. The whole dried fruit is ground to produce the allspice powder of commerce. Both pulp and seeds are aromatic, and contain an oil with qualities similar to clove oil.

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Prunus dulcis (Mill.) D.A. Webb

Rosaceae

Almond

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Almond
Almond oil

Outside links:

Almond—from Mark Reiger, Dept of Horticulture, University of Georgia.

Almond Information from the University of California Fruit & Nut Research and Information Center

Sorghum spp.

Poaceae, Gramineae

Broomcorn, grain sorghum, great millet, Guinea corn, Johnson grass, Kaffir corn, Mississippi chicken corn, shattercane, sorgo, Sudan grass, sweet sorghum

We have information from several sources:

Sweet Sorghum for a Piedmont Ethanol Industry—Glen C. Rains, John S. Cundiff, and Gregory E. Welbaum

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Annual Forages: New Approaches for C-4 Forages—Jeffrey F. Pedersen

New Crops for Canadian Agriculture—Ernest Small

Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products
Broomcorn
Sorghum—Grain (Milo)
Sorghum—Syrup
Sorghum—Forage

Handbook of Energy Crops. James A. Duke. 1983. unpublished.
Sorghum sudanense
Sorghum halepense
Sorghum Xalmum
Sorghum bicolor

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Sorghum spp.
Sorgo
Sorgrass
Chicken corn

- Sudangrass
- Johnsongrass
- *Sorghum almum*
- Grain sorghum
- Forage sorghum

Outside links: Sorghum from Lost Crops of Africa: Volume I: Grains

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Alnus glutinosa (L.) Gaertn.

Betulaceae
European alder, Black alder

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The wood, elastic and soft, fairly light and easily worked, is used for cigarboxes, pumps, and wooden carvings, shoes and slippers. The bark, used for tanning, imparts a hard red appearance to leather. The wood is also used in making the molds for glass manufacture. The tree provides habitat and food for wildlife, watershed protection, and is used in environmental forestry (Ag. Handbook 450). With little ornamental value, it is recommended only for wet sites.

Folk Medicine

According to Hartwell (1967–1971), the leaves are decocted in folk remedies for cancer of the breast, duodenum, esophagus, face, pylorus, pancreas, rectum, throat, tongue, and uterus. The bark and/or roots are used for cancers and inflammatory tumors of the throat. Reported to be alterative, astringent, detersive, diuretic, sudorific, tonic, and vermifuge, black alder is a folk remedy for cancer, fever, foot ailments, tumors, and worms (Duke and Wain, 1981). The bark decoction is taken as a gargle for angina and pharyngitis, as an enema in hematachezia.

Chemistry

The bark contains up to 20% tannin, a flavone glycoside of the hyperoside type, a reddish dye, emodin (?), alnulin ($C_{30}H_{50}O$), protoalnulin ($C_{30}H_{48}O$) phlobaphene, taraxerol, taraxerone, lupeol, β-sitosterol, glutinone ($C_{30}H_{48}O$), and citrullin. The leaves contain alnusfoliendiolone, 3-β-hydroxyglutin-5-en, Δ-amyrenone, taraxerol, β-sitosterol, wax, and sugars (List and Horhammer, 1969–1979). Gibbs (1974) reports l-ornithine in the roots of this species, l-serine in the genus.

Description

Shrub or small tree to 20 m, the bark initially gray-brown, smooth, lustrous, later dark gray and rougher. Leaves rotund or broadly ovate to ellipsoid or ovate, 4–9 cm long, 3–7 cm wide, basally rounded the petiole 1–2 cm long; stipules obtuse, soon deciduous. Male cones purplish brown in autumn and winter, brown in the spring, 6–12 cm long, in clusters of 3–5. Fruits rounded, the seeds winged. Seeds ca 700,000–750,000/kg, but yielding only ca 20–25,000 plantable seedlings.

Germplasm

Reported from the Eurosiberian Center of Diversity, black alder, or cvs thereof, is reported to tolerate frost, poor soil, and waterlogging. Hortus III lists var. *barbata, denticulata*, and *glutinosa*, as well as several cvs 'Aurea', 'Imperialis', 'Incisa', 'Oxycanthifolial, 'Pyramidatis', 'Quercifolia', 'Rubrinervia', and 'Sorbifolia'. Wyman (1974) mentions 'Laciniata'. *Alnus glutinosa* serves as a rootstock for grafting of other alder species.

Distribution

Throughout the Caucasus, Europe, Siberia, into Asia Minor, Iran, and North Africa. Naturalized locally in eastern Canada and Northeastern U.S.

Ecology

Estimated to range from Warm Temperate Dry to Moist through Cool Temperate Steppe to Wet Forest Life Zones, black alder is estimated to tolerate annual precipitation of 4 to 20 dm, annual temperature of 8 to 14°C, and pH of 6 to 8. Ranging north to Wyman's Zone 3.

Cultivation

Seeds which have remained viable after floating for 12 months, are sown at depths of 3–6 mm, in spring or fall. For blanket bogs in England, spot sowings have been recommended ca 15 seeds per spot fertilized with ca 60 g phosphate. Seeds germinate as well under continuous darkness as with normal day lengths. Air-dried seeds stored at 1–2°C retained their viability for two years. Seeds can however be sown immediately as soon as ripe.

Harvesting

Timber and/or firewood harvested as needed, the shrub apparently coppices readily. In the U.S., it flowers from March to May, the fruits ripening in fall, natural dispersal occurring from late fall to early spring.

Yields and Economics

A 13–18-year-old stand with ca 30,000 trees ha (ca 20% *Alnus glutinosa*, the dominant, with Carpinus and Crataegus et al) in an infertile gley at elevation 265 m had a basal area of 24–40 m^2/ha. The standing biomass was about 59.3 MT/ha wood, bark, and branches, 2.8 MT leaves, and 4.3 MT estimated roots. Leaf litterfall was ca 2.5 MT/ha/yr. A British stand dominated by *A. glutinosa* (ca 1600 trees/ha, 55% *Alnus*, 44% *Betula pendula* and *Acer pseudoplatanus*) had a basal area of ca 25 m^2/ha, a leaf area index of 3.6, and a standing biomass of 109 MT/ha.

Energy

According to the phytomass files, annual productivity is estimated at 6 to 9 MT/ha. The tree has yielded 11.8 MT/ha/yr on pulverized fuel ash (Dennington, et al, 1983). Kestemont (1975) estimated annual productivity at 8.66 MT/ha, with 5.87 MT in wood, bark, and branches, 2.79 MT in foliage. According to Cannell, (1982), Hughes (1971) estimated the aerial productivity at ca 6.7 MT/ha/yr with wood, bark, and branches accounting for 4.26 MT + 0.34 MT litter, 1.78 MT leaf and leaf litter, 0.34 MT fruit and fruit litter. NAS (1980a) recommends the black alder for consideration for firewood plantations in Tropical highlands where unseasonal cold might destroy the red alder. Nitrogen-fixation by trees up to 8 years old has been put at 125 kg/ha/yr, for 20 years at 56–130 kg/ha/yr (NAS, 1979). Related red alder has been estimated to fix as much as 300 kg/ha.

Biotic Factors

Agriculture Handbook 165 lists the following diseases for *Alnus glutinosa*: *Phymatotrichum omnivorum* (root rot), *Polyporus versicolor* (sapwood rot), *Septoria alni* (leaf spot), and *Sphaeropsis alnicola* (on twigs). Like other alders, the cv 'Laciniata' is susceptible to a canker which can kill large parts of the plant quickly (Wyman, 1974). Nematodes include *Longidorus maximus,* and *Pratylenchus penetrans* (Golden, pers. commun. 1984).

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Last update December 19, 1997

Alnus maritima Nutt.

Betulaceae
Seaside Alder

"The alder, whose fat shadow nourisheth
Each plant set neere to him long flourisheth."

William Browne, ca 1613.

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Since in its narrower sense; this species has a very limited distribution (including one transplant in my back yard), there is little economic botany data on this species. Van Steenis has elected to include *Alnus japonica* as a synonym of *Alnus maritime*. He notes that it has been planted for reafforestation purposes on eroded slopes in the Philippines. Amerindians had a wide array of uses for alder, for dyestuffs, insect repellant or insecticide, but mostly for folk medicine. Fernald, Kinsey, and Rollins (1958) relate that "the inner bark is a possible emergency food. The young bark and winter buds are popular nibbles with country boys, not alone for their tolerable flavor, but particularly for the beautiful, olive-brown saliva produced." Bees use the pollen to rear their spring broods. None of these uses were specific to *Alnus maritime*.

Folk Medicine

According to Hartwell (1967–1970), the alders are used in folk remedies for cancers, indurations and/or tumors, especially of the breast, epithelium, duodenum, esophagus, face, lip, pancreas, pylorus, rectum, throat, tongue, and uterus. Reported to be astringent and depurative, closely related *Alnus serrulata* is a folk remedy for bruises, burns, diarrhea, eye, hematuria, malaria, poison ivy, scalds, sores, syphilis, and wounds (Duke and Wain, 1981). Erichsen-Brown (1979) lists many other uses of the alder; e.g. the Potawatomi Indians made a bark tea for flushing the vagina or to shrink hemorrhoids via rectal syringe. None of these are specific to *Alnus maritima*, just generic.

Chemistry

Alnus serrulata is said to contain a sedoheptulose.

Description

Shrub or small tree to 10 m tall; bark light brown to reddish-brown, occasionally mottled with gray, with small orange-colored lenticels on younger branches. Twigs reddish-brown and glabrous in winter; buds ovoid, acute, about 6 mm long, with some pale pubescence. Leaves oblong, ovate, or obovate, 7.5–10 cm long, 3.7–5 cm wide, dark green above, glandular dotted below; margins remotely serrulate; tips acuminate or rounded; bases cuneate; petioles 12–18 mm long. Staminate aments green at first, becoming dark orange-brown, 3.75–6.5 cm long, pistillate catkins peduncled, 3 mm long at first, green tinged with red toward tip, enlarging the following spring, becoming broad-ovoid cones, 1.5–3 cm long; nutlets ovate to obovate, 3–4 mm long; wings narrow (Brown and Brown, 1972).

Germplasm

Reported from the American Center of Diversity, seaside alder, or cvs thereof, is reported to tolerate frost, poor soil, and some salinity and waterlogging. *Alnus maritima* "seems to be more affected by water stress and must be closer to a reliable source of water than *Alnus serrulata* to survive" (Stibolt, 1978). $2n = 28$.

Distribution

In the narrow sense, *Alnus maritima* occurs on the Delmarva Peninsula (four counties in Maryland, one in Delaware), two counties near the Red River in Oklahoma. "Because of its restricted range and susceptibility of the habitat to alteration by man's activities, *Alnus maritima* should be considered as threatened" as proposed in the Report on Endangered and Threatened Plant Species of the United States." (Stibolt, 1978). The peculiar disjunction DelmarvaOklahoma has been postulated by Reed (pers. commun.) to reflect Indian transplant, perhaps of a medicinal species. Perhaps they did not distinguish the species from other alders that they used.

Ecology

Probably ranging from Warm Temperate Dry through Moist Forest Life Zones, seaside alder is reported to tolerate annual precipitation of 9.5 to 40 dm, annual temperature of 13. 5 to 18°C, and pH of 6. 1 to 8. 1. Although the Oklahoma site has the higher annual temperature, it is subject to about the same number of freezes and thaws as the Delmarva sites. Generally restricted to damp or wet soils in sunny areas, most often at the edges of ponds, rivers, or streams. Perhaps due to their N-fixing ability, they can survive on N-poor soils. Mg levels ranged from 75–150 ppm, P_2O_5 from 5–14, K_2O from 38 to 51, NO_3 from 9–23, Ca from 561–1500, and soluble salts from 89–132 ppm. Aspiras (1981) states that it flourishes only in cooler parts of the Philippines, e.g. around Baguio at ca 1500–1800 m, annual precipitation ca 40 dm (164 in.) and annual temperature ca 18.5°C (64.8°F).

Cultivation

No data uncovered.

Harvesting

Can be harvested for fuel as needed.

Yields and Economics

Since this is proposed as a threatened or endangered species, there is little data on its productivity. Perhaps it or its hybrids with other alder species could equal the annual productivity of other alders now being considered for biomass or pulp production.

Energy

According to the phytomass files (Duke, 1981b), annual productivity of other *Alnus* spp. ranges from 5 to 26 MT/ha. Citing literature yields of 58–229 kg N/ha, Aspiras noted that *Casuarina equisetifolia* fixes 1,742 nmoles C2H4/24 hrs/g dry weight, compared to 4,479 for *Casuarina rumphinia*, 4,545 for *Casuarina montana*, 2,267 for *Elaeagnus philippensis*, 225 for *Alnus maritima*, 626 for *Alnus nepalensis*, 7,242 for *Coriaria intermedia*, and only 13 for *Myrica javanica*. According to Stibolt, when the nitrate concentration in the soil reaches a certain level, root nodulation is reduced and no net increase occurs (Stibolt, 1978). "The degree of nitrogen fixation in alder nodules usually exceeds that in legume nodules on a per weight basis." (Stibolt, 1978). Comparing *Alnus serrulata*, Stibolt found its nodules had higher nitrogenase activity, while

Alnus maritima nodules had higher fixation rates some of the time. Twenty-four hours after collection, *Aluns serrulata* activitiy was reduced while that of *Alnus maritima* was retained longer or even increased. In spite of this Stibolt concluded that, overall "*A. serrulata* has some advantage in the ability to fix nitrogen.

Biotic Factors

No data uncovered.

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Alnus nepalensis D. Don

Betulaceae
Indian Alder, Nepalese Alder

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Nitrogen-fixing firewood species, the wood of fair quality for use in unexposed situations. It is used to a limited extent in carpentry and house construction and for tea boxes. The timber is rather durable, easily sawed, and seasons well (sp. grav. 0.32–0.37). Locally cultivated by West Java Forest Service to reforest eroded slopes under everwet climate. A fast growing species, suitable for plantation cultivation in tropical uplands (Ramoran and Panot, 1981). The tanniniferous bark is used to deepen the color of *Rubia cordifolia*.

Folk Medicine

The species is cited in the Dictionary of Traditional Chinese Medicine (from which I borrowed the Illustration) as a useful diuretic to reduce swelling of the leg.

Chemistry

Bark reported to contain 7% tannin.

Description

Large tree 8–15 (to 30) m tall, to 1 m DBH with thick silver gray bark. Twigs glabrescent, ribbed, hardly triangular. Leaves alternate, ovate to oblong, acute or short-acuminate, rounded or cuneate at the base, 7–21 x 4–10 cm; nerves 12–16 pairs, puberulous beneath (glabrescent); vein-axils bearded; midrib and nerves sulcate and glabrous above; petiole strong, 1.5–2 cm long. Male catkins to 10 cm by 3–5 mm, in a terminal panicle to 16 cm. Female inflorescences short, axillary, bearing 3–8 oblong, catkins 10–17 by 6–7 mm. peduncles 3–6 mm long. Nuts obtrapezoid, emarginate, incl. the wing 2 mm through, crowned by the style base (van Steenis, 1955–1958).

Germplasm

Reported from the Indonesia-Indochina and Hindustani Center of Diversity, nepalese alder, or cvs' thereof, is reported to tolerate clay, flooding, fog, gravel, sand, shade, slope, waterlogging, and weeds. It is not tolerant of high winds. ($2n = 28$)

Distribution

Native to southeast Asia (Burmese hills, Himalayas, Subtropical China, Indochina). Introduced to Java, India, Hawaii, and the Philippines. I saw a large tree near Kunming in Yunnan China.

Ecology

In its native habitat it ranges from 300–3,000 m, in Hawaii from 300–1,800 m, growing well in areas with more than 500 mm annual precipitation. Van Steenis (1955–1958) suggests it as an afforestation species on eroded slopes under everwet climatic conditions, growing well between 700–1,800 m. Grows best in deep well-drained loams or loamy soils of alluvial soils, but ranges from gravel to sand to clay. I believe it ranges from Subtropical Dry to Wet Forest Life Zones, with annual rainfall estimated at 5–25 dm, annual temperature 19–23°C, and pH 6–8.

Cultivation

Seeds may be sown in nurserys for transplants or direct seeded. In Burma, seed are broadcast during last years of shifting cultivation. It is a fast grower, even capable of outgrowing sugar ratoon crops. Trees coppice well, but regrowth seems to be season dependent. In Hawaii, in aseasonal situations, the trees coppice year round.

Harvesting

In Himachal Pradesh, India, the trees are lopped every other year for fuel (NAS, 1980a).

Yields and Economics

Diameters may increase at the rate of ca 2 cm/yr. In Hawaii, 26 year old trees were 50 cm in diameter.

Energy

According to the phytomass files (Duke, 1981b), annual productivity of other *Alnus* species ranges from 5 to 26 MT/ha. Although used for nitrogen fixation, slope stabilization (both of which help the energy budget of a country), the alder is also used for firewood and might be considered for the generation of electricity. Heat content of *Alnus rubra* is about 4,600 kcal/kg atid it, a temperate species, may yield 10–21 m^3/ha/yr. The wood dries rapidly and burns evenly (Little, 1983).

Biotic Factors

Leaves are sometimes stripped from the tree by coleopterous larvae. Trunk occasionally attacked by borers.

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Last update December 22, 1997

Hazel Alder

Alnus rugosa (DuRoi) Spreng.

Synonym.—*Alnus serrulata* Willd.

Figure 60.—Hazel alder (*Alnus rugosa*)

Other common names.—Tag alder, common alder, red alder, smooth alder, green alder, American alder, speckled alder, swamp-alder, notch-leaved alder.

Habitat and range.—Hazel alder is found in swamps and along the marshy banks of streams from New England south to Florida and Texas and westward to Ohio and Minnesota.

Description.—The hazel alder, although it sometimes attains the height of a tree, is more frequently a shrub from 5 to 20 feet high with smooth, brownish-gray bark. It has somewhat leathery, oval leaves from 2 to 4 1/2 inches long. The flowers, which appear early in the spring before the leaves develop, are reddish green. The male flowers are borne in drooping and the female in erect catkins. The conelike fruit usually remains on the shrub throughout the winter. The bark has a strong, rather aromatic odor and a bitter astringent taste.

Part used.—The bark.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Yautia

Yautia blanca, Yautia amarilla, Coco, Tarrier, Tanier, Eddo, Taya, Tannia,Cuban dasheen, Malanga

Araceae *Xanthosoma* spp.

Source: Magness et al. 1971

This is a tropical plant related to Taro, which see, extensivelycultivated in the West Indies and other tropical countries for the edible cormand cormels. On certain varieties the young leaves and main stems (madre) arealso used as pot herbs. The leaves are large, 1 to 2 feet long, broad-arrow inshape, borne on long petioles radiating from the "mother" or large corm. Thetop of the corm may be at or above ground level. In general exposure of thecorm, the Yautia is similar to turnip. Propagation is by planting small cormelsor the cut off top of the "mother" corm with some of the petioles stillremaining. Yautia blanca corm is white-fleshed and Yautia amarilla isyellow-fleshed. Growing Yautias do not require as much soil moisture as doesDasheen, which see. Yautias are sometimes referred to as *Alocasia* spp.

Last update Friday, June 12, 1998 by aw

Aloe spp.

Aloe barbadensis Mill.

Aloe vera (L.) Webb & Berth.

Liliaceae

NewCROP has the following information:

Aloe vera Response to Plastic Mulch and Nitrogen—Luis Rodolfo Hernãndez-Cruz, Raúl Rodríguez-García, Diana Jasso de Rodríguez, and José Luis Angulo-Sánchez

Ghrita kumari or Guar patha—Pankaj Oudhia

Creeping foxtail

Gramineae *Alopecurus arundinaceus* Poir.

Source: Magness et al. 1971

This is a cool-season, sod-forming grass from Eurasia. It resembles meadow foxtail but has more vigorous rhizomes and broader leaves. It is used to a limited extent for hay, pasture and erosion control on moist sites in the Northern Great Plains, Intermountain Area, and Pacific Northwest. Forage is palatable and nutritious.

Last update February 18, 1999 by ch

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Alopecurus praetensis L.

Poaceae

Meadow foxtail

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update July 3, 1996 by aw

LEMON VERBENA

Family: Verbenaceae, *Aloysia triphylla* (L'Her.) Britt.

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Lemon verbena, *Aloysia triphylla* (L'Her.) Britt., is an aromatic shrub native to Argentina and Chile. Also known as herb Louisa and formerly classified as *Aloysia citriodora* (Cav.) Ort., *Lippia citriodora* (Ort.) HBK, *Verbena citriodora* Cav., and *Verbena triphylla* L'Her., the deciduous plant is commonly cultivated in the tropics and Europe. It is produced commercially in France and North Reaching heights of 1 to 3 meters, the plants are characterized by fragrant, lemon-smelling, narrow leaves and small white flowers borne in terminal panicles.

Lemon verbena prefers full sun and a light loam soil. The plant is sensitive to cold and has high water requirements. Either seeds or vegetative cuttings are used for generating new plants. Commercial areas are generally harvested in early summer at full bloom and in the autumn just prior to cold, killing temperatures. Essential oil is extracted by steam distillation as soon as possible to minimize volatilization, because yields of the oil are very low (14.1-11).

The essential oil, known as oil of verbena, contains -citral, -citral, methyl heptenone, carvone, l-limonene, dipentene, linalool, -terpineol, borneol, nerol, geraniol, and other constituents (14.1-11). Because of the its high price, oil of verbena is often adulterated with distillates from other plant material. Extraction of verbena with petroleum ether and alcohol gives the concrete and absolute of verbena (14.1-11).

The leaves and flowering tops of lemon verbena are used in teas and to flavor alcoholic beverages. The plant is also an ingredient in some desserts, fruit salads, and jams. It is used in perfumery, especially in making toilet water and eau de cologne. The plant is often grown as an ornamental, but it needs to be kept indoors during winter months in northern regions.

As a medicinal plant, the leaves and flowers of lemon verbena have been used as an antispasmodic, antipyretic, sedative, and stomachic.

Lemon verbena is generally recognized as safe for human consumption in alcoholic beverages (21 CFR section 172.510 [1982]).

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Finn, C. 1999. Temperate berry crops. p. 324–334. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Temperate Berry Crops

Chad Finn

Wherever humans have lived, they have made berries a part of their diet. Most of these have never been developed beyond local markets but some have become economically important crops. In this paper, the berry crops have been divided into four groups based on their current international popularity and potential future value. An overview of the status of development, current production, and future potential for these crops is presented with an American perspective. The discussion is limited to temperate "berry" crops that are produced on a shrub, a perennial herbaceous plant, or a vine, which excludes many of the cherry/plum (*Prunus* sp., Rosaceae) relatives; jujube (*Ziziphus jujuba* Mill., Rhamnaceae); *Cornus* sp. Cornaceae; *Sorbus* sp., Rosaceae; and many other tree fruit.

MAJOR BERRY CROPS

The most economically important and best described berry crops worldwide include strawberry (*Fragaria ×ananassa* Duch., Rosaceae) (Galletta and Bringhurst 1990; Hancock et al. 1996); blueberry (*Vaccinium corymbosum* L., *V. angustifolium* Ait., *V. ashei* Reade, Ericaceae) (Eck et al. 1990; Pritts et al. 1992; Galletta and Ballington 1996); cranberry (*V. macrocarpon* Ait., Ericaceae) (Dana 1990; Eck 1990; Roper and Vorsa 1997); black currant (*Ribes nigrum* L., Grossulariaceae) (Harmat et al. 1990; Brennan 1996); table and wine grapes (*Vitis* spp., Vitaceae) (Ahmedullah and Himelrick 1990); raspberry (*Rubus idaeus* L., Rosaceae) (Jennings 1988; Crandall and Daubeny 1990; Pritts and Handley 1989; Daubeny 1996); and blackberry (*Rubus* sp., Rosaceae) (Pritts and Handley 1989; Hall 1990; Moore and Skirvin 1990; Crandall 1995). These need no further discussion as information is widely available on each.

Other major berry crops have large production areas worldwide but for a variety of reasons have not reached the stature and importance of the above. These include the hybrid berries such as 'Logan' and 'Boysen' (*Rubus* sp., Rosaceae); black raspberry (*R. occidentalis* L., Rosaceae); lingonberry (*Vaccinium vitis-idaea* L., Ericacea); gooseberry (*Ribes uva-crispa* L. Grossulariaceae); and red currant (*Ribes rubrum* L., Grossulariaceae). These will be discussed in turn below.

Hybridberries

'Logan' is a result of cross between red raspberry (*R. idaeus* L.) and a blackberry (*R. ursinus* Cham. & Schldl., Rosaceae derivative) (Logan 1909; Brown 1916; Logan 1955; Jennings 1980). 'Logan' fruit are similar in color and appearance to red raspberry but the torus remains with the fruit like a blackberry and they have a distinctive flavor. The fruit are excellent for processing and are dried, juiced, and canned. In the late 1800s to mid 1900s, 'Logan' was planted on thousands of hectares and accounted for millions of dollars in sales. Today approximately 40 ha remain in commercial production in Oregon. Many factors have led to 'Logan's' decline in popularity including: the difficulty of picking the fruit especially with a mechanical harvester, relatively low yields, and a decline in popularity in a younger generation of consumers.

'Boysen' was discovered on Rudolph Boysen's farm in California. This red raspberry (or 'Logan') × blackberry hybrid was the basis for the initial development of the Knott's Berry Farm fruit and entertainment empire. 'Boysen' has the growth habit of trailing blackberry and the fruit are similar in appearance, larger on average, with larger drupelets, and a purple fruit color. 'Boysen' was widely produced in California, Oregon, and New Zealand into the 1980s. Currently, a few thousand hectares of 'Boysen' are grown in Oregon and New Zealand but California production has largely disappeared. The market for 'Boysen' remains strong.

'Logan' and 'Boysen' can be grown wherever trailing blackberries such as 'Marion' can be grown. Information is available on cultural practices at the Northwest Berry and Grape Infonet (http://osu.orst.edu/dept/infonet/).

Lingonberry

Stang et al. (1990) specifically addressed lingonberries (*Vaccinium vitis-idaea* L., Ericaceae) at the First New Crops Symposium in 1988. Lingonberry continues to be largely a European crop. However, the Pacific Northwest has seen a substantial increase in plantings the last 3 years. Lingonberry is harvested from native stands in northeast China and in some localities a substantial quantity of juice is produced. Lingonberry is found natively on acidic soils in northern temperate zones and can range to near the Arctic Circle, but in many of these northern areas they are protected by snow cover. In addition to Stang et al. (1990), St.-Pierre (1996) has published production information. Since lingonberry is largely a processed crop, either better cultivars or better machines must be developed that will make mechanical harvest viable.

Black Raspberry

Black raspberry (*Rubus occidentalis* L., Rosaceae) production is concentrated in Oregon where 400–600 ha are harvested for processing into juice and jam. Ohio growers are planning on doubling their crop area to 250 ha in the next few years (J. Scheerens, pers. commun.). The juice is valuable as a natural colorant. In other regions, particularly regions of Ohio and Pennsylvania, black raspberry is harvested fresh as a pick-your-own crop. 'Munger' is the most important cultivar worldwide. Black raspberries are relatively easy to grow, however, they are short-lived. Plantings often last only 2–3 harvest seasons due to virus and disease infestation. Poor pollination from rain during bloom can limit the crop. The plants are trellised in the eastern US for fresh harvest but in the western US the plants are "hedged" at about 1 m for mechanical harvesting and processing. The biggest challenge with large-scale production is the fluctuation in fruit price. In 1997, the fruit sold for $US 4.18/kg whereas the price in 1995 had only been $US 1.32/kg (USDA-NASS-ERS 1998). Black raspberries can be established relatively quickly and cheaply so growers are constantly getting into and out of production in response to the fruit price.

Gooseberry and Red Currant

These two members of the *Ribes* have a long history of cultivation. They are widely adapted to temperate regions and many soil types. While they are popular in Europe as a fresh market and processed product, they have had limited success in the US, in part due to white pine blister rust (*Cronartium ribicola* Fisher) restrictions. Both are grown throughout the eastern US primarily as a fresh market crop for local sales. In the Pacific Northwest, they are grown and shipped nationally on the fresh market and Washington has about 40 ha in production. Both of these crops are primarily processed into pies or preserves in the case of gooseberries, and juice or jelly in the case of red currants. Since 1966, when federal legislation was deregulated, 17 states in the US continue to restrict the production of some or all of the *Ribes* species because they are a cohost for white pine blister rust. Some of these states are considering repealing their restrictions so that *Ribes* can be grown. Some *Ribes* genotypes are resistant to this disease and some are immune (Hummer and Finn 1998b). Gooseberry production in the US is often limited by powdery mildew (*Sphaerotheca mors-uvae* [Schwein.] Berk. & Curt), which can regularly cause defoliation in plants. While the primary cultivars grown in the US have been 'Oregon Champion', 'Poorman', and 'Pixwell' due to their reliable production, other cultivars are suitable and are mildew resistant (Hummer and Finn 1998a). The main limitation to these crops appears to be consumer education and acceptance. A number of hybrids between gooseberry and black currant are larger fruited and milder flavored than black currant; 'Josta' is the best known example (Reich 1991). While not widely planted, there are some very small commercial plantings and market development seems to be the biggest drawback to further expansion.

NEGLECTED BERRIES

Neglected berries include those that are regionally important such as elderberry (*Sambucus canadensis* L., Caprifoliaceae); aronia (*Aronia melanocarpa* [Michx.] Elliott, Rosaceae); cloudberry (*R. chamaemorus* L., Rosaceae); arctic raspberry (*R. arcticus* L., *R. stellatus* Sm., and their hybrids, Rosaceae); mora (*R. glaucus* Benth., Rosaceae); alpine strawberry (*F. vesca* L., Rosaceae); muscadine grape (*Vitis rotundifolia* Mich., Vitaceae); Juneberry/saskatoon (*Amelanchier* sp., Rosaceae); hardy kiwi (*Actinidia arguta* [Siebold & Zucc.] Planch. ex Miq., Actinidiaceae); edible honeysuckle (*Lonicera caerulea* L., Caprifoliaceae); sea buckthorn (*Hippophae rhamnoides* L., Elaeagnaceae); and schisandra (*Schisandra chinensis* [Turcz.] Baill., Schisandraceae).

Elderberry

The juice and preserves of *Sambucus canadensis* L., native to eastern North America, and *S. nigra* L., native to Europe, have often been mainstays of rural pantries and Native Americans and early settlers used them as a dried and medicinal crop. Elderberry was seldom cultivated because it was so common in fence rows and along roadsides. While limited, information is available on commercial production (Way 1981; Stang 1990). Selections of superior plants from the wild have traditionally been used locally but high quality cultivars were developed from *S. canadensis* by breeding programs in New York, Pennsylvania, and Nova Scotia (Ritter and McKee 1964; Way 1964; Craig 1966; Darrow 1975). Pennsylvania and Oregon have a few fairly large plantings, Kansas has a small elderberry wine industry and the Austrians have substantial plantings. 'Haschberg', a wild selection of *S. nigra* from near Vienna, is the main European cultivar (R. Wrolstad pers. commun.). The fruit is in demand for processing in preserves, as a natural colorant, and for wine making. In Europe, a company has just released an anthocyanin/flavonoid enriched extract primarily from elderberry for colorant and nutraceutical use. While the crop would benefit from further breeding, it is generally adapted to most locations although viruses can be a problem in the northwestern US. Incorporating the desirable acylated anthocyanin pigments of *S. canadensis* into *S. nigra* and improving pigment stability in processed products (R. Wrolstad pers. commun.) are improvements desired by processors.

Baby Kiwi, Hardy Kiwi, Tara, Wild Fig, Wee-kee

Actinidia arguta (Siebold & Zucc.) Planch. ex Miq., a smooth-skinned, winter tolerant relative of the kiwifruit (*A. chinensis* Planch./ *A. deliciosa* [A. Chev.] C. F. Liang & A. R. Ferguson, Actinidiaceae), has many common names. Recently, it has been developed from a novelty into an economically important crop (Ferguson 1990; Strik and Cahn 1998). The fruit are small, about the size of a large table grape, and are packaged multiply in "clam shell" containers rather than as single fruit. Darrow, in 1937, presented this species as a potential crop but it was not until the 1990s that it has become a small scale commercial crop. As the New Zealanders brought the fuzzy Chinese gooseberry (renamed the kiwifruit) to world attention, homeowner enthusiasts spread the more winter tolerant *A. arguta* across North America. It might have remained in the realm of enthusiasts until Hurst's Berry (Sheridan, Oregon) decided it would fit well in a diverse fresh berry product line. Their interest and development of this crop demonstrate the impact a single company, with good marketing savvy, can have on a relatively obscure crop. While the consistent demand for this crop is undetermined, more than 35 ha of fruit have been planted in Oregon since 1994 and there are a few growers with substantial plantings in Pennsylvania. *Growing Kiwifruit* is an excellent guide to growing *A. arguta* commercially (Strik and Cahn 1998). The major drawbacks to this crop are the expense of establishing a planting and the length of time to the first crop. *Actinidia arguta* requires a substantial trellis system, irrigation, and takes three years until a small crop is produced. Once in production, the biggest problems are frosts that kill newly emerged shoots that would produce the flowers, and abrasion on the fruit surface due to wind. Irrigation and other forms of frost protection reduce this problem. The fruit is harvested and put into storage when it is mature but before it begins to soften. When it is ready to ship it is treated with ethylene to begin the final ripening process. In storage, the pedicels, which do not form an abscission zone with the fruit, dry out and harden which can be of concern to consumers. This problem has yet to be solved but mechanical or genetic solutions may be possible.

Alpine Strawberry

Fragaria vesca L. production seems to have reached its peak prior to the development of *F. ×ananassa* as the primary commercial strawberry. There seems to be a constant interest in producing these small but aromatic fruit (Reich 1991). Bakers like to use these small fruit in products such as muffins where an entire berry is desirable. Homeowners often write passionately about them. They are not likely to have a major commercial impact but could be grown and marketed successfully to niche markets if the labor costs of harvest and low yields can be justified. While the plants are relatively easy to grow and can be raised from seed, they are short-lived where virus pressure is high. In breeding programs, *F. vesca* is often used as in indicator plant for strawberry viruses.

Rubus

Cloudberry (*R. chamaemorus*) and arctic raspberry (*R. arcticus*, *R. stellatus* and their hybrids) in northern Europe and mora (*R. glaucus*) in Andean South America are regionally extremely important and valuable crops. As a group, their perishable nature lends them to processing as juice, preserves, and liqueurs. Rapp et al. (1993) addressed the potential of *R. chamaemorus* at the 1992 New Crops Symposium.

Arctic raspberries are native to the colder regions of the northern hemisphere and are renowned for the strong aromatic character of their fruit. Breeding programs in Finland and Sweden have developed cultivars from these species (Jennings 1988). The cultivars are largely self-sterile so more than a single cultivar must be planted. The cultivars are apparently widely and successfully grown in Scandinavia. Production at this point in time appears to be limited to Scandinavia.

Rubus glaucus is commonly sold in the Andean countries of South America. This crop is typically grown in small, up to 0.5 ha plantings for local sale. Large bottles (2 L) of mora carbonated soda were available in grocery stores suggesting larger scale commercial production is viable. A large fruit processor seriously considered commercial production of this crop in the US in the 1970s but pulled out just before the plantings were to be established. This crop may be similar to the 'Marion' blackberry, which is renowned for its flavor and aroma and excellent processing characteristics. However, as with 'Marion', *R. glaucus* fruit are too perishable for the fresh market. This crop appears to be a developed "land-race;" cultivars have not been developed but the species has commercial qualities. Plants require irrigation on their native volcanic soils and are often trellised (Gaitoni ~1970; Federación Nacional de Cafeteros de Columbia ~1984 [The exact date of these publications is unknown but they are available upon request]). Because the species is native to high elevation near the equator (little change in photoperiod and moderate temperatures year round), widely adapted types must be developed if this crop were to be more widely planted. Commercial production has been reported in Mexico and Central and South America (Gaitoni ~1970; Federación Nacional de Cafeteros de Columbia ~1984; Rincon 1987).

Aronia, Chokeberry

Aronia melanocarpa is native to the eastern US, however, this crop was popularized and is commonly planted in Eastern Europe and the former Soviet Union. Prior to World War II, aronia was primarily used as an ornamental. Seeds were later imported from Germany to the former Soviet Union where cultivars were developed for fruit production (Kask 1987). By 1971, 5400 ha were planted in the former Soviet Union, 4000 of which were in Siberia. The original species is diploid, however, most of the cultivars are tetraploid. The 4*x* cultivars are sometimes designated as *Aronia mitshurinii* Skvorsov et Majjtulina, Rosaceae. The fruit was designated as a "healing plant" in the former Soviet Union. Experimental plantings of cultivars have been established in Czechoslovakia, Scandinavia, and Germany. The fruit is valued for its juice which is very high in anthocyanins, blends well with other fruit juices and is reputed as a source of "phenols, leucoanthocyanins, catachines, flavonoles, and flavones" that are considered to be bioactive in humans. The plants have no special cultural or site requirements. In the Pacific Northwest, the extremely vigorous plants will bear a small crop one year after rooted cuttings are planted. The plants resemble *Amelanchier*, Rosaceae in many respects. Yields of up to 17 kg/bush with 10 kg/bush average are reported in Eastern Europe. The fruit is often hand harvested by cutting the fruit clusters, but they can be mechanically harvested. In Oregon, an unidentified spring rust on the fruit caused some yield loss but its effect appeared to be minimal. Currently, there is interest in establishing commercial production of *Aronia* in the US. (Much of this information is from an unpublished document of an unknown source but is available upon request.)

Muscadine Grape

Vitis rotundifolia, a southeastern US native, seems to primarily have consumer appeal in that region. While evolutionarily related to the "bunch grapes" such as *V. vinifera* L., Vitaceae and *V. labrusca* L., Vitaceae, the muscadines differ in many ways including chromosome number, vine and berry anatomy and morphology, and physical and chemical characteristics of the fruit and juice (Olien 1990). The fruit with its distinctive musky or fruity aroma is eaten fresh but is even more commonly made into juice, wines, pies, jellies, and other processed products. While the fruit has been cultivated by indigenous peoples for more than 400 years, production has been limited to the South. Most of the 1600 ha in production is concentrated in the coastal states from North Carolina to Louisiana (Olien and Hegwood 1990). Traditionally, muscadines have been grown where Pierce's disease has limited the production of American and French-hybrid grapes (Olien 1990). Lack of research on improved cultivars, cultural techniques, and processing methods has also limited commercial expansion of the industry (Olien 1990). Currently, the price for fruit has been good. In 1998, muscadines were being sold at 1.6 times the price of 'Thompson Seedless' on the fresh market (J. Clark, pers. commun.). Although more research is needed, information is available about production practices (Dearing 1947; Hegwood et al. 1983; Olien 1990; Anderson 1996) and breeding of muscadines has been reviewed (Goldy 1992)

Juneberry/Saskatoon

A number of *Amelanchier* sp. have been harvested for their fruit and included in breeding programs (Reich 1991). The Saskatchewan government has developed excellent production guides for saskatoons (St.-Pierre 1997). While this crop has widespread commercial potential, because the purple fruit appear somewhat similar to blueberries (*Vaccinium* sp., Ericaceae), success in the fresh market will probably be limited to areas where blueberry cannot be grown due to extremely cold winter temperatures or alkaline soils (Stang 1990). However, there is certainly the potential to develop processed products that are uniquely different from blueberry. Currently, the industry is concentrated in the Canadian Provinces of Alberta (500 ha), Saskatchewan (200 ha) and Manitoba (80 ha) where growers feel they do not have enough production to meet the demand (Mazza and Davidson 1993; Delidais 1998).

Edible Honeysuckle

Lonicera caerulea (Synonym of *Lonicera caerulea* var. *edulis* Turcz. ex Herder, Caprifoliaceae) is widely harvested in regions of China and northern Eurasia. Superior Russian cultivars have been developed. The cylindrical, blue fruit ripen extremely early in the season on 1–2 m tall bushes. As with *Amelanchier*, its similar appearance to blueberry will make it difficult to establish a marketing foothold. However, it is extremely winter hardy and can grow in regions where blueberry cannot. In trial plantings in the US, it has been extremely susceptible to leaf disease in the Midwest (M. Widrlechner pers. commun.) and, as with apricot, it flowers very quickly given warm temperatures and can be severely damaged by frost. However, the flowers are reported to be able to survive temperatures several degrees below freezing.

Schisandra

A native of northeastern China and the former Soviet Union, *Schisandra chinensis* (Turcz.) Baill. vines produces red fruit that are high in vitamin C. It is harvested from the wild for local consumption and has received a great deal of attention for its reputed medicinal qualities. While it is mentioned as a cure for a large number of maladies, most refereed publications seem to focus on its effects on liver function (Ahumada et al. 1989; Mizoguchi et al. 1991; Ko et al. 1995a,b). Managed plantings would be most comparable to grape production. Currently, most production is from wild harvested fruit and commercial viability is unknown. I could find no references that discussed cultural management. Improved selections from the wild are currently being evaluated in Jilin Province by the Chinese Academy of Agricultural Science (Shen Yugie pers. commun.).

Sea Buckthorn

Hippophae rhamnoides, a native of the colder regions of Eurasia, has been harvested on a large scale in eastern Europe as a vitamin C rich fruit for processing into jellies, juices, and liqueurs. Cultural management (Li and Schroeder 1986; Bernáth and Földesi 1992; Pietilä 1998) and breeding potential (Anderson and Wahlberg 1994) have recently been reviewed for sea buckthorn. This crop could be a valuable crop in North America. Plants can tolerate extremely harsh winters and poor soils. The main limitations are the development of an infrastructure for a processing market. The "Catch-22" with this crop, and others that are only suitable for processing, is that processors are not likely to get interested unless there is a market and conversely, there is not likely to be a market developed unless there are processed products in place.

POTENTIAL NEW BERRIES

Many locally harvested crops from indigenous and introduced fruit could become economically important crops. For example, several companies in the western and northwestern US are hiring pickers to harvest wild fruit for regionally, nationally, and internationally distributed fresh and processed products. In Europe and Asia, native fruit are also commonly harvested to supply a growing nutraceutical industry. Native *Vaccinium* and *Rubus* are the most common examples of these "wild" harvested crops. Potential new crops often follow a natural progression. Interest is first generated in the crop from "wild" harvested plants. When the suppliers run into difficulty with erratic supply, interest in stabilizing the supply of the crop through cultivation follows. If the crop can be adapted to cultivation economically and the market remains in place the crop can become a new crop with commercial potential. In this group I include examples of *Rubus* and *Vaccinium* that are currently harvested form the wild.

Vaccinium "Huckleberries"

"Huckleberry" is a confusing common name. Most accurately huckleberries would describe species in the genus *Gaylussacia* Kunth., Ericaceae. However, in the commerce, this name is often used regionally as a name for the local wild *Vaccinium* species. In late summer and early fall, pickers fan out over the Northwest from the Cascade Mountains as far east as the mountains of Montana to primarily pick *V. membranaceum* Douglas ex Torr. (syn. *V. globulare* Rydb.), Ericaceae as well as *V. ovalifolium* Smith and *V. deliciosum* Piper. The fruit is sold on roadsides and to wholesalers. The restaurant trade is a major consumer of fruit and a company in Montana has become well known nationally for their "chocolate-covered huckleberries." Stark and Baker (1992) present a great deal of information on the biology of the species and propose how they could be raised commercially. While their suggested production practices may be valid they are not practical for large scale production. Recently, our US Dept. of Agriculture laboratory has begun to evaluate populations of these species at a low elevation location using cultural practices that are similar to those used for highbush blueberry (*V. corymbosum*). While the planting is only three years old, it has begun to fruit, and some genotypes appear to be adapted to low elevation production. Whether this crop will prove to be commercially viable in cultivated stands has yet to be determined. In the Northwest, some fruit is also harvested in the Coastal Range from *V. ovatum* Pursh which is more commonly cut as an evergreen "green" for floral arrangements or used as an ornamental plant in the landscape. In the past two years, more than 3 ha have been planted for commercial fruit production. While *V. ovatum* has been grown successfully in the landscape for decades, the fruit are much lower quality, particularly aromatic components to fruit flavor, than the other species discussed.

Mortiño

Vaccinium floribundum Kunth., Ericaceae grows profusely in northern South America (Popenoe 1924). The evergreen nature of this species and its fruit are similar to *V. ovatum* of North America and *V. confertum* Kunth of Mexico and *V. consanguineum* Klotzch of southern Mexico and Central America. In Ecuador, baskets of fruit are commonly available in the market. Mortiño could be more widely grown as it is a popular crop and should be amenable to cultivation. However, if production is expanded it will most likely be successful in a niche market similar to the *Vaccinium* huckleberries of North America. Since, commercial highbush blueberries, which are relatives and produce a somewhat similar fruit, are in such wide production in North America, Chile, and Argentina, it would be difficult for *V. floribundum* to displace this market.

Bilberry

Bilberry (*Vaccinium myrtillus* L., Ericaceae) has a long history in European folk medicine (Morazzoni and Bombardelli 1996) and while the fruit is largely harvested from the wild, commercial production is not unknown (Dierking and Dierking 1993). Recently attention has been focused on bilberry as efforts to determine whether cultivated North American blueberries have similar nutraceutical characteristics to *V. myrtillus* (Kalt and McDonald 1996; Kalt 1997; Prior et al. 1998). These preliminary studies indicate that while *V. myrtillus* has higher levels of antioxidants than the North American commercial blueberries, the commercial blueberries do contain high levels. Although there is potential for commercial production of *V. myrtillus*, Dierking and Dierking (1993) would not recommend it from a horticultural point of view. From a nutraceutical point of view, it would appear that the commercial blueberries, produced in such great abundance and at a relatively low cost, could satisfy this demand.

Bog Bilberry

Millions of hectares of *Vaccinium uliginosum* L., Ericaceae stretch across circumboreal regions of the Northern Hemisphere. In China, we saw these fruit harvested and sold locally and the fruit pressed for juice that was marketed around China and in the Western US. In Scandinavia, the fruit are sold from wild harvested plants and cultivars have been developed for commercial production (Hiirsalmi 1989; Hiirsalmi and Lehmushovi 1993). Unfortunately, this crop has the same niche as North America's commercial blueberry industry. While it would be hard to justify cultivation of this crop if it is to be marketed in competition with the North American blueberries there would seem to be ample justification for improved management of the huge expanses of this species for the processing market.

Trailing Blackberry

Rubus ursinus Cham & Schldl., Rosaceae is an early colonizer of disturbed sites throughout the Northwest. In this era where timber is clear-cut and agriculture has disturbed many sites, the northwest trailing blackberry is very common. As with the *Vaccinium* huckleberries, pickers harvest these fruit from native stands for the restaurant trade and specialty markets. The species is dioecious and the fruit are medium sized, soft, and have a very aromatic flavor. 'Marion' blackberry is remarkable for its flavor and this can be traced to the *R. ursinus* in its pedigree. Trailing species can be grown like the commercial trailing cultivars. However, the only justification for establishing a managed planting of the species as opposed to cultivars is if the "wild" label is critical to marketing. In general, the species is much more susceptible to foliar diseases than the cultivars. Our first generation hybrids between cultivars and this species have yielded disease tolerant, thornless, and early ripening genotypes that retain the species flavor. Whether these are commercially viable will be determined in the future.

Miscellaneous *Rubus*

As you move to different regions, there is often a *Rubus* species that is harvested from the wild for local sales. These species are very similar in their place in the market to the *R. ursinus* just described. Examples worldwide would include the southern dewberries (*Rubus trivialis* Michaux) in the US; *Rubus parvifolius* L. of China and Japan; *R. phoenicolasius* Maxim. in Japan; *R. crataegifolius* Bunge; *R. niveus* Thunb. and *R. coreanus* Miq. in China; and the many blackberry species (*Rubus*) in Europe (Anon. 1912a,b; Card 1915; Williams and Darrow 1940; Sherman and Sharpe 1971; Jennings 1988; Finn et al. 1998). Any of these crops could be developed into a major crop. However, as with mortiño, they will be competing against a well established, productive industry that produces a somewhat similar crop, i.e. red (*R. idaeus*) and black raspberry (*R. occidentalis*), and blackberry (*Rubus* sp.).

POTENTIAL CROPS WITH UNMET POTENTIAL

Finally, many crops that have previously been mentioned in these sorts of forums have not been further developed. Usually, market drives the production, either a large market does not exist or another berry is filling that market niche. A few examples of previously described potential crops in this class include: Nanking cherry (*Prunus tomentosa* Thunb., Rosaceae); cranberry bush (*Viburnum opulus* L., Caprifoliaceae); and buffalo berry *(Shepherdia argentea* Nutt. Elaeagnaceae*)*.

Nanking Cherry/Hansen Bush Cherry

Prunus tomentosa is native throughout temperate regions of eastern Asia and is widely sold in the local markets. At least a century ago, seed lots were brought to the US and breeding programs released a few cultivars in the first half of this century (Darrow 1937; Fogle 1975; Kask 1989). Hansen in South Dakota recognized that the superior cold hardiness of this productive, but small fruited, cherry might be valuable for the northern Great Plains (Kask 1989). While the species has not developed into a commercial crop, it is commonly sold through catalogues to homeowners (Reich 1991). This crop will remain in the realm of homeowners in North America and in local markets of Asia because the fruit are inferior to the commercially available sour cherries (*P. cerasus* L.).

Cranberry Bush

Viburnum opulus (syn. *V. trilobum* Marsh.) is found in northern temperate regions. While popular as an ornamental plant in the landscape, the species has never developed into a commercial fruit crop. The fruit is unpalatable fresh and must be processed into jellies or juice (Card 1915). Cultivars with superior fruit and processing characteristics have been released (Darrow 1975). Cranberry bush may have potential for small scale, local production, or for a unique processed product (Stang 1990) but, in general, the fruit is too similar to cranberry (*Vaccinium macrocarpon*) or red currant (*Ribes rubrum*) as a processed product (Darrow 1975) to justify large scale production.

Buffalo Berry

Shepherdia argentea has been stuck in the "potential" class for nearly two centuries. In 1915, Card wrote, "The buffalo berry has enjoyed the distinction of remaining a new fruit for a very long time.... Yet we are still talking about buffalo berry as a new fruit which ought to be introduced." He cites references back to 1841 that state that buffalo berry was widely grown. This species is native to the Great Plains of the US (Darrow 1975). I think horticulturists continue to return to this crop because the plants are productive, extremely winter hardy, and drought tolerant, the flowers are frost tolerant, and the scarlet fruit are very high in Vitamin C. Despite being dioecious and spiny, it would appear that it might be well adapted for mechanical harvesting and processing as a juice. Buffalo berry is likely to retain its "potential" label until someone aggressively develops the market for the fruit.

CONCLUSION

Berries have been an important part of the diet of indigenous people. The world is now a global market which will have adverse and beneficial effects on crops that have developed from a specific region. Some crops that formerly had only local interest will develop demand worldwide. Other crops may be lost as similar crops from other regions will displace them. These crops will remain regionally important but will not develop worldwide importance.

Blueberry, strawberry, and grape production will continue to expand worldwide. Cranberry production will likely expand rapidly where the proper soil and water requirements can be found or where "wetlands regulations" are not as stringent as they are in the US. Red raspberry, blackberry/hybridberry, lingonberry, and black currant will steadily increase in production. It becomes more difficult to predict the future of "neglected" berries, as there seems to be serious problems with each crop except *Actinidia arguta*. *Actinidia arguta* shows tremendous promise and will see increased production worldwide. Elderberry, aronia, and sea buckthorn production will increase if their unique anthocyanin characteristics are desirable for the colorant and nutraceutical markets. Alpine strawberry, muscadine grape, juneberry, cloudberry, arctic raspberry, and mora will continue to play important roles in regional or niche markets but are not likely to join the lists of major crops worldwide. Similarly, we hope that the "potential new crops" will develop stable crop areas with consistent production as they solidify their standing as important regional or niche market crops. I do not see great potential in Nanking cherry, cranberry bush, or buffalo berry unless someone energetically develops markets for them. The rising interest in the nutraceutical characteristics of foods has carried over to berries. Schisandra and bilberry are two examples of crops primarily harvested for their nutraceutical potential. Whether this is a trend or a fad may impact which new crops will develop a large commercial industry.

Each era has their surprises as to which new crops develop into important crops. In 1915, Card had blueberries listed in the miscellaneous section of his book. By the second half of this century blueberries had become an important crop and today they are one of the major berry crops worldwide. Who would have thought a few years ago that a major chain store in the US would be promoting "Aronia Berry Juice Cocktail?" George Darrow in 1975, gave equal space to *Actinidia arguta* and *Viburnum trilobum* (syn. *V. opulus*) in a chapter on minor temperate fruit. Twenty-five years later, *A. arguta* is on the verge of becoming an important fruit crop while *V. trilobum* remains "only" a beautiful ornamental for the landscape. Let us hope in the future that we continue to be surprised by the neglected or unknown crops.

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Galangal

Zingiberaceae *Alpinia officiarum* Hance, *Langras galaga* (L.) Stantz.

Source: Magness et al. 1971

These two species, respectively known as lesser and greater galangal are tropical perennials, cultivated mainly for the underground rhizomes. The plants and rhizomes are similar to ginger. The tuberous rhizomes are the spice used in making vinegar and beer and in liquors, especially in Russia. The spice is also used in curries.

Last update February 18, 1999 by ch

Trifolium species

Fabaceae

Clover, Peavine, Cowgrass

We have clover information from several sources:

Some 250 species of *Trifolium* are recognized throughout the world, with about 50 indigenous in the United States. None of these native species are cultivated although they contribute to grazing and may be an important part of wild hay crops. They contribute nitrogen and thus promote the growth of associated grass. The clovers may be annual or perennial. Leaves are mostly trifoliate, rarely 5 to 7 leaflets. Flower heads are usually short spikes or umbels with numerous small individual flowers in the head. The important agricultural species are described as follows:

Trifolium pratense Handbook of Energy Crops. James A. Duke. 1983. unpublished.

Red Clover Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed Crops of the United States.

FactSHEET on *T. ambiguum* Kura clover contributed by: Norman L. Taylor

T. agrarium, T. campestre, T. dubium - Hop clovers

T. fragiferum - Strawberry clover

T. glomeratum , T. lappaceum - Cluster clover, Lappa clover

T. hirtum - Rose clover

T. hybridum - Alsike clover Swedish clover

T. incarnatum - Crimson clover, Italian or Scarlet clover

T. michelianum - Bigflower clover

T. nigrescens - Ball Clover

T. resupinatum - Persian clover

T. striatum - Striate clover

T. subterraneum - Sub clover

[*T. variegatum* - Whitetip clover]

[*T. willdenovii* - Seaside clover]

Alyce Clover

Leguminosae *Alysicarpus vaginalis* (L.) DC.

Source: Magness et al. 1971

This is a summer annual native to tropical Asia. It was introduced into the United States in 1910 and has proven adapted to areas near the Gulf of Mexico. In thin stands the stems branch, but in thick stands stems reach 3 feet in height with little branching. Leaves are oval, unifoliate, and borne on short petioles along the entire stem. Alyce clover is grown mainly for hay and soil improvement, but also makes good pasturage. The hay appears about equal to other legume hays in feeding value. The crop is seeded in late spring and matures seed the same season. If seed matures and shatters, a volunteer crop is produced in succeeding years. Seed was harvested from about 5000 acres (1954, 1959 censuses), sufficient to plant about 80,000 acres.

Last update February 18, 1999 by ch

Amaranthus species

Amaranthaceae

Amaranth, *Achis*, *achita*, african spinach, amarante, *bledos*, bondue, bush greens, *choito*, *coimi*, *coyo*, *cuime*, green leaf, *buautli*, Indian spinach, Joseph's-coat, kiwicha, livid amaranth, love-lies-bleeding, *millmi*, pale-seeded amaranth, pigweed, princess-feather, purple amaranth, quintonil, redroot, spinach-grass, Surinam spinach, wild beet, wild blite

Many species are used including:

- *Amaranthus atropurpureus* - Lal-nati
- *A. caudatus* - Pendant amaranth, Love-lies-bleeding, Tassel flower
- *A. cruentus* - Mexican grain amaranth, Purple amaranth, Prince's feather
- *A. cruentus* x *A. powellii* - Hopi red-dye, Komo
- *A. dubius* - Khada sag, Bayam bhaji
- *A. graecizans* - Prostrate amaranth
- *A. hybridus* - pigweed, wild beet
- *A. hypochondriacas* - Guegui, Bledo, Ramdana
- *A. lividus* - Purple amaranth
- *A. mantegazzianus* - Quinoa de Castilla
- *A. paniculatus* - Reuzen amaranth
- *A. quitensis* - Ataco, Sangorache
- *A. retroflexus* - Redroot pigweed
- *A. spinosus* - Blero Spinach, Calaloo, Calalu, Prickly amaranth
- *A. tricolor* - Tampala, Joseph's coat
- *A. viridus* - Green amaranth, Bayam hedjo

NewCROP has Amaranth information at:

Non-Shattering Grain Amaranth Populations—D.M. Brenner

Response of Grain Amaranth Production to Density and Fertilization in Tarija, Bolivia—V. Apaza-Gutierrez, A. Romero-Saravia, F.R. Guillén-Portal, and D.D. Baltensperger

Grain Amaranth—Charles S. Kauffman and Leon E. Weber

Amaranth Rediscovered—Gilbert F. Stallknecht and J.R. Schulz-Schaeffer

Amaranth Production in Mexico and Peru—Daniel K. Early

Simply Inherited Genetic Variation in Grain Amaranth (Abstract)—P.A. Kulakow

Hybridization of Grain Amaranths: Implications for Long-term Development (Abstract)—J.W Lehmann and R.L. Clark

Amaranth Intercropping Techniques of Andean Quechua Peasants (Abstract)—Daniel K. Early

Row Spacing and Population Effects on Yield of Grain Amaranth in North Dakota—T.L. Henderson, A.A. Schneiter, and N. Riveland

Amaranth: New Crop Opportunity—Robert L. Myers

Grain Amaranth Harvest Timeliness in Eastern North Dakota—S.A. Fitterer, B.L. Johnson, and A.A. Schneiter

Determining Amaranth and Canola Suitability in Missouri Through Geographic Information Systems Analysis—Robert L. Myers

Field Evaluation of Grain Amaranth in Chile—Marisol Berti, Humberto Serri, Rosemarie Wilckens, and Inés Figueroa

Variability in 'Plainsman' Grain Amaranth—F.R. Guillen-Portal, D.D. Baltensperger, L.A. Nelson, and N. D'Croz-Mason

Plant Population Influence on Yield and Agronomic Traits in 'Plainsman' Grain Amaranth—F.R. Guillen-Portal, D.D. Baltensperger, and L.A. Nelson

Amaranth: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.).
Amaranthus cruentus, Amaranthus hypochondriacus
Amaranthus caudatus

Vegetable amaranth

Vegetable Amaranths: Cultivar Selection for Summer Production in the South—Ramsey L. Sealy, E.L McWilhams, J. Novak, F. Fong, and C.M. Kenerley

Population Density and Soil pH Effects on Vegetable Amaranth Production—Bharat P. Singh and Wayne F. Whitehead

Management Methods for Producing Vegetable Amaranth—Bharat P. Singh and Wayne F. Whitehead

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Chinese Amaranth In: Magness, J.R. et al. 1971. Food and feed crops of the United States.

Blero Spinach In: Magness, J.R. et al. 1971. Food and feed crops of the United States.

Outside links to more Amaranth info:

Kiwicha can be found in Lost Crops of the Incas from National Academy Press

Amaranth Saskatchewan Agriculture and food

Amaranth Grain Production in Nebraska

All about Amaranths (Chinese Spinach) from Texas A & M University.

Amaranthus Germplasm Sources:
(2630 total *Amaranthus* accessions with 721 available accessions)
David Brenner, Curator
North Central Region Plant Introduction Station
Agronomy Department
Iowa State University
Ames Iowa 50011 USA
Tel: 515-294-6786
FAX: 515-294-4880
Email:nc7db@ars-grin.gov

The Amaranth Institute
c/o Dr. James Lehmann
PO Box 248
Bricelyn, MN 56014 U.S.A.

European Amaranth Association
Professor Ishan Magomedovich Magomedov, President
Saint Petersburg, Russia
email: ishan@toma.usr.pu.ru
fax (7-812) 3497779

Morton, J. 1987. Amazon Tree-Grape. p. 64. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Amazon Tree-Grape

Moraceae

The Amazon tree-grape, *Pourouma cecropiaefolia* Mart., of the family Moraceae, is the best-known of about 50 species of *Pourouma* in Central America and tropical South America. It is known in Brazil generally as *puruma, cucura, imbauba mansa, imbauba-de-vinho, imbauba de cheiro*; in Bahia as *tararanga preta* and in Manaus as *mapati*. In Colombia it is called *puruma, caime, caimaron, caimaron silvestre, uva caimarona, camuirro, cucura, uva, sirpe, hiye* or *joyahiye*. In Peru, it is simply *uvilla*.

The tree resembles *Cecropia* spp., which are called *imbauba* in Brazil. It reaches 23 to 50 ft (7-15 m) in height. The bark is gray and marked with leaf scars. The alternate leaves, on long petioles, are nearly circular but deeply cleft into obovate oblong-lanceolate lobes to 1 ft (30 cm) long. They are green on the upper surface, whitish or bluish-gray and velvety beneath; agreeably aromatic, like wintergreen, when crushed. The unopened inflorescence is reddish-purple, densely coated with fine white hairs. The white male and female flowers are borne on separate trees. Borne in bunches of 20 or more, the fruit is grapelike except for its wintergreen odor. It is round or round-ovate, usually 3/8 to 3/4 in (0.5-1 cm) wide, occasionally to 1 1/2 in (4 cm). The skin is very rough to the touch, inedible but easily peeled; purple when ripe. The pulp is white, mucilaginous, juicy; of subacid, very mild flavor; and encloses 1 conical seed with fibrous, grooved coat.

The tree grows wild in the western part of Amazonas, Brazil, and adjacent areas of Ecuador and Peru. It is especially abundant in the vicinity of Iquitos. It has been cultivated since pre-Hispanic times by the Indians of southwestern Colombia and is grown by Indians and non Indians in Brazil. Patino says that around 1940 propagation was begun at the Estacion Agricola at Palmira, Colombia, and seeds and plants were given to the Estacion at Calima in 1945. Some trees are being grown, too, at the Estacion Agricola de Armero. There is today renewed interest in encouraging cultivation.

The tree grows on high dry land at altitudes below 1,640 ft (500 m). It may be subject to flooding every 4 or 5 years. It cannot stand prolonged drought. The seeds have short-term viability. If planted in time, they may show 86% germination. Cuttings are difficult to grow. Seedlings bear in 1 to 3 years after setting out. There may be 2 crops per year. Some trees that have been at least 3 years in the plantation have yielded 110 lbs (50 kg). The fruit is eaten raw or made into wine.

The wood is light, coarse and non-durable. It is used only for making charcoal.

Spondias cytherea Sonn.

Spondias dulcis Forst.

Anacardiaceae

Ambarella, Jobo de la India, Otaheite apple

We have information from several sources:

Ambarella—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Monday, March 1, 1999 by ch

Amelanchier species

Rosaceae

Juneberry, Saskatoon berry, Saskatoon serviceberry, Serviceberry, Shadblow, Shadbush, Western serviceberry

We have information from several sources:

Saskatoon Berry: A Fruit Crop for the Prairies—G. Mazza and C.G. Davidson

Temperate Berry Crops—Chad Finn

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Saskatoon Berry Research University of Saskatchewan

Registry Of The Genus Amelanchier

Saskatoon Berries Manitoba Agriculture

Juneberry For Commercial and Home Use on the Northern Great Plains

Juneberry—from Mark Reiger, Dept of Horticulture, University of Georgia.

American Linden

Tilia americana L.

Synonyms.—*Tilia glabra* Vent.; *T. canadensis* Michx.

Figure 6.—American linden (*Tilia americana*)

Other common names.—Basswood, whitewood, bast tree, black lime tree, American lin tree, American lime tree, beetree, daddynut tree, monkeynut tree, whistlewood, white lind, red basswood, yellow basswood, wickup.

Habitat and range.—This native forest tree is found in rich woods, especially along the mountains, from Canada to Georgia and west to Texas and Nebraska.

Description.—The American linden is a large tree attaining a height of from 60 to 125 feet with a trunk diameter of 2 to 5 feet, with spreading branches. The somewhat leathery leaves are pointed at the apex, heart-shaped at the base, with sharply toothed margins and are borne on stems about 1 or 2 inches long. The flowers are produced in great abundance from May to June in drooping clusters composed of from 6 to 20 yellowish, very fragrant flowers. At the base of each cluster and grown to its stalk is a leaflike bract 2 to 4 inches in length. The roundish, grayish-green fruit is dry and woody and contains one or two seeds.

Part used.—The flowers, carefully dried in the shade.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Wednesday, March 11, 1998 by aw

Podophyllum peltatum L.

Berberidaceae

American mayapple

We have information from several sources:

The American Mayapple and its Potential for Podophyllotoxin Production —Rita M. Moraes, Hemant Lata, Ebru Bedir, Muhammad Maqbool, and Kent Cushman

Propagule Type and Planting Time for Field-established Mayapple—Muhammad Maqbool, Kent E. Cushman, and Rita M. Moraes

Assessment of Genetic Diversity in *Podophyllum peltatum* by Molecular Markers—Hemant Lata, Rita M. Moraes, Andrew Douglas, and Brian E. Scheffler

Bioprospecting for Podophyllotoxin—Ebru Bedir, Ikhlas Khan, Rita M. Moraes

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

American Mountain-Ash

Sorbus americana Marsh.

Figure 7.—American mountain-ash (*Sorbus americana*)

Synonym.—*Pyrus americana* DC.

Other common names.—Roundwood, round-tree, American rowan tree American servicetree, mountain sumac, dogberry, quickbeam, wild ash, winetree, witchwood, life-of-man, Indian mozemize, missey-moosey, moose-misse.

Habitat and range.—The American mountain-ash occurs in swamps, low woods, or moist ground from Newfoundland south along the mountains to North Carolina and to Michigan. It is most abundant in the northern portion of its range.

Description.—This smooth-barked tree reaches a height of 30 feet with a trunk 18 inches in diameter. The leaves resemble those of the sumac, consisting of from 11 to 17 lance-shaped, pointed leaflets about 1 1/4 to 4 inches long. When young they are slightly hairy, both sides soon becoming smooth. The white flowers are borne from May to June in dense clusters measuring from 3 to 6 inches across. The flowers are followed later in the season by large, dense, showy clusters of bright-red berries about the size of peas, which give the tree a brilliant appearance.

Part used.—The bark with the outer layer removed.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Wednesday, March 11, 1998 by aw

Hedeoma pulegioides L.

Lamiaceae (Labiatae)

American Pennyroyal

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980.

Sievers, A.F. 1930. The Herb Hunters Guide.

Last update Wednesday, July 08, 1998 by aw

Gossypium hirsutum L.

Syn.: *Gossypium mexicanum* Tod.

Malvaceae

Cotton

We have information from several sources:

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Feasibility of Cotton as a Crop for Pennsylvania—Polly S. Leonhard

Handbook of Energy Crops—James A. Duke. 1983.

The Herb Hunters Guide—Sievers, A.F. 1930.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Web links to other cotton information sources:

Fox Fibre Naturally colored cottons

Cotton Inc.

Cotton Production Guidelines for North Carolina

Australian Cotton Cooperative Research Centre

National Cotton Council

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Phyllanthus emblica L.

Emblica officinalis Gaertn.

Euphorbiaceae

Amla, emblic

We have information from several sources:

Emblic—Julia Morton, Fruits of warm climates

FactSheet contributed by Dr. Chiranjit Parmar

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Beachgrasses

Gramineae

American beachgrass *Ammophila breviligulata* Fern.
European beachgrass *A. arenaria* (L.) Link

Source: Magness et al. 1971

These grasses are tough, coarse perennials with extensively creeping rhizomes. They produce good growth on sands of low fertility, and are used primarily for erosion control in sandy areas. For this purpose, dividing and transplanting clumps of the grasses is the most effective method of establishing stands. If planted not more than 3 feet apart, spaces between plants are rapidly filled in. These grasses are resistant to the cutting effect of blowing sand. They are of little value except for stabilization of sandy soils.

Last update February 18, 1999 by ch

Cardamom

Zingiberaceae *Elettaria cardamomum* (L.) Maton.

***Amomum cardamomum* L.**

Source: Magness et al. 1971

Both the above related species of tropical plants produce the cardamom seeds of commerce. Both are tropical, perennial herbs, the tops growing each year from underground rhizomes. *E. cardamomum* reaches 5 to 10 feet, with lanceolate leaves up to 2 feet long. The capsules are oblong to globular, ribbed and indehiscent. These dried capsules are the principal cardamoms of commerce. The seeds and plant of *A. cardamomum* are very similar to "grains of paradise" These seeds are also sold as cardamom.

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Bothriochloa pertusa (L.) A. Camus

Syn.: *Amphilophis pertusa* (L.) Stapf
Andropogon pertusus (L.) Willd.
Holcus pertusus L.
Poaceae
Hurricane grass, Seymour grass, Barbados sourgrass, Pitted bluestem, Comagceyana

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Much valued as a good fodder grass, both for grazing and for stacking. Satisfactory for lawns, as it sends out numerous creeping shoots which root at the nodes. Although valued by some for pasture, others consider it a weed. In the Virgin Islands, e.g., some forms are difficult to eradicate and replace with better pasture grasses (Bogdan, 1977).

Folk Medicine

No data uncovered.

Chemistry

On a zero moisture basis the early-bloom grass (34.7% DM) contains 5.7% CP, 34.9% CF, 11.7% ash, 1.0% EE, 46.7% NFE (Venezuela); the mature grass (India) contains 3.9% CP, 37.9% CF, 10.0% ash, 2.3% EE, 45.9% NFE; the hay (94.3% DM) contains 5.7% CP, 34.9% CF, 11.7% ash, 1.0% EE, 46.7% NFE (India) (Gohl, 1981).

Description

Stoloniferous or tufted perennial grass; culms ascending, branching, sometimes long running, rooting at the nodes, about 30 cm tall, much taller when cultivated; sheaths rounded; leaf-blades flat; panicle axis shorter than the lower branches, purplish, emitting an aromatic odor when crushed; racemes few to several, sparsely villous; first glumes of sessile spikelets always pitted; awn of sessile spikelet geniculate, 10–15 mm long; pedicellate spikelet about as long and broad as the sessile ones. $2n = 60$. Fl. summer-fall.

Germplasm

Reported from the Africa, Mediterranean, and Near East Centers of Diversity, comagueyana or cvs thereof is reported to tolerate drought, grazing, and slope. Both apomictic and sexual reproduction have been observed in India, the latter predomina.tly. ($2n = 40, 60$)

Distribution

Widely distributed in Old World Tropics, from Arabia and Tropical Africa to Southeast Asia, India, Sri Lanka, and Indonesia. Considered one of the better pasture grasses in the West Indies, Uganda and India. Sparingly introduced in southern United States on experimental basis.

Ecology

Ranging from Warm Temperate Moist through Tropical Very Dry to Wet Forest Life Zones, comagueyana is reported to tolerate annual precipitation of 5 to 40 dm (mean of 7 cases = 13.9), annual temperature of 17 to 27°C (mean of 7 cases = 23.3), and pH of 5.0 to 7.8 (mean of 7 cases = 6.9) (Duke, 1978,1979). Bogdan (1977) suggests that it occurs where rainfall is 500–900 mm, mainly on well drained soil. Rather common in disturbed as well as undisturbed areas, along roadsides, and in rather dry areas. Can withstand moderate periods of drought. Thrives on a wide range of soils in tropical climates. Does not tolerate frost.

Cultivation

Cultivated mainly in pasture mixtures. Also seeded along roadside embankments in warmer regions. Germinated quickly and established readily.

Harvesting

Mature plants stand repeated cutting, continuous grazing and trampling. Because of its ability to withstand being trampled and its habit to send out rooting shoots, it is used for lawns. Moisture-free grass contains 8.8% protein, 33% fiber, 46.1% N-free extract and 1.7% fat.

Yields and Economics

Said to be low yielding (Gohl, l981), but yield figures approach 15 MT DM/ha. An excellent pasture grass in many tropical areas of the world, as West Indies, East Africa, India, in the last where it is suggested for reseeding degraded grassland. Used to some extent in warmer parts of the United States along roadsides.

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges to 15 MT/ha.

Biotic Factors

Following fungi have been reported on this grass: *Balansia sclerotica, Claviceps purpurea, Physoderma bothriochloae, Puccinia cesatii, P. duthiae, P. erythroaeensis, P. pusilla, Sphacelotheca tenuis, Ustilago bothrioch- loae, Uromyces andropogonis-annulati.*

References

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- Duke, J.A. 1978. The quest for tolerant germplasm. p. 1–61. In: ASA Special Symposium 32, Crop tolerance to suboptimal land conditions. Am. Soc. Agron. Madison, WI.
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- Duke, J.A. 1981b. The gene revolution. Paper 1. p. 89–150. In: Office of Technology Assessment, Background papers for innovative biological technologies for lesser developed countries. USGPO. Washington.
- Gohl, B. 1981. Tropical feeds. Feed information summaries and nutritive values. FAO Animal Production and Health Series 12. FAO, Rome.

Complete list of references for Duke, Handbook of Energy Crops

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Last update December 30, 1997

Anacardium occidentale L.

Anacardiaceae

Cashew, Cashew Apple, Cashew Fruit, Cashew Nut

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States. Interregional Research Project IR-4, IR Bul. 1 (Bul. 828 New Jersey Agr. Expt. Sta.)

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Cashew Apple—Julia Morton, Fruits of warm climates.

Cashew Links:

California Rare Fruit Growers - Anacardium

Cashew—from Mark Reiger, Dept of Horticulture, University of Georgia.

Cashew Information from the University of California Fruit & Nut Research and Information Center

Ananas comosus (L.) Merr.

Bromeliaceae

Anana, *Ananas*, Cayenne pineapple, Hawaiian pineapple, Nana, Piña, Pineapple

NewCROP has Pineapple information at:

Pineapple—Julia Morton, Fruits of warm climates

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States. Interregional Research Project IR-4, IR Bul. 1 (Bul. 828 New Jersey Agr. Expt. Sta.).

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

And outside links to more pineapple info:

PINEAPPLE "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Pineapple Information from the University of California Fruit & Nut Research and Information Center

The Pineapple Page News and information about pineappe (Edited and Maintained by Duane P. Bartholomew).

Pineapple—from Mark Reiger, Dept of Horticulture, University of Georgia.

Pineapple Info from the FAO Tropical Feeds Database

Ancistrocladus korupensis D. Thomas & Gereau

We have information from several sources:

Ancistrocladus: Potential Anti-AIDS Source

Drug Discovery and Development at the National Cancer Institute: Potential for New Pharmaceutical Crops—Gordon M. Cragg, James E. Simon, Johnson G. Jato, and Kenneth M. Snader

last update October 21, 1997 by aw

Bhuinimb or Kalmegh (*Andrographis paniculata* Nees.)

Contributor: Pankaj Oudhia

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English Name: Creat , Green Chirayta, King of bitters.

Common (Indian) Name:

Hindi: Kalmegh, Kiryat, Mahatit,
Gujrati: Kiriyata, Olikiriyat
Marathi: Olen Kirayat,
Canarese: Nelabevu gida
Sanskrit: Bhuinimb, Kirata, Mahateet
Malyalam: Nilaveppu, Kiriyatta,
Telugu: Nela Vemu
Tamil: Nilavempui

Family: Acanthaceae

Distribution: Kalmegh is an annual herb found through India, specially in dense forests.It is under cultivation in many states of India.

Botany: It is an erect branched annual, 0.3-0.9 meters high, branches sharply quadrangular winged in the upper part; leave - lanceolate, acute, undulate, pale beneath; Flowers small, solitary distant, in axillary or terminal racemes or panicles, bracts lanceolate; Corolla - 2 lipped, upper lip 2-toothed, lower 2 lobed, rose coloured; Flowers - Capsule, linear - oblong, acute at both ends; Seeds many, rugosely pitted, yellowish brown. Flowering time in India is November - December.

Useful parts: Whole plant.

Medicinal Properties: According to Ayurveda the plant is bitter, acrid, cooling, laxative, vulnerary, antipyretic, antiperiodic, anti-inflammatory, expectorant, depurative, soporific, anthelmintic, digestive and useful in hyperdispsia, buring sensation, wounds, ulcers, chronic fever, malarial and intermittent fevers, inflammations, cough, bronchitis, skin diseases, leprosy, colic, flatulence, diarrhoea, dysentery, haemorrhoids etc. Kalmegh is also a reputed Homoeopathic drug. In Bengal (India), household medicine known as "Alui" is prepared from fresh leaves and is given to children suffering from stomach complaints. Recent experimental finding indicated that Kalmegh is having antityphoid and antibiotic properties. It has been proved to be hepatopratective drug.

Chemical Constituents: Kalmegh contains bitter principles andrographolide, a bicyclic diterpenoid lactone and Kalmeghin (upto 2.5%). The leaves contain the maximum active principle content while in the stem it is in lesser amount.

Cultivation: In India, it is cultivated as rainy season (Kharif) crop. Any soil having fair amount of organic matter is suitable for commercial cultivation of this crop. About 400 gms. seed are sufficient for one hectare. The spacing is maintained 30 × 15 cm. No major insect and disease infestation has been reported. The plants at flowering stage (90–120 days after sowing) is cut at the base leaving 10–15 cm stem for plant regeneration. About 50–60 days after first harvest, final harvest is performed. In Indian condition, the yield varies between 2000–2500 Kg dry herb per hectare.

Resource Person:
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Andropogon gayanus Kunth

Poaceae
Gamba grass

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Considered one of the best grazing grasses in northern Nigeria and northern Ghana. Makes valuable hay and green fodder grass in central and northeastern Brazil. In Africa, this grass grows in large tufts up to 2 m tall. Young shoots are preferred, but cattle will eat it up to time of flowering. Stems, flattened, are used for coarse matting (weaving grass mats and thatching). Plants are useful for planting on banks for erosion control.

Folk Medicine

No data uncovered.

Chemistry

On a zero moisture basis, fresh Ghanan grass (19.9% DM) contains 12.9% CP, 25.6% CF, and 8.5% ash; the same (24 weeks old) (59.4% DM) contains 5.4% CP, 29.9% CF, and 5.5 % ash. Nigerian hay (88.5% DM) contains 6.1% CP, 35.1% CF, 7.9% ash, 1.7% EE, and 49.2% NFE, while silage (DM 25.0%) contains 5.8% CP, 37.4% CF, 7.4% ash, 1.9% EE, and 47.5% NFE (Gohl, 1981).

Description

Tall annual or perennial, tussock grass; culms erect, up to 3 m tall, more or less stout, about 0.6 cm in diameter, glabrous, many-noded, producing flowering branches from the third node upward; leaves glabrous or softly pubescent, rarely villous or tomentose; sheath tight, striate; ligule short, rounded or truncate, glabrous or somewhat hairy on back, rarely exceeding 0.2 cm long; lamina linear to lanceolate-linear in the lower leaves, usually from a much attenuated base and there often forming a terete petiole, tapering to a fine point, over 30 cm long, up to 1.6 cm broad, glaucescent or reddish, margin scabrous; inflorescence in panicles up to 6 or more primary mixed 2 to many rayed tiers, the inner ray of lower or lowest tiers often up to 30 cm long (sometimes up to 60 cm long), with 2–4 secondary few-rayed tiers; spatheoles pale green, herbaceous, lanceolate-oblong, 6.5–7.5 cm long, at length more or less tightly enrolled and turning red; racemes in pairs, 3.5–6.5 cm long, one sessile, the other with a bare base about 0.4 cm long, joints stout, cuneate-clubshaped; sessile spikelets greenish or tipped brown or red, about 0.8 cm long including the obtuse callus; scantily bearded at base; glumes equal; awn 1.3–2.2 cm long, twisted well below middle, column brown, bristle pale; pedicellate spikelets male and glabrous. Fl. April–June in tropical Africa.

Germplasm

Several varieties are recognized: var. *gayaunus* with pedicelled spikelets glabrous, the joints and pedicles ciliate on one margin only; var. *squamulatus*, with pedicelled spikelets scaberulous, the joints and pedicels ciliate on both margins; var. *argyophoeus*, with pedicelled spikelets plumosely villous, basal leaves villous; var. *bisquamulatus*, with pedicelled spikelets not so hairy, basal leaves not villous. *Squamulatus* and *bisquamulatus* are "dry ground" varieties which grow best on well-drained sandy clays of medium to high fertility (Bowden, 1963). Reported from the Africa Center of Diversity, gamba grass or cvs thereof is reported to tolerate drought, fire, frost, high pH, heavy soil, low pH, poor soil, savanna, slope, and waterlogging. Var. *gayanus* is more likely to tolerate waterlogging and frosts than the "dry-land" varieties (Duke, 1978). ($2n$ = 20, 40, 44)

Distribution

Native and widely distributed in tropical Africa, north and south of Equator; introduced to other tropical areas, as tropical Queensland, Brazil, India, and western Australia.

Ecology

Ranging from Warm Temperate Moist through Tropical Dry to Wet Forest Life Zones, gamba grass is reported to tolerate annual, precipitation of 8 to 27 dm (mean of 9 cases = 12.2), annual temperature of 15 to 32°C (mean of 9 cases 21.4), and pH of 4.3 to 8.3 (mean of 5 cases = 6.1). In grassy places, damp places, low-lying meadows, edge of thickets; often forming large areas. Also thrives in areas with long dry season up to 7 months long. Adapted to a wide range of soil types, with different ecotypes adapted to various soils varying from sandy to heavy black cracking clays. Very drought resistant and not to susceptible to frost.

Cultivation

Propagated by seed. Caryopses germinate better with chaff removed and covered over by soil or sand. Clean seedbed required, but sowing should not be delayed more than 2 months after beginning of rains (in India). It is often under-sown in corn, sesame or millet. Seeding rate varies: in Brazil, 5 kg/ha; in Nigeria, 35–70 kg/ha, of uncleaned seed. Seed production is often very low. Sometimes grown in mixture with *Clitoria ternatea* in tropical Australia. May also be propagated by splints, those from mature woody stumps doing best (Bowden, 1963). Highest return of dry matter per unit N (14.4 kg DM/kg N) occurred at 28 kg N/ha; CP content increased only modestly as N was increased, reaching a maximum 10.5% with the highest N level. At higher levels of N, *A. gayanus* was replaced by less desirable grasses (Haggar, 1974). Bogdan (1977) reports trebling of yields with 100 kg N/ha and double to treble with 20 MT fym/ha.

Harvesting

Plants persist well under grazing, but are only palatable before flowering. The flowering stems, which are produced in quantity, are hard and should be removed by mowing or burning. Frequent burning tends to suppress this grass and allows it to be replaced by less useful species. In one experiment (Bowden, 1963) over three years, plots were cut only when grass reached 6, 9, 12 and 15 dm, necessitating 12, 9, 8 and 7 cuts respectively. The taller the grass when cut, the higher the annual DM yield. Plants grown in rows gave more DM, CP and soluble carbohydrate than plants grown in swards.

Yields and Economics

Haggar (1974) reported yields of 2–7 MT in 1964, 10–12 in 1965, and 6–12 in 1966, at 0 to ca 200 kg/N/ha respectively. According to Bogdan (1977), this is one of the high yielding grasses of West Africa, being outyielded by *Melinis minutiflora*, *Panicum maximum* and/or *Pennisetum purpureum*. Fresh fodder yield of 57 MT are recorded from India, 76 from Mali. From the Cameroons, DM yields of 7.1–7.8 MT/ha, 4 MT/DM from Australia, and 2.4–8.6 MT elsewhere (Bogdan, 1977). Seed yields up to 30 kg/ha per cut with 3 cuts per year have been recorded in Brazil. In pure stands in Ghana, dry matter yields per harvest from March 12 to November 12 (in 5 harvests) averages 7,478 kg/ha, with total harvest being 37,391.35 kg/ha. In

Andropogon-Desmodium stands 34,334 kg/ha; in Andropogon-Centrosema, 30,397.45 kg/ha (Tetteh, 1972). Widely cultivated and used grass used in tropical Africa (Nigeria and Ghana), Brazil, India, and Australia for fodder, grazing, hay and to some extent for erosion control.

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges from 4 to 25 MT/ha. According to Gohl, the ME (metabolizable energy) for cattle ranges from 1.71 megacalories/kg DM in silage to 1.65 in hay, 2.02 in mature forage and 2.33 in early vegetative forage.

Biotic Factors

Following fungi have been reported on this grass: *Fusarium moniliforme* (on seed), *Phyllachora assimilis, Puccinia erythraeensis, P. versicolor, Sphacelotheca andropogonis, S. ischaemicola*. Nematodes isolated from this grass include: *Criconemella* sp., *Helicotylenchus cavenessi, R. pseudorobustus, Memicriconemoides cocophilus, Hemicycliophora oostenbrinki, Scutellonema clathricaudatum, Tylenchorhynchus annulatus, Xiphinema ebriense*, and *X. nigeriense*.

References

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- Bowden, B.N. 1963., Studies on *Andropogon gayanus* Kunth. I. The use of *Andropogan gayanus* in agriculture. Empire J. Exper. Agric. 31(123):267–273.
- Duke, J.A. 1978. The quest for tolerant germplasm. p. 1–61. In: ASA Special Symposium 32, Crop tolerance to suboptimal land conditions. Am. Soc. Agron. Madison, WI.
- Duke, J.A. 1981b. The gene revolution. Paper 1. p. 89–150. In: Office of Technology Assessment, Background papers for innovative biological technologies for lesser developed countries. USGPO. Washington.
- Gohl, B. 1981. Tropical feeds. Feed information summaries and nutritive values. FAO Animal Production and Health Series 12. FAO, Rome.
- Hagger, R.J. 1974. The effect of quantity, source, and time of application of nitrogen fertilizers on the yield and quality of *Andropogon gayanus* at Shika, Nigeria. J. Agr. Sci. Cambr. 84:529–535.
- Tetteh, A. 1972. Comparative dry matter yield patterns of grass/legume mixtures and pure stands (*Andropogon gayanus, Digitaria decumbens, Centrosema pubescens, Desmodium leiocarpum*). Ghana J. Agr. Sci. 5(3):195–199.

Complete list of references for Duke, Handbook of Energy Crops

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Last update December 22, 1997

Big bluestem

Gramineae *Andropogon gerardii* Vitm.

Source: Magness et al. 1971

This is a vigorous, rather coarse bunchgrass, native over most of the United States; but of major importance in the Central States and the eastern edge of the Great Plains. The stems, which may reach to 6 feet, are solid between nodes. The leaves reach 12 inches or more in length, and are 0.5 inch or less in width and hairy near the base. Growth starts late in the spring and continues throughout the summer, providing good grazing for all kinds of livestock. Good quality hay is produced if mowed before seed heads have formed. Roots penetrate deeply; but the grass thrives best on moist, well drained soils of good quality. Propagation is by seeds.

Last update February 18, 1999 by ch

Sand bluestem

Gramineae, Poaceae *Andropogon hallii* Hack.

Source: Magness et al. 1971

This is a sod-forming grass native from North Dakota and Montana south to Texas and Arizona. It generally resembles big bluestem but differs in having a hairy panicle (the seed head) and more vigorous rhizomes, resulting in more rapid and extensive lateral spread. Stems reach up to 7 feet under the best conditions. It is found mainly on deep, sandy soils and is a valuable range grass on such soil.

Last update June 28, 1996 bha

Broomsedge

Gramineae *Andropogon virginicus* L.

Source: Magness et al. 1971

Broomsedge is a native bunchgrass, widely distributed over the United States, closely related to big and little bluestem grasses. The palatability of broomsedge is poor, so it ranks low as livestock feed. However, it thrives on soils of low fertility and is often the dominant growth on worn out, unproductive soils, affording protection from erosion and some forage. Because of its low palatability it is not used in seeded pastures.

Last update February 18, 1999 by ch

Anethum graveolens L.

Apiaceae (Umbelliferae)

Dill

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, March 2, 1998 by aw

Angelica archangelica L.

Apiaceae (Umbelliferae)

Angelica

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Tuesday, December 30, 1997

Purplestem Angelica

Angelica atropurpurea L.

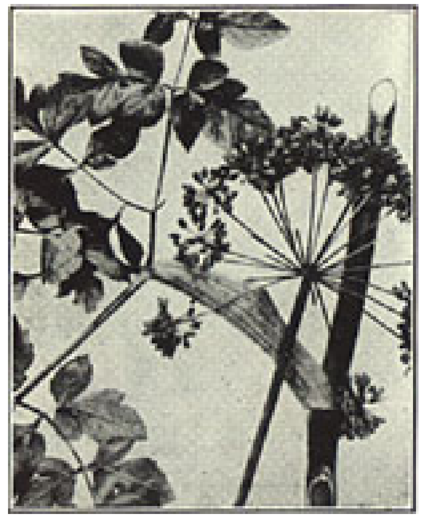

Figure 89.—Purplestem angelica (*Angelica atropurpurea*)

Synonym.—*Archangelica atropurpurea* Hoffm.

Other common names.—American angelica, great angelica, high angelica, purple angelica, masterwort.

Habitat and range.—Purplestem angelica is a native herb, common in swamps and damp places from Newfoundland to Delaware and west to Minnesota.

Description.—This strong-scented, tall, stout perennial reaches a height of from 4 to 6 feet. It has a smooth, dark purple, hollow stem 1 to 2 inches in diameter. The leaves are divided into three parts, each of which is again divided, with many broad leaflets. The lower leaves are sometimes 2 feet in width, but the upper ones are smaller, and all have very broad stalks. From June to July the greenish-white flowers are produced in somewhat roundish heads, which sometimes are 8 to 10 inches in diameter. The root is branched, from 3 to 6 inches long, and less than an inch in diameter. It has an aromatic odor, and the taste at first is sweetish and spicy, afterwards bitter. The fresh root is said to be poisonous.

Part used.—The root, dug in autumn. It must be carefully dried and preserved, because it is very subject to the attacks of insects.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Luffa acutangula (L.) Roxb.

Cucurbitaceae

Angled luffa, Chinese okra, smooth loofah, sponge gourd, vegetable sponge

We have information from several sources:

Asian Vegetables: Selected Fruit and Leafy Types—Marita Cantwell, Xunli Nie, Ru Jing Zong, and Mas Yamaguchi

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Anigozanthos species

Haemodoraceae

Kangaroo paw

We have information from several sources:

New Flower Crops—Abraham H. Halevy

New Floral Crops in the United States—Mark S. Roh and Roger H. Lawson

Pimpinella anisum L.

Apiaceae (Umbelliferae)

Anise, Aniseed, *jintan*, sweet cumin

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Annona cherimola Mill.

Annonaceae

Anona, Cherimoya, Chirimolla, Chirimoya, Custard Apple, Sherbet-fruit

NewCROP has Cherimoya information at:

Cherimoya—Julia Morton, Fruits of warm climates

Atemoya—Julia Morton, Fruits of warm climates

Commercialization of Carambola, Atemoya, and Other Tropical Fruits in South Florida—Jonathan H. Crane

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

New Horticultural Crops in New Zealand—Errol W. Hewett

South American Fruits Deserving Further Attention—Richard J. Campbell

Magness J.R. et al. 1971. Food and feed crops of the United States. (also includes information on *Annona diversifolia*)

Outside links:

Cherimoya Crop Information from University of California Davis

Cherimoya can be found in Lost Crops of the Incas from National Academy Press

CHERIMOYA"FRUIT FACTS" (Fruit Facts are a series of publications of the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Cherimoya nutritional information provided by Frieda's.

Morton, J. 1987. Wild Custard Apple. p. 86–88. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Wild Custard Apple

Annona chrysophylla

A noteworthy, useful African member of the Annonaceae is the wild custard apple, *Annona chrysophylla* Boj. (syn. *A. senegalensis* Auct. non Pers., often cited erroneously as *A. senegalensis* Pers.). The tree is so popular in its native land that it has acquired a wealth of vernacular names: wild soursop, in several localities; *mavulu, mugosa, mbokwe, makulo, mlamote*, etc., in Kenya; *mtopetope* and *mchekwa* in Zanzibar and Pemba; *mabengeya, elipo, obwolo, ovolo*, etc., in Uganda; *aboboma, batanz; bangoora, bullimbuga*, etc., in Ghana; *mposa, muroro* and *mponjela* in former Nyasaland; *dilolo, iolo*, and *malolo* in Angola; *sougni; mete*, d*angan, sounsoun, tangasou, dougour, ianouri*; *ndong, anigli* in former French West Africa.

Description

This is a sprawling shrub or a tree to 20 ft (6 m) high with smooth, silvery bark. The leaves are aromatic, deciduous, alternate, blue-green, broad-elliptic or broadovate, 3 to 7 in (7.5-17.5 cm) long, 1 1/2 to 4 in (4-10 cm) wide, rounded at apex and base, blue-green above, downy, prominently veined beneath. The flowers, borne singly or in pairs in the leaf axils on stalks 1 to 1 1/2 in (2.5-4 cm) long, are clasped by a 3-parted calyx and have 3 triangular, thick, waxy, velvety, whitish outer petals, 3 pale-yellow inner petals, and numerous stamens. Typically compound, the pineapple-scented fruit is smooth but with the carpers distinctly outlined on the surface; yellow or orange when ripe; rounded oval; 1 to 4 in (2.5-10 cm) long; fleshy; seedy.

Origin and Distribution

This species is native and common in savannas throughout tropical Africa from the Cape Verde Islands and the Nile and Upper Guinea to the Transvaal and Zululand. It is little-known outside its natural range. It was long ago introduced by the United States Department of Agriculture into Florida as a potential rootstock for related species, and into Puerto Rico in 1924 and again in 1925 and grown at the Insular Experiment Station, Rio Piedras. According to G.L. Cruz (1979), verbatim from his 1965 publication (see Bibliography), it has become well established as *araticum da areia* in Brazil, especially around Minas Gerais, Bahia and Espirito Santo, but he describes the fruit as rough-surfaced and 8 to 12 in (20-30 cm) in diameter, so he must have it confused with some other species unless there is great variation among seedlings.

Varieties

The botanical variety, *deltoides*, with elliptic to oblongelliptic leaves, rounded to broadly deltoid at the base, is the most common form in Ghana. Eggeling mentions a variety *porpetac* in Uganda with oblong-elliptic, ovalelliptic or elliptic leaves, rounded-obtuse or broadly cuneate at the base. There is reportedly a dwarf form, the fruits of which are borne so low they touch the ground, and are of better quality than those of taller types.

Climate

The wild custard apple is limited to tropical areas up to an elevation of 5,000 ft (1,500 m) and thrives best where its roots can reach water. It remains leafless for several months in the dry season.

Food Uses

The fruit pulp is edible and said to have an apricot-like flavor. Williamson quotes an unidentified source as saying that it is one of the best of the indigenous fruits in parts of tropical Africa. It is much appreciated in the wild by shepherds. According to Irvine, the unopened flower buds are used in soup and to season native dishes; and the leaves are eaten.

Food Value

The dried leaves contain 8.2% protein.

Other Uses

Fruit: The green fruit, because of its high tannin content, is made into ink.

Leaves: Fresh leaves are employed as fodder for domestic animals. Boiled leaves serve as native perfume, and dried leaves are used as filling for mattresses.

Wood: The soft, grayish wood is fashioned into hoe handles and employed in building huts.

Ashes: The wood ashes are used in making soap and native snuff.

Bark and roots: The bark yields a yellow or brown dye. It is pounded in water and the liquid is then used as a hair dressing. A poor-quality fiber derived from the bark is made into rope for tying fences. A combination of the bark and roots serves as an insecticide, and the root has been used for homicidal purposes. The irritant, gummy sap of the bark is an adhesive for arrow poison. There are many superstitious uses of the various parts of the plant.

Medicinal Uses: Fresh fruits in quantity and dried fruits are applied on Guinea worm sores. The parched green fruits are taken to relieve diarrhea and dysentery. A tea of the young leafy twigs or of the roots is taken to alleviate pulmonary complaints. An infusion of the leaves is a popular eye lotion. Dried, powdered leaves are regarded as purgative and as a remedy for mucous diarrhea. With quantities of water, the pulverized leaves are given to horses to expel worms. Combined with the roots and bark and other materials, they are said to be effective in treating yaws in horses. The leaves also enter into a tonic for horses. Venereal diseases and intestinal disorders are treated with preparations of the roots. The bark is chewed to relieve stomachache. It is an emetic and a vermifuge and is given to overcome convulsions in children. The bark infusion, held in the mouth, relieves toothache. In the Upper Volta, an ointment made from the bark is applied on burns. Bark and roots together will halt dysentery, expel worms, and are part of a remedy for sleeping sickness. The root infusion is employed as eye drops. Charcoal of the burned roots is applied on twitching eyelids. The root bark is considered an antidote for snakebite and is used by Nigerian medicine men as a cancer remedy. Investigations have revealed antitumor activity against sarcoma 180 ascites, and antibiotic activity. The trunk bark contains alkaloids, including 0.02% anonaine, also tannins and saponins. The leaves contain rutin, quercetin and quercetrin.

Related Species

The mountain soursop, *A. montana* Macf. (syns. *A. Marcgravii* Mart.; *A. sphaerocarpa* Splitg.; *A. Pisonis* Mart.) is also called wild soursop, *guanabana cimarrona, guanabana de perro, guanabana de loma, corossol zombi; corossolier batard, boszuurzak, araticum-ponhe* and *araticum de paca*. It grows wild from sea-level to 2, 000 ft (650 m) throughout the West Indies and southward into Peru and Brazil, and is cultivated in the Philippines and rarely in Florida.

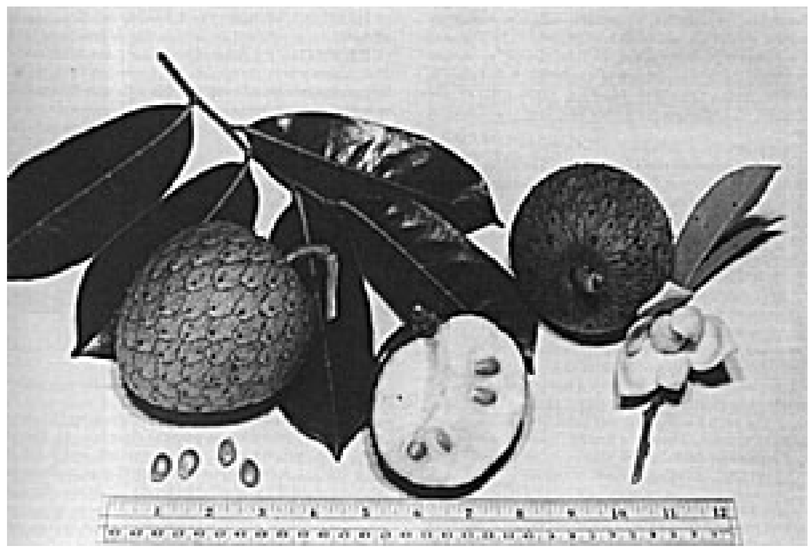

Fig. 25: The scarcely-edible mountain soursop (*Annona montana*).

The tree somewhat resembles that of the soursop but has a more spreading crown and very glossy leaves. It is slightly hardier and bears more or less continuously. The fruit is nearly round or broad-ovoid, to 6 in (15 cm) long. Its dark-green skin is studded with numerous short, fleshy ";spines";. It becomes very soft and falls when ripe. The pulp is yellow, peculiarly aromatic, sour to subacid and bitter, fibrous, and contains many light-brown, plump seeds. The quality is variable but generally very poor. The fruit is generally regarded as inedible but is referred to as ";edible but mediocre"; in Brazil. There, the firm core attached to the base of the peduncle is pulled out and eaten as a tidbit. In southern Florida, exotic parrots eat the fruits and scatter the seeds, and a few trees are consequently occurring as escapes. The tree is of minor interest to horticulturists as an ornamental and rootstock. The wood is soft, fibrous and useful only as fuel.

The pond apple, *A. glabra* L. (syn. *A. palustris* L.), is also called alligator apple, monkey apple, custard apple, corkwood, *mamon de perro, cayur, cayuda*, and various other colloquial names. It grows wild in the Florida Everglades and in coastal swamps and marshes of the Bahamas and throughout the West Indies, in southern Mexico, Central America, and southward into Peru and Argentine; also on the coast of West Tropical Africa. It is occasionally planted in southern Florida and has been introduced into Malaya and the Philippines.

The tree may reach 45 ft (13.5 m), is rather open and spreading; may become very thick at the base; has glossy, leathery, deciduous leaves. The fruit is oval or heartshaped, to 5 in (12.5 cm) long with thin, faintly reticulated, glossy yellow skin and salmon-colored, resinous, subacid, dryish pulp containing many light-brown, flattened-oval, longitudinally-winged seeds that float on water. When fully ripe and soft, the pulp is edible and some specimens are of fair quality and have been made into jelly or wine. The pond apple is of value as a ";survival"; food in extremity and of great importance as fare for wild creatures. Fishermen fashion the light, corklike wood into floats. The leaf decoction is a common, multipurpose folk remedy in the Netherlands Antilles, Mexico and South America. Seedlings are useful as rootstock for other Annona species in wet soils.

Annona diversifolia Saff.

Annonaceae

Ilama, Anona blanca

NewCROP has Ilama information at:

Ilama—Julia Morton, Fruits of warm climates

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 47-62.

Magness J.R. et al. 1971. Food and feed crops of the United States.(also includes information on *Annona diversifolia*)

last update Thursday, January 28, 1999 by ch

Annona muricata L.

Annonaceae

Soursop, Dutch durian, guanabana

We have information from several sources:

Soursop—Julia Morton, Fruits of warm climates

New Crops from Brazil—David Arkcoll

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update October 8, 1997 by aw

Morton, J. 1987. Soncoya. p. 85. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Soncoya

Annona purpurea

Among lesser species of the family Annonaceae, the soncoya, *Annona purpurea* Moc. & Sesse (syns. *A. manirote* HBK. *A. involucrata* Baill., *A. prestoli* Hemsl.) is called *cabeza de negro, cabeza de ilama, chincua, ilama*, or *ilama de Tehuantepec* in Mexico; *anona sincuya, chincuya, cabeza de muerto, sencuya, suncuyo, soncolla*, or *matacuy* in Guatemala; *guanabano torete* or *toreta* in Panama; *gallina gorda, guanabano pun*, or *matimba* in Colombia; *castiguire, manire, manirote, tiragua*, or *tucuria* in Venezuela.

Description

The tree is small to medium, to 20 or even 33 ft (6-10 m) high, with short trunk to 1 1/2 ft (45 cm) in diameter, and spreading branches, which are rusty woolly when young. The deciduous leaves are alternate, short-petioled, undulate, oblong-elliptic or oblong-lanceolate to oblongobovate, 8 to 12 in (20-30 cm) long and 4 to 5 1/2 in (1014 cm) wide, acuminate at the apex, brown-hairy on both surfaces and with prominent veins beneath. Strongscented flowers, which emerge with the new leaves, are solitary, fleshy, large, conical, usually enclosed at first by a pair of bracts; are held at the base by a rusty-hairy, 3 parted calyx, and have 3 very thick outer petals, brownhairy outside, yellowish and purple mottled within, and 3 smaller, thinner inner petals, creamy white outside, purple inside. The fruit, thick stalked, is ovoid or nearly round, 6 to 8 in (15-20 cm) wide, set with hard, somewhat 4-sided, conical protuberances, each tipped with a curved hook, and is coated overall with a brown felt. The pulp is agreeably aromatic, suggesting the mango; abundant, yellow or orange, soft, fibrous, of mild, agreeable flavor. Seeds are numerous, obovate, 1 to 1 3/16 in (2.5-3 cm) long, dark-brown, and each is enclosed in a thin, closefitting membrane. The fruit carpers separate easily when ripe.

Origin and Distribution

The soncoya is native and common in coastal lowlands from southern Mexico to Panama, Colombia and Venezuela. It is grown in dooryards and the fruit is sold in local markets, though it is of mediocre quality and not popular because it is outwardly so hard. The tree was introduced into the Philippines in the early 1900's, grew well and flowered at Lamao but apparently did not set fruit for several years. It was planted at the Federal Experiment Station at Mayaguez, Puerto Rico, in 1918 and in St. Croix in 1930. Several trees have grown well and borne poorly at the Lancetilla Experimental Garden, Tela, Honduras.

Climate

The soncoya requires a hot, humid climate and it never occurs at an altitude higher than 4,000 ft (1,200 m).

Season

The fruits ripen in August in Yucatan; generally in the fall in Central America.

Food Uses

In Colombia, the pulp is eaten raw or is strained for juice, drunk as a beverage or folk remedy.

Toxicity

The seed extract destroys fleas. In Guatemala and Costa Rica, rural people believe the fruit to be unwholesome.

Medicinal Uses

In Mexico, soncoya juice is regarded as a remedy for fever and chills. Elsewhere it is given to relieve jaundice (probably because of its color). The bark decoction is effective against dysentery and a tea of the inner bark is administered in cases of edema.

Annona reticulata L.

Annonaceae

Custard Apple

We have information from several sources:

Custard Apple—Julia Morton, Fruits of warm climates

Annona reticulata —Neglected Crops : 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 85-92.

Last update Thursday, January 28, 1999, by ch

Neglected Crops : 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 85-92.

Custard apples

(*Annona* spp.)

The author of this chapter is H. Mahdeem (Boynton Beach, Florida, USA).

There are an estimated 2200 species of Annonaceae in the world. These include numerous fruit-trees, especially of the genera *Annona and Rollinia;* the majority of *Annona* species and all the *Rollinia* species originate from the New World.

Many of these species were carefully cultivated by indigenous peoples in Mesoamerica, the inter-Andean valleys, the Amazon region and other areas. Other Annonaceous fruits of the New World include species of *Asimina, Duguetia, Fusaea* and *Porcelia.* These fruit-trees have a considerable diversity and degree of adaptation to different environments and are valuable material for hybridization, selection and vegetative propagation studies. The high nutritional value of the fruit, its very distinct flavours and aromas and its attractive shapes and colours justify these efforts.

There are three species, *Annona cherimola, A. muricata* and *A. squamosa,* which are marginal in several regions of tropical America; in other regions, the technology for producing and handling the product has been developed to such a degree that they cannot really be included in this category. The known techniques and selected cultivars can be extended to regions where cultivation is still underdeveloped. Another three, *A. diversifolia, A. reticulata* and *A. scleroderma,* however, have been marginalized in spite of their intrinsic value and potential as fruit-trees.

The fruit of the Annonaceae must not be seen solely as a luxury item for rich consumers, but also as part of the diet of indigenous populations. This fruit is not only special because of its good flavour; it is also highly nutritional. Its food value varies considerably, but most forms have an abundance of carbohydrates, proteins, calcium, phosphorus, iron, thiamine, niacin and riboflavin, while some are rich in magnesium, ascorbic acid and carotene. If they were plentiful and sold at reasonable prices, they would considerably improve the nutrition of many people.

Annona cherimola Miller, the cherimoya, is thought to originate from cold but frost-free valleys of the Andes at an altitude of between 700 and 2400 m.

Excellent cultivars are known, all produced by vegetative propagation, which are planted on a commercial scale in Spain, Chile, Australia, Israel, the United States (California, Florida) and the island of Madeira. The fruit is sold in the supermarkets of many countries and is highly regarded.

The commercial cultivars include Bay Ott, Chaffey, Dr White, Libby, Nata, Orton and Spain.

In the regions where the cherimoya is still a marginal crop, new methods must be applied: artificial pollination, grafting of superior cultivars either on to stock of the same species or on to stock of *A. squamosa* or *A. glahra;* the control of anthracnosis and seed-boring insects; the control of green leaflhoppers; and fruit handling and packaging.

A. muricata L. (English. soursop; Spanish: guanábana; Portuguese: graviola) is possibly native to the Antilles and to the northern part of South America. It grows between 0 and 1000 m altitude. Its commercial production has been developed in Brazil, Venezuela, Costa Rica and other countries for local consumption and export. Cultivation practices have been established in the production areas mentioned; they include the control of insects and diseases and protection of the fruit in plastic bags. There is a great deal of variation in fruit size and sugar content. Trees of higher quality or resistance must be grafted on to stocks of the same species of *A. purpurea* and *A. montana* or, with great difficulty, on *A. glabra*.

A. squamosa L. (English: sugar apple, sweetsop, custard apple; *Spanish:* sarumuyo, anón; Portuguese: ata, pinha) seems to be native to southeastern Mexico, in dry areas and between 0 and 1000 m, although it grows well in regions of medium humidity. It has spread throughout the tropics and displays great variability in India. It is propagated by seed with satisfactory results; however. commercial cultivars are grafted. Of these. Red Sugar, with a red skin and white flesh, is recommended. The main problems are seedboring insects, the green leaflhopper, the tendency towards mummification of the fruit and harvesting and packaging difficulties caused by the fruit's lack of firmness.

The name "atemoyas", derived from "ata" (in Portuguese) and "cherimoya", is given to hybrids between these two species. Several cultivars are known which are sown commercially in the United States (Florida) and Australia. The best atemoyas combine adaptation to low altitudes and hot climate and the high productivity and good flavour of *A. squamosa* with the firm skin, low flesh/seed ratio and the flavour and aroma of *A. cherimola so* that, from the standpoint of quality and packaging, the product is comparable to the best cherimoyas, although it has a higher sugar content. At present, crosses are being made between cultivars of cherimoya and *A. squamosa* Red Sugar and M-2, with the aim of obtaining atemoyas with red- or pink-skinned fruit, which is more attractive than the green fruit of those currently available. The most famous green cultivars are Gefner in Israel and the United States and African Pride in Australia.

Annona diversifolia

Botanical name: *Annona diversifolia* Saff.

Family: Annonaceae

Common names. English: llama; Spanish: anona blanca; other: llama, ilamatzapotl, izlama, papausa

This fruit-tree, which is very highly regarded in its area of origin, has not been developed as it deserves, since it is virtually planted exclusively by indigenous peoples. Although it is greatly esteemed and fetches a good price on the markets of Guatemala, its cultivation does not attract other agricultural owners, nor do the latter obtain bank credit for this tree, whereas they do obtain it for exotic fruit-trees. Other factors that add to its neglect are: the tree's low productivity; the difficulty of seed germination (although methods to encourage germination artificially are already known); and the short shelf-life of the fruit at the markets (two to three days at ambient temperature). If it is left to ripen on the tree, the fruit splits, but if it is picked in this state and stored at normal temperature, the splits scar over. In Guatemala, it is customary to pick the fruit split in this way and to ripen them subsequently in crates or other closed places.

Botanical description

A. diversifolia is distinguished from other species of *Annona* in that it has two classes of leaf: the usual obovate, glabrous leaves with a petiole; and leaves in the form of round, deciduous bracts without a petiole, which grow on the base of the small branches. The undersides of the leaves, small branches and fruit have a powdery, whitish appearance, which is more noticeable in the white-fleshed varieties.

The flowers have three outer petals that are 2 to 5 cm long, and three minute inner petals; the colour is a varietal characteristic and ranges from pink to purplish red.

The fruit, which is about 12 cm long, has white, pink or reddish flesh, with a typical aroma and a sweet, exquisite flavour which, according to most people, is superior to that of the cherimoya. The fruit is very resistant and sometimes completely immune to attack from seed-boring insects.

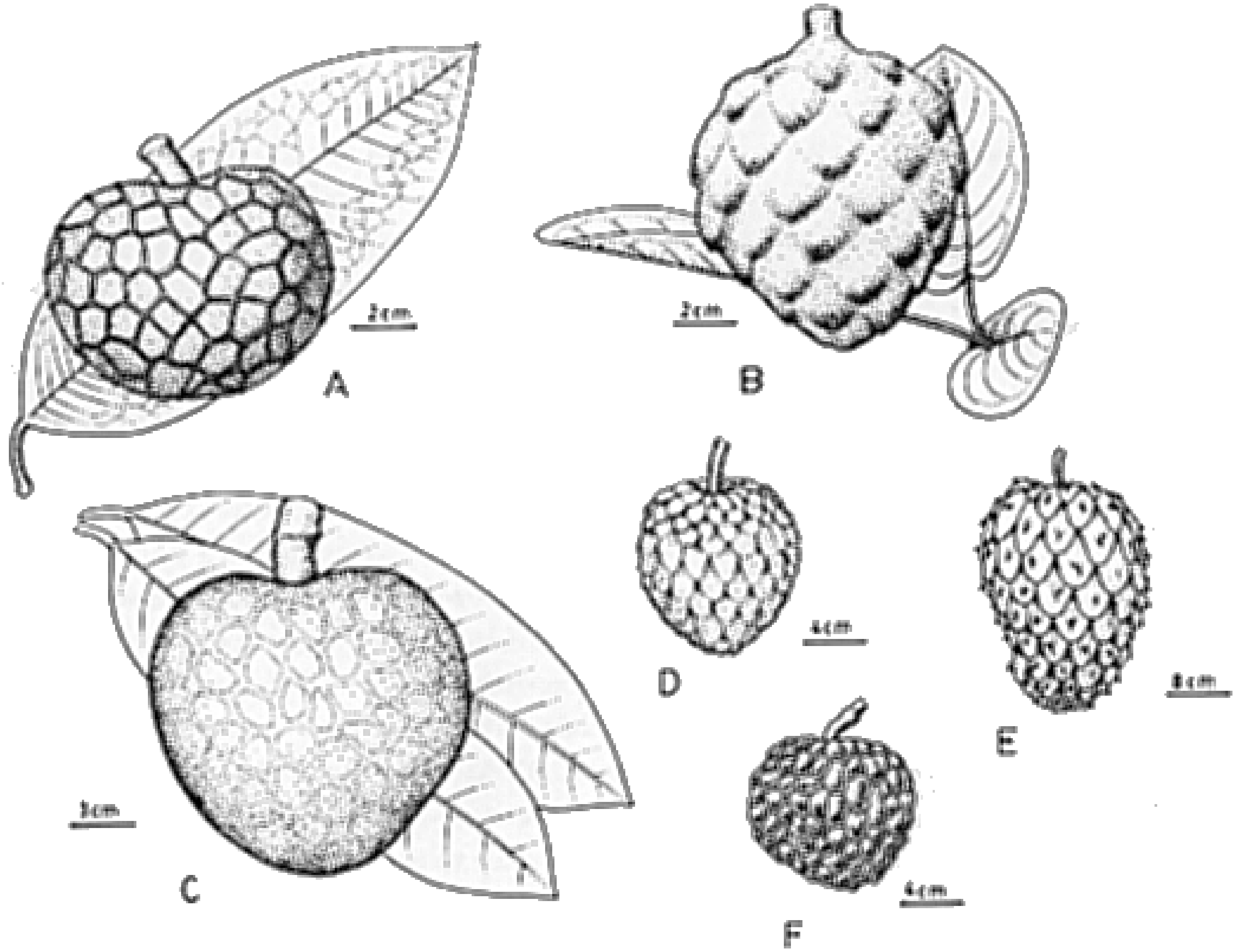

Figure 7. Custard apples: A) *Annona scleroderma*; B) *A. diversifolia*; C) *A. reticulate*; D) *A. cherimola*; E) *A. muricata*; F) *A. squamosa*

Ecology and phytogeography

The llama grows between 0 and 1800 m on the Pacific slope from central Mexico to El Salvador, but it is sown more intensively between 200 and 600 m in southwestern Guatemala. This region has a pronounced dry season (December to March), with an annual rainfall of between 1000 and 1400 mm and very fertile volcanic soils.

Genetic diversity

A. diversifolia is grown alone in vegetable gardens with few trees, and a wide variability is noted. This is particularly expressed in the characteristics of its fruit: its colour (see list of cultivars): its texture, which can range from slightly pasty to juicy, soft or with concentrations of harder grain; and its sweet taste, with a typical aroma. Following is a list of A. *diversifolia* cultivars:

- **Fairchild, Rosendo Pérez, Guillermo** and **Gramajo** have a thick-skinned, greyish green fruit with prominent round areoles and pink flesh. Rosendo Peréz and Gramajo have big fruit. (These cultivars have been bred for Florida.)

- **Imery** (bred in El Salvador) has big fruit that has a thinner skin, low prominences, is pinkish green (greyish brown when ripe) and has pink flesh with bolder spots.
- **Pajapita** has a soft, pink surface (brown when ripe) and bright-pink flesh.
- **Nilito** has a slightly irregular surface, which is bluish green, and red flesh.
- **Roman** has smaller fruit with a hard skin, which is bluish green with pink spots, and purple flesh.
- **Genova white** has a smooth, thin, whitish green skin, and white flesh.
- **Efrain** has up to 200 fruits per tree.

Guatemalan markets sell an llama that has bluish green fruit, with swirling marks such as those in a Van Gogh painting, and delicious bright-red flesh which is easily separated from the seeds. The trees from which this fruit comes have not yet been studied.

The only region to be evaluated as regards genetic erosion is southwestern Guatemala, where the problem does not seem to be serious. There are no gene banks, nor are any preservation techniques known other than live collections. The most promising areas for future exploration are southwestern Guatemala and the state of Chiapas in Mexico.

Cultivation practices

The llama is only grown together with other fruit trees, on the patios of houses or on smallholdings belonging to indigenous peoples. It is always propagated by seed with a long dormancy period which is difficult to interrupt. The seeds should not be sown without being pretreated to interrupt dormancy, such as soaking them in a solution of gibberellic acid, exposing them to the sun, immersing them in hot water or storing them for two to three months.

Prospects for improvement In the case of *A. diversifolia*, urgent work is needed in the following areas:

- vegetative propagation, by grafting, of the best varieties, using various stocks and grafting methods;
- effective interruption of seed dormancy;
- picking and commercial handling of the fruit;
- increasing the production period (July-August) by selecting early and late varieties;
- the establishment of gene banks, at least in localities of the Pacific area of Central America and Mexico;
- stepping up exploration of the species' production areas in Mexico, Guatemala and El Salvador;
- hybridization with other species of *Annona* for the production of more adaptable varieties;
- research on stock of the related wild species *A. macroprophyllata*, from Guatemala and El Salvador;
- research into the possibility that the absence of mycorrhizae or other soil factors are responsible for the growth of this species in other regions of Mesoamerica with favourable climate and soils, and into the possible use of grafting in these cases.

Annona reticulata

Botanical name: *Annona reticulata* L.

Family: Annonaceae

Common names. English: bullock's heart, custard apple, sugar apple; Spanish. anona, anona colorada, anona rosada, corazón; Portuguese: coração de boi; other: cahuex, pox, qualtzapotl, tzumuy

Althosugh it is said that *A. reticulata* is a native of the Antilles. the presence in Guatemala and Belize of a wild variety, *A. reticulata* var. *primigenia*, and also of a very wide variability of cultivars suggests that this zone is the species' area of origin. It has been introduced in other regions of the American tropics and Southeast Asia, without achieving a level of importance comparable to that of *A. cherimola* or *A. squamosa*.

Of the causes of *A. reticulata's* current marginalization, two seem to be the most notable: reproduction by seed, which results in many trees producing much smaller fruit; and the attack of the seed weevil which lays its eggs in the young fruit. When the adult insect develops, it bores tunnels through the flesh, causing mycotic infections and a consequent deterioration of the fruit.

The most attractive aspects of this species are: its pleasant-tasting fruit, which is generally sweet and creamy; the relatively small volume taken up by the skin and seed; and the plant's modest soil requirements.

Botanical description

A. reticulata is a low tree with an open, irregular crown and slender, glabrous leaves which in some varieties are long and narrow, 10 to 20 x 2 to 7 cm, straight and pointed at the apex; and in other varieties wrinkled and up to 10 cm wide. The flowers are generally in groups of three or four, with three long outer petals and three very small inner ones. The fruit is heart-shaped or spherical and 8 to 15 cm in diameter; according to the cultivar, the flesh varies from juicy and very aromatic to hard with a repulsive taste. There is a wide variability in the presence of groups of hard cells that are similar to grains of sand. Both the outside and inside colour varies according to the cultivar.

Ecology and phytogeography

A. reticulata grows between 0 and 1500 m in the areas of Central America that have alternating seasons, and has spread to South America. However, it is in the former region that the varieties previously classified as species are to be found: *primigenia,* already mentioned; and *lutescens.* the yellow custard apple which grows from Mexico to Costa Rica.

Genetic diversity

In Florida (United States) superior cultivars have been selected. especially from Belize and Guatemala. They differ in the characteristics of their fruit and even in their compatibility with stocks.

- **Tikal** is of excellent quality and medium yield; its flesh is bright-red, except in the white areas surrounding the seeds.
- **Canul** has a medium fruit with a waxy, shiny dark-red surface and purplish red flesh; it is very aromatic and deliciously sweet with few concretions of hard cells.
- **Sartenaya** has a medium fruit with a waxy, shiny red surface and pink flesh with a magnificent taste and texture. Although the fruit is not as attractive in appearance as that of the previous two cultivars. the tree is sturdier.
- **San Pablo** has a long, large fruit with an opaque, light-red surface. The flesh is dark-pink with a good aroma and taste. It is a vigorous, productive cultivar.
- **Benque** has a big conical fruit with a dark-red surface and very tasty dark-pink flesh.
- **Caledonia** has a small fruit with a dark surface: it is very attractive to cochineal insects (*Philophaedra* sp.), which are not very common in other varieties. The flesh is pink and has an excellent taste.
- **Chonox** has a medium fruit with a red skin and juicy. very tasty pink flesh; it is very productive and, for this reason, often has low-quality fruit. It produces abundant flowers in groups of up to 16.

No selections have been made from yellow custard apple and there are apparently no great risks of genetic erosion. It is possible that more intensive exploration in Belize, Guatemala and El Salvador might allow new cultivars to be found.

Cultivation practices

A. reticulata is generally propagated by seed, the germination rate of which ranges from low to medium. Grafting is usually done on stock of the same species. The fruit is harvested after its colour changes patterns although in some cultivars this does not occur and ripeness is determined by feel. The skin is very thin and the fruit must therefore be handled carefully. Most fruit is produced for family consumption and it is not commonly found on the markets outside Guatemala. The commercial future of this species depends on two factors: the establishment of grafted trees of high-yielding cultivars with fruit of a high quality and good appearance; and the adoption of control practices such as using protective bags or eradicating seed-boring insects.

Annona scleroderma

Botanical name: *Annona scleroderma* Saff.

Family: Annonaceae

Common names. English: poshte; Spanish. chirimoya, anona del monte; other: cawesh, cahuex, poshté

A. scleroderma is one of the least-known fruit trees of the genus; it is grown mainly in southwestern Guatemala and is notable for the structure of its fruit which, unlike the other cultivated species, has a very tough skin, allowing it to be handled much more easily and making it resistant to insect attack. The fruit may be cut and the flesh removed with a spoon. Its potential value is in its high-quality flesh, hard skin and high yield. It could become an export item and a product for wide local consumption.

However, the height of the tree (which does not facilitate fruit harvesting), the fact that the fruit is attacked by birds and the defoliation caused by wind are an obstacle to exploitation of this species.

Botanical description

A. *scleroderma* is a tall tree which reaches 15 to 20 m and has tough, lanceolate leaves measuring 10 to 25 x 5 to 8 cm. They are shiny on the upper side, slightly pubescent on the underside and have fragile, 3 cm long petioles. The flowers are greenish yellow, the outer petals have a longitudinal prominence which arises in the small branches or in groups in the old part of the thick branches. The fruit occurs in compact spherical groups, is 5 to 10 cm in diameter and generally falls off when ripe, without a noticeable colour change. The cream-coloured flesh has a bittersweet flavour and a soft texture.

Ecology and phytogeography

This species apparently grows wild on the Atlantic slope from Campeche to Honduras but is only grown in southwestern Guatemala between 300 and 1000 m on the Pacific slope. In this area. which is called the Bocacosta and has very fertile volcanic soils, there is a short dry season and an annual rainfall of around 4000 mm. The plant fruits between late December and April, with a maximum yield around the beginning of February.

Genetic diversity

The most visible characteristic of variability is in the fruit's surface. The areoles are generally marked by raised edges which form a hexagon. In some varieties, the edges are reduced to a crisscross of brown lines on a smooth, green surface; in other varieties, there is a central prominence on each areole; in some varieties there are well developed edges and prominences, while still others have an irregular, corrugated surface. The fruit also seems to vary in the thickness of its skin, which is on average 3 mm, but slightly thicker and tougher in the smooth-skinned varieties. The Pacific varieties are green or green with brown spots, while those from the Atlantic side have a thicker, reddish green skin.

No cultivars are known to be established by vegetative propagation. Genetic erosion is evident, since it is a crop with a restricted area in a highly populated region where land is required for building or cultivating coffee. Trees which were sown on coffee plantations have been destroyed or deformed because they produce too much shade or because they were damaged by children picking their fruit.

Genetic erosion is very pronounced in *A. scleroderma*; there are no gene banks and a few plants have been introduced into Australia and the United States (Florida). For this reason, material urgently needs to be collected in southwestern Guatemala (from San Felipe, San Andrés Villa Seca, San Sebastián, Colomba, El Tumbador, etc.).

Cultivation practices

Fresh seeds take about a month to germinate. whether they are collected and dried on the same day or stored in bags for a week or two. They do not need to be soaked or treated in any other way. Seeds that have been stored for two to three months need about six months to germinate. In Australia, *A. scleroderma* grows well when grafted on to stocks of *A. muricata* and *Rollinia mucosa*. When grafted material is planted. it must be borne in mind that the trees should be pruned so that a wide crown remains to facilitate fruit harvesting. This also reduces exposure to wind and bird damage.

The shade requirements of young plants—shade seems to promote growth—need to be studied. However, trees located in sunny positions would have a lower, more compact habit. Trees grown from seed begin to produce at around tour years when they reach a height of 4 to 6 m.

Prospects for improvement

The advantages of *A. scleroderma* as a fruit for local consumption and export are its high productivity and the fact that the flavour and aroma of its flesh are not as strong as in other *Annona* species, but are different and pleasant. The abundant, cream-coloured or creamy grey flesh separates easily from the seeds and it does not have sandy grains or fibres that adhere to the seed membrane. The thick, leathery skin does not split and is very resistant to insect attack and ordinary packaging and transport.

Activities that merit close attention regarding *A. scleroderma* are:

- the collection and evaluation of genetic material;
- propagation through grafting on to stock of the same species or related species to obtain low trees with an open crown, which facilitate fruit harvesting;
- running small market gardens or interplanted crops;
- marketing, since it is a "new" fruit even for Guatemalan markets;
- packaging and transport technology to prolong the good condition of the fruit and its acceptance on the market.

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last update Tuesday, May 05, 1998 by aw

Annona squamosa L.

Annonaceae

Custard apple, Anona, Bullock's-heart, *Corazon*, Nona, Pawpaw, Sugar apple

We have information from several sources:

Sugar Apple—Julia Morton, Fruits of warm climates

Custard Apple—Julia Morton, Fruits of warm climates

Atemoya—Julia Morton, Fruits of warm climates

Commercialization of Carambola, Atemoya, and Other Tropical Fruits in South Florida—Jonathan H. Crane

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

South American Fruits Deserving Further Attention—Richard J. Campbell

Food and feed crops of the United States.—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Eragrostis tef (Zucc.) Trotter

Poaceae

Teff, annual bunch grass, lovegrass, t'ef, toff, warm-season annual bunch grass

Ethiopian: Tef
Oromigna: Tafi
Tigrigna: Taf

We have information from several sources:

Teff FactSHEET—contributed by Gilbert F. Stallknecht

Teff: Food Crop for Humans and Animals—G.F. Stallknecht, K.M. Gilbertson, and J.L. Eckhoff

See: Teff—In: The Western Regional Plant Introduction Station: A source of germplasm for new crop development. Bradley, V.L., R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark. 1993. p. 99-102. In: J. Janick and J.E. Simon (eds.), New Crops. Wiley, New York.

Love grasses—In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Including the following:

- Boer lovegrass, *Eragrostis chloromelas*
- Weeping lovegrass, *Eragrostis curvula*
- Lehmann lovegrass, *Eragrostis lehmanniana*
- Sand lovegrass. *Eragrostis trichodes*

Outside links:

Tef—from Lost Crops of Africa: Volume I: Grains

Tef—by Beyfu Ketema—Link to the publication on the International Plant Genetic Resources Institute web site

Artemisia annua L.

Asteraceae, or Compositae

annual wormwood, sweet annie, sweet wormwood, qinghao (Chinese)

NewCROP information sources for*Artemisia annua* L. :

FactSHEET contributed by: Jules Janick

Artemisia annua L.: A Promising Aromatic and Medicinal—James E. Simon, Denys Charles, Ernst Cebert, Lois Grant, Jules Janick, and Anna Whipkey

Distribution of Artemisinin in *Artemisia annua*—Jorge F.S. Ferreira and Jules Janick

Effect of Water Stress and Post-harvest Handling on Artemisinin Content in the Leaves of *Artemisia annua* L.—Denys J. Charles, James E. Simon, Clinton C. Shock, Erik B.G. Feibert, and Robin M. Smith

For a source for large-quantities of commercial of high-quality artemisia leaf extracts:
Grown by:
Burka Coffee Estates LTD.
P.O. Box 90
Arusha, Tanzania

And Marketed by:
Axel Bolte
Susenbergstrasse 158
CH-8044 Zurich Switzerland
tel: +41-1-364-1812
FAX: +41-1-364-2463
moble: : +41-70-404-0818
email: bolte@access.ch

Links to related species:
Artemisia abrotanum
Artemisia absinthium
Artemisia dracunculus

last update October 21, 1997 bha

Anthriscus cerefolium Hoffm.

Apiaceae (Umbelliferae)

Chervil, Garden Chervil, Leaf Chervil, Salad Chervil, Sweet Cicely, Turnip Chervil, Turnip-rooted Chervil

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Morton, J. 1987. Bignay. p. 210–212. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Bignay

Antidesma bunius Spreng.

When Corner referred to this member of the Euphorbiaceae as a "shady, rather gloomy tree", he could not have been viewing it in fruit, a spectacle that has always aroused enthusiasm. The colorful bignay, *Antidesma bunius* Spreng., is called *bignai* in the Philippines; *buni* or *berunai* in Malaya; *wooni* or *hooni*, in Indonesia; *ma mao luang* in Thailand; *kho lien tu* in Laos; *choi moi* in Vietnam; *moi-kin* and *chunka* by the aborigines in Queensland. Among English names are Chinese laurel, currant tree, nigger's cord, and salamander tree.

Description

The tree may be shrubby, 10 to 26 ft (3-8 m) high, or may reach up to 50 or even 100 ft (15-30 m). It has wide-spreading branches forming a dense crown. The evergreen, alternate leaves are oblong, pointed, 4 to 9 in (10-22.5 cm) long, 2 to 3 in (5-7.5 cm) wide, dark-green, glossy, leathery, with very short petioles. The tiny, odorous, reddish male and female flowers are produced on separate trees, the male in axillary or terminal spikes, the female in terminal racemes 3 to 8 in (7.5-20 cm) long. The round or ovoid fruits, up to 1/3 in (8 mm) across, are borne in grapelike, pendent clusters (often paired) which are extremely showy because the berries ripen unevenly, the pale yellowish-green, white, bright-red and nearly black stages present at the same time. The skin is thin and tough but yields an abundance of bright-red juice which leaves a purple stain on fabrics, while the pulp, only 1/8 in (3 mm) thick is white with colorless juice. Whole fruits are very acid, much like cranberries, when unripe; are subacid, slightly sweet, when fully ripe. Some tasters detect a bitter principle or "unpleasant aftertaste" which is unnoticeable to others. There is a single, straw-colored stone, an irregular, flattened oval, ridged or fluted, very hard, 3/8 in (1 cm) long, 1/4 in (6 mm) wide.


Plate XXVI: BIGNAY, *Antidesma bunius*

P.J. Wester mentions a "very distinct and superior variety" as reliably reported from the Mountain Province, Philippines.

Origin and Distribution

The bignay is native and common in the wild from the lower Himalayas in India, Ceylon, and southeast Asia (but not Malaya) to the Philippines and northern Australia. It is an abundant and invasive species in the Philippines; occasionally cultivated in Malaya; grown in every village in Indonesia where the fruits are marketed in clusters.

The United States Department of Agriculture received seeds from the Philippines in 1905 (S.P.I. #18393); twice in 1913 (S.P.I. #36088 and #34691), and again in 1918 (S.P.I. #46704). Quite a few trees have been planted in southern Florida in the past and the fruits were formerly appreciated as a source of juice for jelly, commercialized in a limited way, but are rarely so used today. There are specimens in experimental stations in Cuba, Puerto Rico, Honduras and Hawaii.

Climate

The tree is not strictly tropical for it has proved to be hardy up to central Florida. It thrives in Java from sea-level to 4,000 ft (1,200 m). It grows well and flowers but does not set fruit in Israel.

Propagation

Many seeds are non-viable in Florida, perhaps because of inadequate pollination. Since seedlings may turn out to be male, and female seedlings may not bear for a number of years, vegetative propagation is preferred. The tree is readily multiplied by cuttings, grafting or air-layering. The air-layers have borne fruit in 3 years after transplanting to the field. Ochse recommends grafting in the wet season because scions will remain dormant in dry weather. Most female trees will bear some fruit without the presence of a male because many of the flowers are perfect.

Culture

The trees should be spaced 40 to 45 ft (12-14 m) apart, each way. And one male tree should be planted for every 10 to 12 females to provide cross-pollination. Wind-protection is desirable when the trees are small. Otherwise they require very little cultural attention.

Yield

Yield varies greatly from tree to tree if they are grown from seed. A mature tree in Florida has produced 15 bushels of fruit in a season. One very old tree at the home of Dr. David Fairchild produced 22 bushels yielding 72 gals (273 liters) of juice.

Season

In Indonesia, the trees flower in September and October and the fruits mature in February and March. The fruiting season is July to September in North Vietnam. In Florida it extends from late summer through fall and winter because some trees bloom much later than others.

Pests and Diseases

The tree is attacked by termites in Southeast Asia. In Florida, the leaves may be heavily attacked by mealybugs and by scale insects and sooty mold develops on their excretions. Here, also, the foliage is subject to green scurf and algal leaf spot caused by *Cephaleuros tirescens.*

Food Uses

In Malaya, the fruits are eaten mostly by children. Indonesians cook the fruits with fish. Elsewhere the fruits (unripe and ripe together) are made into jam and jelly though the juice is difficult to jell and pectin must be added. Some cooks add lemon juice as well. If the extracted bignay juice is kept under refrigeration for a day or so, there will be a settling of somewhat astringent sediment which can be discarded, thus improving the flavor. For several years, the richly-colored jelly was produced on a small commercial scale in southern Florida. The juice makes an excellent sirup and has been successfully fermented into wine and brandy.

In Indonesia and the Philippines, the leaves are eaten raw or stewed with rice. They are often combined with other vegetables as flavoring.

Food Value Per 100 g of Edible Portion*	
Moisture	91.11-94.80 g
Protein	0.75 g
Ash	0.57-0.78 g
Calcium	0.12 mg
Phosphorus	0.04 mg
Iron	0.001 mg
Thiamine	0.031 mg
Riboflavin	0.072 mg
Niacin	0.53 mg

*According to analyses made in Florida and the Philippines.

Toxicity

The bark contains a toxic alkaloid. The heavy fragrance of the flowers, especially the male, is very obnoxious to some individuals.

Other Uses

Bark: The bark yields a strong fiber for rope and cordage.

Wood: The timber is reddish and hard. If soaked in water, it becomes heavy and, according to Drury, "black as iron". It has been experimentally pulped for making cardboard.

Medicinal Uses: The leaves are sudorific and employed in treating snakebite, in Asia.

Related Species

The **Herbert River cherry,** *A. dallachyanum* Baill., is a bushy tree, seldom over 25 ft (7.5 m) in height. The young shoots are slightly hairy. Mature leaves, almost hairless, are ovate to lanceolate-elliptical, 2 to 6 in (5-15 cm) long; deep-green above, bright-green beneath; thick and leathery. The odoriferous male flower spikes are hairy, generally in panicles in the leaf axils, occasionally solitary, more or less interrupted. The greenish female flowers are borne in racemes. The fruits, single or in clusters of 4 to 30, are round to obovoid, up to 3/4 in (2 cm) wide, rich-red when unripe, dark purple-red (nearly black) when ripe and very acid. They ripen fairly evenly in the cluster.

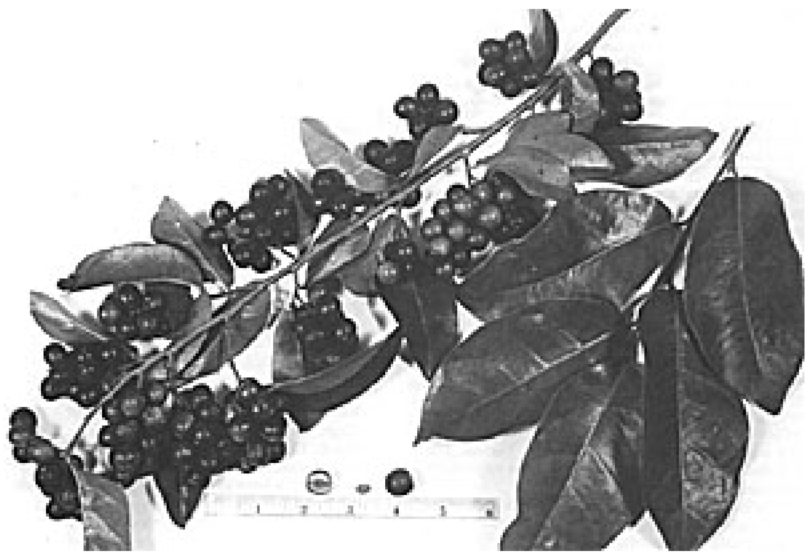

Fig. 55: The Herbert River Cherry of Australia *(Antidesma dallachyanum)* is less showy than the bignay but the fruits have more flesh.

The tree is native to coastal North Queensland, growing on the borders of rain forests and on the banks of streams and lagoons. Seeds were imported by the University of Florida Agricultural Research and Education Center, Homestead, Florida, in 1941 and the seedlings grew and bore well. The seeds germinate readily and seedlings begin to fruit at about 6 years of age when they may be 8 ft (2.4 m) tall. Multiplication may also be by cuttings, air-layering or grafting. One nursery in Florida offered grafted plants for sale but they did not become popular and the species is still rare.

In Australia, the trees bloom from December to February and again in September and the fruits mature in their fall and winter months. In Florida, blooming takes place from April to June and the fruit is in season in September and October.

The extracted juice is very dark-red, nearly black, but it yields, with the addition of pectin, a deep-red jelly.

The tree, like that of the bignay, is prone to infestation by mealybugs and scale insects and associated sooty mold.

The **black currant tree,** *A. ghaesembilla* Gaertn. (syn. *A. pubescens* Roxb.), called *dang kiep kdam* in Cambodia, *chop moi, choi moi, chua moi* or *chum moi* in Vietnam, is a deciduous shrub or bushy tree up to 26 or, at most, 40 ft (8-12 m), with short, russet hairs on the young branches, rosy new foliage and inflorescences. The mature leaves are broad-ovate or nearly circular, 1 1/2 to 3 in (4-7.5 cm) long, glossy on the upper surface. Male flower spikes, purplish or light-yellow with pollen, are dense, 1 to 2 in (2.5-5 cm) long; the erect female shorter and not as compact. Both types occur in terminal panicles or rarely solitary. Some trees bear both male and female flowers but on separate branches. The trees flower off and on during the year but mostly March to May in Asia.

The fruit is velvety, dark-red or very dark-purple, obliquely ovoid with one seed or occasionally double with 2 seeds. The seed kernels are sharply angular. When fully ripe the fruit is subacid to somewhat sweet.

This species has a wide natural range: in tropical Africa, and from the moist tropical lower Himalayas in northern India through Ceylon, southern China, Southeast Asia and Malaysia to the Walsh River region of Queensland. Generally the fruits are eaten mainly by children, but they are appreciated as thirst-quenchers by forest people of Thailand. They were made into jam by early settlers in Australia. In Malaya and Indonesia, they are made into a kind of relish, and the very young leaves are added as acid flavoring to various foods.

The wood is red, hard, close-grained, smooth and used for light rafters in huts, but for little else. Small branches are lopped twice a year for fuel. In India, the leaves are used to treat fever, headache and swollen abdomens. In Cambodia, various parts of the tree are valued in native medicine. The bark, combined with tobacco, is applied on wounds of animals. Combined with the bark of other species, it is boiled and the decoction given to halt diarrhea. The leaves and wood are similarly employed. A decoction of young branches and papaya roots is considered an effective emmenagogue. Crushed leaves are applied on the head of a newborn infant.

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Tropaeolum tuberosum Ruiz & Pav.

Tropaeolaceae

Mashua, Añu

We have information from several sources:

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Andean Tuber Crops: Worldwide Potential—Calvin R. Sperling and Steven R. King

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy.

Outside links

Mashua can be found in Lost Crops of the Incas from National Academy Press

Apios americana Medik.

Fabaceae

Bog potato, groundnut, Indian potato, potato bean, Virginia potato, wild bean, wild potato

We have information from several sources:

FactSHEET—contributed by: Berthal D. Reynolds

Domestication of *Apios americana*—B.D. Reynolds, W.J. Blackmon, E. Wickremesinhe, M.H. Wells, and R.J. Constantin

Protein Quality Evaluation of *Apios amaericana* Tubers (Abstract)—Holly E. Johnson, Maren Hegsted, and William J. Blackmon

Protein Quality in *Apios americana* Tubers and Seeds (Abstract)—P.W Wilson, F.J. Pichardo, W.J. Blackmon, and B.D. Reynolds

Compositional Changes in *Apios americana* Tubers During Storage (Abstract)—D.H. Picha, W.J. Blackmon, P.W. Wilson, L.P. Hanson, and B.D. Reynolds

Inoculation, Nitrogen, and Cultivar Effects on Nodulation and Tuber Yield of *Apios americana* (Abstract)—D.H. Putnam, L. Field, and G.H. Heichel

Evaluations of Preemergence Herbicides for Use in *Apios americana* (Abstract)—D. Wayne Wells and R.J. Constantin

Evaluating *Apios americana* as a Wetland Tuber Crop (Abstract)—Mary E. Musgrave, Alston G. Hopkins, Jr., and Wilham J. Blackmon

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Apium graveolens L.

Apiaceae (Umbelliferae)

Celery, Celeriac, *Céleri Rave*, Celery Heart, Hamburg Celery, Knob Celery, Pascal Celery, True Celery, Turnip-rooted Celery, Wild Celery

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Celery production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Celery
Celery seed
Celeriac

Hemp Dogbane

Apocynum cannabinum L.

Other common names.—Black hemp, black Indian hemp, Canadian hemp, American hemp, amy-root, bowmans root, bitterroot, Indian-physic, rheumatism weed, milkweed, wild cotton, Choctaw-root.

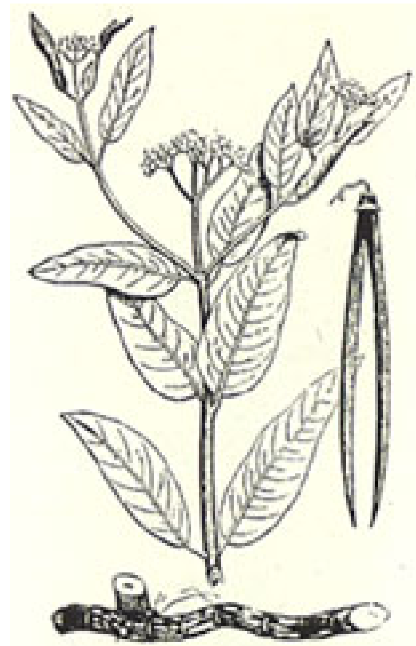

Figure 62.—Hemp dogbane (*Apocynum cannabinum*)

Habitat and range.—Hemp dogbane is a native of this country and may be found in thickets and along the borders of odd fields throughout the United States.

Description.—Hemp dogbane is from 2 to 4 feet high, with erect branches and sharp-pointed, short-stalked leaves from 2 to 6 inches long. The small greenish white flowers which appear from June to August are borne in dense heads followed later by the slender, pointed pods which are about 4 inches in length. The plant contains a milky juice.

Other species.—The roots of a closely related species, *Apocynum androsaemifolium* L., are also collected. The branches of this plant are diverging and forked and the flower heads loose and spreading. It also contains a milky juice. There are several well-recognized forms which formerly were recognized as varieties of *A. cannabinum* and *A. androsaemifolium*, but which are now considered distinct species. The roots of all these species possess somewhat similar properties, but they are not all acceptable to the trade.

Part used.—The root, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Malus sp.

Rosaceae

Apple, cider apple, cooking apple, crab (wild) apple, dessert apple, Golden Delicious, Granny Smith, Gravenstein, Jonathan, McIntosh, Northern Spy, pipin, pome(-fruit), Red Delicious, Rome Beauty, Rome Delicious, Russet, Stayman, Winesap, Yellow Delicious, York, York Imperial

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

New Horticultural Crops in New Zealand—Errol W. Hewett

Exploration and Exploitation of New Fruit and Nut Germplasm—Maxine M. Thompson

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Apple Cultivars for Indiana HO-165 Purdue University Cooperative Extension Service

Home Storage of Apples—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Training and Pruning Fruit TreesHO-49 Purdue University Cooperative Extension Service

PRI disease resistant apple breeding program an apple breeding cooperative of Purdue University, Rutgers, and the University of Illinois.

Outside links:

Apples, *Malus domestica* from Mark Reiger, Horticulture Dept., University of Georgia.

Cereus peruvianus (L.) Mill

Cactaceae

Apple cactus

We have information from several sources:

Development of (*Cereus peruvianus*) Apple Cactus as a New Crop for the Negev Desert of Israel—Julia Weiss, Avinoam Nerd, and Yosef Mizrah

New Crops as a Possible Solution for the Troubled Israeli Export Market—Y. Mizrahi and A. Nerd

Climbing and Columnar Cacti: New Arid Land Fruit Crops—Yosef Mizrahi and Avinoam Nerd

New Fruits for Arid Climates—Yosef Mizrahi, Avinoam Nerd, and Yaron Sitrit

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Prunus armeniaca L.

Rosaceae

Apricot, apricock

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Exploration and Exploitation of New Fruit and Nut Germplasm—Maxine M. Thompson

Outside Links:

Apricot, *Prunus armeniaca* from Mark Reiger at the University of Gerogia.

Apricot kernel oil

Rosaceae *Prunus armeniaca* L.

Source: Magness et al. 1971

Fairly large tonnages of apricot seeds are available from fruits dried or canned. The kernels constitute about 20 percent of the pit weight and contain 40 to 45 percent of a semi-drying oil. To obtain the oil the pits are cracked, shells and kernels separated by flotation in brine, and the oil expressed. The oil is used for edible purposes as well as in cosmetics and some pharmaceuticals.

Last update February 18, 1999 by ch

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Eugenia stipitata McVaugh

Myrtaceae

Arazá, Araça-boi

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

New Crops from Brazil—David Arkcoll

Last update Friday, June 12, 1998 by aw

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Arachis hypogaea L.

Fabaceae

Earth nut, Goober pea, Groundnut, *Mani*, Monkey nut, Peanut, Runner peanut, Spanish peanut, Valencia peanut, Virginia peanut

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Peanut: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Forage, Grain, and Energy Crops for Humid Lower South, US—Gordon M. Prine and Edwin C. French

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Peanut
Peanut oil

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Udo

Araliaceae *Aralia cordata* Thunb.

Source: Magness et al. 1971

Udo is a vegetable grown for its tender, etiolated spring shoots, somewhat like asparagus. It is grown in Japan and to a limited extent by Oriental gardeners in the U.S. The plant is a strong growing perennial, producing the edible shoots from the roots each spring. The summer growth reaches 4 to 8 feet in height, with large, compound pinnate leaves. In culture, the roots are established in beds or rows, like asparagus. As the young shoots start in spring, they are kept covered woth soil for complete blanching. The shoots harvested are up to 18 inches long and 1.5 inches diameter at the base. Prior to use, shoots are boiled in salt water, or are sliced and held in cold water, to remove a turpentine like resin. They are then eaten raw as a salad or cooked.

Season, from growth start in spring to harvest: 2 to 4 weeks.

Production in the U.S.: No data, very limited.

Use: As raw salad or cooked vegetable.

Part consumed: Young etiolated stems only.

Last update June 27, 1996 bha

Wild-Sarsaparilla

Aralia nudicaulis L.

Other common names.—False sarsaparilla Virginian sarsaparilla, American sarsaparilla, small spikenard, rabbitroot, shotbush, wild licorice.

Figure 119.—Wild-sarsaparilla (*Aralia nudicaulis*)

Habitat and range.—Wild-sarsaparilla grows in rich, moist woods from Newfoundland west to Manitoba and south to North Carolina and Missouri.

Description.—This plant produces a single, long-stalked leaf and flowering stalk from a very short stem. The leafstalk is about 12 inches long and is divided at the top into three parts each bearing about five leaflets from 2 to 5 inches long. The flowering stalk produces in May to June three flower clusters consisting of from 12 to 30 small greenish flowers followed later in the season by round purplish black berries. The rootstock is rather long, creeping, somewhat twisted, and possesses a very fragrant, aromatic odor and a warm, aromatic taste.

Other species.—The American spikenard (*Aralia racemosa* L.), known also as spignet, spiceberry, Indian root, petty-morrel, life-of-man, and old-man's root, is used for the same purpose as *A. nudicaulis*. It is distinguished from this by its taller form, its much-branched stem from 3 to 6 feet high, and very large leaves. The flowers are arranged in numerous clusters instead of only three, as in *A. nudicaulis*, and they appear several months later. The range of this species extends as far south as Georgia.

Part used.—The root, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Iwu, M.W., A.R. Duncan, and C.O. Okunji. 1999. New antimicrobials of plant origin. p. 457–462. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

New Antimicrobials of Plant Origin

Maurice M. Iwu, Angela R. Duncan, and Chris O. Okunji

Infectious diseases account for approximately one-half of all deaths in tropical countries. In industrialized nations, despite the progress made in the understanding of microbiology and their control, incidents of epidemics due to drug resistant microorganisms and the emergence of hitherto unknown disease-causing microbes, pose enormous public health concerns. Historically, plants have provided a good source of antiinfective agents; emetine, quinine, and berberine remain highly effective instruments in the fight against microbial infections. Phytomedicines derived from plants have shown great promise in the treatment of intractable infectious diseases including opportunistic AIDS infections. Plants containing protoberberines and related alkaloids, picralima-type indole alkaloids and garcinia biflavonones used in traditional African system of medicine, have been found to be active against a wide variety of micro-organisms. The profile of known drugs like *Hydrastis canadensis* (goldenseal), *Garcinia kola* (bitter kola), *Polygonum* sp., *Aframomum melegueta* (grains of paradise) will be used to illustrate the enormous potential of antiinfective agents from higher plants. Newer drugs such as *Xylopia aethiopica*, *Araliopsis tabouensis*, *Cryptolepis sanguinolenta*, *Chasmanthera dependens* and *Nauclea* species will be reviewed.

INFECTIOUS DISEASE

World wide, infectious disease is the number one cause of death accounting for approximately one-half of all deaths in tropical countries. Perhaps it is not surprising to see these statistics in developing nations, but what may be remarkable is that infectious disease mortality rates are actually increasing in developed countries, such as the United States. Death from infectious disease, ranked 5th in 1981, has become the 3rd leading cause of death in 1992, an increase of 58% (Pinner et al. 1996). It is estimated that infectious disease is the underlying cause of death in 8% of the deaths occurring in the US (Pinner et al. 1996). This is alarming given that it was once believed that we would eliminate infectious disease by the end of the millenium. The increases are attributed to increases in respiratory tract infections and HIV/AIDS. Other contributing factors are an increase in antibiotic resistance in nosicomial and community acquired infections. Furthermore, the most dramatic increases are occurring in the 25–44 year old age group (Pinner et al. 1996).

These negative health trends call for a renewed interest in infectious disease in the medical and public health communities and renewed strategies on treatment and prevention. Proposed solutions are outlined by the CDC as a multi-pronged approach that includes: prevention, (such as vaccination); improved monitoring; and the development of new treatments. It is this last solution that would encompass the development of new antimicrobials (Fauci 1998).

Historic Use of Plants as Antimicrobials

Historically, plants have provided a source of inspiration for novel drug compounds, as plant derived medicines have made large contributions to human health and well-being. Their role is two fold in the development of new drugs: (1) they may become the base for the development of a medicine, a natural blueprint for the development of new drugs, or; (2) a phytomedicine to be used for the treatment of disease. There are numerous illustrations of plant derived drugs. Some selected examples, including those classified as antiinfective, are presented below.

The isoquinoline alkaloid emetine obtained from the underground part of *Cephaelis ipecacuanha*, and related species, has been used for many years as and amoebicidal drug as well as for the treatment of abscesses due to the spread of *Escherichia histolytica* infections. Another important drug of plant origin with a long history of use, is quinine. This alkaloid occurs naturally in the bark of *Cinchona* tree. Apart from its continued usefulness in the treatment of malaria, it can be also used to relieve nocturnal leg cramps. Currently, the widely prescribed drugs are analogs of quinine such as chloroquine. Some strains of malarial parasites have become resistant to the quinines, therefore antimalarial drugs with novel mode of action are required.

Similarly, higher plants have made important contributions in the areas beyond antiinfectives, such as cancer therapies. Early examples include the antileukaemic alkaloids, vinblatine and vincristine, which were both obtained from the Madagascan periwinkle (*Catharanthus roseus* syn. *Vinca roseus*) (Nelson 1982). Other cancer therapeutic agents include taxol, homoharringtonine and several derivatives of camptothein. For example, a well-known benzylisoquinoline alkaliod, papaverine, has been shown to have a potent inhibitory effect on the replication of several viruses including cytomegalovirus, measles and HIV (Turano et al. 1989). Most recently, three new atropisomeric naphthylisoquinoline alkaloid dimers, michellamines A, B, and C were isolated from a newly described species tropical liana *Ancistrocladus korupensis* from the rainforest of Cameroon. The three compounds showed potential anti-HIV with michellamine B being the most potent and abundant member of the series. These compounds were capable of complete inhibition of the cytopathic effects of HIV-1 and HIV-2 on human lymphoblastoid target cell in vitro (Boyd et al. 1994).

The Development of Phytomedicines and the Ethnomedicinal Approach

The first generation of plant drugs were usually simple botanicals employed in more or less their crude form. Several effective medicines used in their natural state such as cinchona, opium, belladonna and aloe were selected as therapeutics agents based on empirical evidence of their clinical application by traditional societies from different parts of the world. Following the industrial revolution, a second generation of plant based drugs emerged based on scientific processing of the plant extracts to isolate "their active constituents." The second-generation phytopharmaceutical agents were pure molecules and some of the compounds were even more pharmacologically active than their synthetic counterparts. Notable examples were quinine from *Cinchona*, reserpine from *Rauvolfia*, and more recently taxol from *Taxus* species. These compounds differed from the synthetic therapeutic agents only in their origin. They followed the same method of development and evaluation as other pharmaceutical agents.

The sequence for development of pharmaceuticals usually begins with the identification of active lead molecules, detailed biological assays, and formulation of dosage forms in that order, and followed by several phases of clinical studies designed to established safety, efficacy and pharmacokinetic profile of the new drug. Possible interaction with food and other medications may be discerned from the clinical trials.

In the development of "Third Generation" phytotherapeutic agents a top-bottom approach is usually adopted. This consists of first conducting a clinical evaluation of the treatment modalities and therapy as administered by traditional doctors or as used by the community as folk medicine. This evaluation is then followed by acute and chronic toxicity studies in animals. Studies should, when applicable, include cytotoxicity studies. It is only if the substance has an acceptable safety index would it be necessary to conduct detailed pharmacological/ biochemical studies.

Formulation and trial production of the dosage forms are structured to mimic the traditional use of the herb. The stability of the finished product is given careful attention during the formulation of the final dosage form. This is a unique blend of the empiricism of the earlier first *generation* botanicals with the experimental research used to prove the efficacy and safety of second *generation* isolated pure compounds. Several pharmaceuticals companies are engaged in the development of natural product drugs through the isolation of the so-called active molecules from plant extracts.

PRESENT USE OF PLANTS AS ANTIMICROBIALS

It is estimated that today, plant materials are present in, or have provided the models for 50% Western drugs (Robbers 1996). Many commercially proven drugs used in modern medicine were initially used in crude form in traditional or folk healing practices, or for other purposes that suggested potentially useful biological activity. The primary benefits of using plant derived medicines are that they are relatively safer than synthetic alternatives, offering profound therapeutic benefits and more affordable treatment.

Therapeutic Benefit

Much of the exploration and utilization of natural products as antimicrobials arise from microbial sources. It was the discovery of penicillin that led to later discoveries of antibiotics such as streptomycin, aureomycin and chloromycetin. (Trease 1972). Though most of the clinically used antibiotics are produced by soil micro-organisms or fungi, higher plants have also been a source of antibiotics (Trease 1972). Examples of these are the bacteriostatic and antifugicidal properties of *Lichens*, the antibiotic action of allinine in *Allium sativum* (garlic), or the antimicrobial action berberines in goldenseal (*Hydrastis canadensis*) (Trease 1972). Plant based antimicrobials represent a vast untapped source for medicines. Continued and further exploration of plant antimicrobials needs to occur. Plants based antimicrobials have enormous therapeutic potential. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials. They are effective, yet gentle. Many plants have tropisms to specific organs or systems in the body. Phytomedicines usually have multiple effects on the body. Their actions often act beyond the symptomatic treatment of disease. An example of this is *Hydrastis canadensis*. *Hydrastis* not only has antimicrobial activity, but also increases blood supply to the spleen promoting optimal activity of the spleen to release mediating compounds (Murray 1995).

Economic Benefit

World wide, there has been a renewed interest in natural products. This interest is a result of factors such as: consumer's belief that natural products are superior; consumer's dissatisfaction with conventional medicines; changes in laws allowing structure-function claims which results in more liberal advertising; aging baby boomers; national concerns for health care cost.

Sales of products in this market have increased dramatically in the last decade. Sales of botanical products in the United States have reached $3.1 billion of the $10.4 billion dollar dietary supplement industry 1996 (NBJ June 1998). The industry anticipates growth on the order of 15–20% into the new millenium (Herbalgram 1996). This growth rate will be maintained in an industry that is still considered to be in its infancy. Many plants that were previously wildcrafted will need to be grown domestically to meet the demands of the consumer. This represents many opportunities for the cultivation of crops for this industry.

A market based illustration of the need for plant based antimicrobials is demonstrated by the dissection of the herbal products market. In reviewing the top botanicals used as antiinfectives, the primary botanical used as an antimicrobial is *Hydrastis* with sales of 4.7% in 1995 (Gruenwald 1997). While antiinfectives agents make up 24 % of the pharmaceutical market (1992 Census of Manufactures 1994).

A similar, analysis of *Hypericum* (St. John's wort), demonstrates the value of such an evaluation. Though *Hypericum* is an antiviral, it is primarily used for its antidepressant activity. In 1995 it was not among the top selling herbs (Gruenwald 1997). However, by 1997, it had become an overnight success, with sales increasing over 20,000% in the mass market sector (Aarts 1998). The meteoric increase in the sales of *Hypericum* is multifactorial, but one factor in its in popularity was the existence of an unexploited market opportunity. In 1994 21% of pharmaceuticals sold were for the conditions affecting the central nervous system (1992 Census of Manufactures). Most of the drugs sold in this category are for depression. During this period of time, none of the top selling herbs sold had a primary indication for depression. This market hole, coupled with the media exposure produced a market success.

Many market holes exist. When using the same strategy to look at antimicrobial agents there is a similar gap. If the market dissection for antiinfectives is viewed in the same light as the *Hypericum analogy,* then perhaps this market is prime for receiving new plant based antimicrobials.

The potential for developing antimicrobials into medicines appears rewarding, from both the perspective of drug development and the perspective of phytomedicines. The immediate source of financial benefit from plants based antimicrobials is from the herbal products market. This market offers many opportunities for those cultivating new crops, as many of the plants that are wildcrafted today must be cultivated to match the demands of this market. Again *Hydrastis,* one of the top selling antimicrobials in the US herbal market, represents an example of a herb that has undergone domestication. Originally this plant, native to eastern North America, was wild crafted. *Hydrastis,* has been used by Native Americans for many conditions, including as an antimicrobial for infections. Efforts to cultivate this plant were undertaken in order to supply the demands of the herbal products market and to battle it's threatened extinction.

It is vital to be in the position to capitalize on the phytomedicine market, providing environmentally responsible solutions to public health concerns presented by new trends in infectious disease. In order to be prepared, the industry must be able to sustainably harvest and supply the herbal market. That means we must be able to anticipate the market needs and develop products to satisfy this market.

PLANTS WITH PROMISING ANTIINFECTIVE ACTIVITY

In our organizations, our major emphasis has been on drug discovery from ethnomedicinal information using the "Third Generation Approach." This method differs in that the clinical evaluation in humans takes place before the precise active constituents are known but the chemical composition and safety of the extracts are determined before formulation into dosage forms.

Plants containing protoberberines and related biflavones used in traditional African system of medicine have been found to be active against a wide variety of micro-organisms. Many medicinal plants of Africa have been investigated for their chemical components and some of the isolated compounds have been shown to posses interesting biological activity. Some of these plants are discussed below.

Garcinia kola, bitter kola (Guttiferae)

Garcinia kola, is found in moist forest and grows as a medium size tree, up to 12 m high. It is cultivated and distributed throughout west and central Africa. Medicinal uses include, purgative, antiparasitic, antimicrobial. The seeds are used in the treatment of bronchitis and throat infections. They are also used to prevent and relieve colic, cure head or chest colds and relieve cough. Also the plant is used for the treatment of liver disorders and as a chewing stick (Iwu 1993).

The constituents include—biflavonoids, xanthones and benzophenones. The antimicrobial properties of this plant are attributed to the benzophenone, flavanones. This plant has shown both anti-inflammatory, antimicrobial and antiviral properties. Studies show very good antimicrobial and antiviral properties. In addition, the plant possesses antidiabetic, and antihepatotoxic activities (Iwu 1993).

Aframomum melegueta (Zingiberaceae) Grains of Paradise

This is a spicy edible fruit that is cultivated and occurs throughout the tropics. It is a perennial herb. The medicinal uses of *Aframomum* include aphrodisiac, measles, and leprosy, taken for excessive lactation and post partem hemorrhage, purgative, galactogogue and anthelmintic, and hemostatic agent (Iwu 1993). The constituents are essential oils—such as gingerol, shagaol, paradol. Studies show antimicrobial and antifungal activity and effective against schistosomes (Iwu1993).

Xylopia aethiopica, Ethiopian Pepper (Abbibacceae)

An evergreen, aromatic tree growing up to 20 m high with peppery fruit. It is native to the lowland rainforest and moist fringe forest in the savanna zones of in Africa. Largely located in West, Central and Southern Africa. Medicinal uses of the plant are, as a carminative, as a cough remedy, and as a post partum tonic and lactation aid. Other uses are stomachache, bronchitis, biliousness and dysentery. It is also used externally as a poultice for headache and neuralgia. It is used with lemon grass for female hygiene. It is high in copper, manganese, and zinc (Smith 1996).

Key constituents are diterpenic and xylopic acid. In studies, the fruit as an extracts has been shown to be active as an antimicrobial against gram positive and negative bacteria. Though it has not been shown to be effective against *E. coli* (Iwu 1993). Xylopic acid has also demonstrated activity against *Candida albicans* (Boakye-Yiadom 1977).

Cryptolepis sanguinolenta Lindl. Schltr. (Periplocaceae)

A shrub that grows in the rainforest and the deciduous belt forest, found in the west coast of Africa. Related species appear in the east and southern regions of the continent. Its main medicinal use is for the treatment of fevers. It is used for urinary tract infections, especially *Candida*. Other uses are inflammatory conditions, malaria, hypertension, microbial infections and inflammatory conditions, stomach aches colic (Iwu 1993).

Active principals identified are indo quinoline alkaloids. Studies show inhibition against gram negative bacteria and yeast (Silva 1996). Additionally studies have shown this plant to have bactericidal activity. Clinical studies have shown extracts of the plant were effective in parasitemia. Recent in vitro study shows activity against bacteria specifically, enteric pathogens, most notably *E. coli* (but also staphylococcus, *C. coli*, *C. jejuni*, pseudomonous, salmonella, shigella, streptococcus, and vibrio) and some activity against *candida* (Sawer 1995). It has shown histamine antagonism, hypotensive, and vasodilatory activities (Iwu 1993). In addition it has demonstrative antihyperglcyemic properties (Brierer 1998).

Chasmanthera dependens Hoschst (Menispermaceae)

A woody climber that grows wild in forest margins and savanna. The plant is cultivated. It is used medicinally for venereal disease, topically on sprained joints and bruises and as a general tonic for physical and nervous debilities. The constituents include berberine type alkaloids, palmatine, colombamine, and jateorhizine. Studies show that the berberine sulfate in the plant inhibits lieshmania.

Nauclea latifolia Smith (Rubiaceae)

It is a shrub or small spreading tree that is a widely distributed savanna plant. It is found in the forest and fringe tropical forest. Medicinal uses are as a tonic and fever medicine, chewing stick, toothaches, dental caries, septic mouth and malaria., diarrhea and dysentery (Lamidi 1995).

Key constituents are indole-quinolizidine alkaloids and glycoalkaloids and sapponins. There are studies showing the root has antibacterial activity against gram positive and negative bacteria and antifungal activity (Iwu 1993). It is most effective against Corynebacterium *diphtheriae*, *Streptobacillis* sp., *Streptococcus* sp., *Neisseria* sp., *Pseudomonas aeruginosa*, *Salmonella* sp. (Deeni 1991).

Araliopsis tabouensis (Rutaceae)

It is a large evergreen tree found throughout west tropical Africa. Its medicinal use is for the treatment of sexually transmitted diseases. The bark infusion is drunk for gonorrhea in the Ivory Coast (Irvine 1961). Its major constituents are alkaloids. Seven alkaloids have been isolated from the root and stem bark (Fish 1976).

CONCLUSION

Thomas Jefferson wrote that "The greatest service which can be rendered any country is to add a useful plant to it's culture." Plants have forever been a catalyst for our healing. In order to halt the trend of increased emerging and resistant infectious disease, it will require a multi-pronged approach that includes the development of new drugs. Using plants as the inspiration for new drugs provides an infusion of novel compounds or substances for healing disease. Evaluating plants from the traditional African system of medicine, provides us with clues as to how these plants can be used in the treatment of disease. Many of the plants presented here show very promising activity in the area of antimicrobial agents, warranting further investigation.

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Thuja occidentalis L.

Cupressaceae

Arborvitae, Northern white cedar

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

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Burdock, Edible

Gobo, Harlock, Clotbur

Source: Magness et al. 1971

Compositae *Arctium lappa* L.

Burdock plants are rather coarse perennials which are weeds in many temperate areas, including the U.S. Tops die down in winter. New sprouts rising from roots in spring are peeled and eaten raw or after cooking. Roots are also eaten in Japan. Sparingly grown as a vegetable in Japan and possibly other countries.

Season, start of growth from old roots to harvest of sprouts: 2 to 4 weeks.

Production in U.S.: 100 acres, 1959 census; 187 tons, 1968 census.

Use: Sprouts as salad or pot herb. Roots cooked.

Part of plant consumed: Tender spring sprouts, roots.

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Burdock

Arctium minus (Hill) Bernh.

Synonym.—*Lappa major* Gaertn.

Other common names.—Cockle button, cuckold dock, beggar's-buttons, hurr-burr, stick-button, hardock, bardane.

Figure 28.—Burdock (*Arctium minus*)

Habitat and range.—Burdock, one of our most common weeds, was introduced from the Old World. It grows along roadsides and in fields, pastures, and waste places, being very abundant in the Eastern and Central States and in some scattered localities in the West.

Description.—Burdock is a coarse, unsightly weed. During the first year it produces only a rosette of large leaves from a long tapering root. In the second year the plant grows to a large size, measuring from 3 to 7 feet in height. The stem is round, fleshy, and much branched and bears very large leaves, the lower ones frequently measuring 18 inches in length. The flowers are not produced until the second year, appearing from July until frost. They are purple and are borne in small clustered heads armed with hooked spines, and the spiny burs thus formed are a great pest, attaching themselves to clothing and to the wool and hair of animals. The plant has a large fleshy taproot. When dry this root is much wrinkled lengthwise.

Part used.—The roots, collected from plants of the first year's Growth. As they are large and fleshy they are likely to become moldy, and it is best to slice them lengthwise, so that drying may proceed more rapidly. The roots of other species of Arctium are also used.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

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Bearberry

Arctostaphylos uva-ursi (L.) Spreng.

Figure 14.—Bearberry (*Arctostaphylos uva-ursi*)

Other common names.—Uva-ursi, red bearberry, bear's-grape, bear's bilberry, bear's whortleberry, foxberry, upland cranberry, mountain cranberry, crowberry, mealberry, rockberry, mountain box, kinnikinnic, killikinnic, universe vine, brawling, burren myrtle, creashak, sagachomi, rapper dandies (fruit).

Habitat and range.—Bearberry, also commonly known in the trade as uva-ursi is a native of this country, growing in dry sandy or rocky soil from the middle Atlantic States north to Labrador and westward to California and Alaska.

Description.—The bearberry is a low, much-branched shrub trailing over the ground and having numerous leathery evergreen leaves about 1 inch in length. The waxy flowers, which appear in May, are few and are borne in short, drooping clusters at the ends of the branches. They are white with a pinkish tinge, 5-lobed, and somewhat bell-shaped in form. Smooth, red, globular fruits containing five nutlets follow the flowers.

Part used.—The leaves, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

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Mizrahi, Y. and A. Nerd. 1996. New crops as a possible solution for the troubled Israeli export market. p.37-45. In: J. Janick (ed.), Progress in new crops. ASHS Press, Alexandria, VA.

New Crops as a Possible Solution for the Troubled Israeli Export Market

Y. Mizrahi and A. Nerd

In stimulating articles, Noel Vietmeyer (1986, 1990) pointed out that relatively few plant species, most of which were domesticated thousands of years ago, serve as food for humans and animals, as medicinal plants, and as industrial crops. As a result of atmospheric CO_2 increase and global warming, dryer conditions are expected in the future and many existing crop species will unable to survive. Many undeveloped and neglected species could be the new crops of the future, which will tolerate these changing climatic conditions. Research and Development on the development of tolerant crops should be initiated world wide to meet these challenges. New crops should have the potential to thrive in marginal, infertile, dry lands where common crops fail to provide the diversification required to enable sustainable agricultural systems in the future and offer viable commercial opportunities.

Israel is small country (~5 million people and 22,000 km^2) that is self sufficient in agricultural production. The local market is tiny and is subject to dramatic fluctuations in supply and demand. When extra few tonnes of fresh fruits and/or vegetables are dumped onto the local markets, prices plummet and farmers cannot make a living. In contrast the export market, mainly Europe, with hundreds of millions of consumers is unlimited from an Israeli point of view. Thus, Israel is basically an export oriented producer. At its peak, the export volume of fresh agriculture produce (mainly fruits, vegetables, and flowers) from Israel was valued around US$1 billion/year. In the 1960s the fruit export industry (mainly citrus, with the famous `Jaffa' orange being the main product) constituted one of the main sources of foreign currency (out of a total export market of US$211 million agricultural produce comprised about US$64 million, i.e., 30.3% of the total!). Today, Israel is an industrial exporting country with total annual export value of US$14 billion while exports of agricultural fresh produce amount to US$547 million, a mere 3.9% of the total (Statistical Abstracts 1994). It is obvious that a small country such as Israel has to compete in world markets in terms of quality rather than quantity. As a result, millions of R&D dollars have been invested in the past two decades to enable Israel to compete in the world markets with the best possible products giving the highest possible return to the growers. Despite the huge input of R&D in the agricultural sector, the production of the citrus is diminishing (Fig. 1) due to lack of profitability (Fig. 2) and farmers are complaining. Citrus sales have diminished by 30.6% from 1990 to 1993 and profitability in terms of revenue's buying power has declined to 57.3% when inflation is taken into account (Fig. 2; Statistical Abstracts 1994; BDO 1995). The Israeli tomato export industry has stagnated at 8,000 t annually for the past few years, despite the enormous R&D efforts that have produced the world's finest quality (Statistical Abstracts 1994). Israel has additional cost limitations on its competitiveness. Water is a major limiting factor and its actual price is very high (US$0.22 per m^3) and the alternative price is even higher. Labor is very expensive, since farmers are in the upper middle class strata. More than 90% of the agricultural community in Israel is either a kibbutz (community farm) or a moshav (family farm) with minimum hired labor, where most of the work is performed by the farm owners and their families. Gross income below US$100 and even 150 US$/day is considered very low. Israel's competitors in the world markets pay to agricultural workers 10% and less of this sum! Finally, energy is expensive, since almost all the country's energy is imported.

These problems have led many experts in Israel to raise the possibility of giving up agricultural production, even for the local markets, and purchasing all the country's agricultural needs abroad, as do Singapore and Hong Kong. We subscribe to a totally different approach. We believe that supplying the new crops niche in the world markets will serve as a remedy for the troubled Israeli agricultural export industry.

PRODUCT PROFIT CYCLE

In a free market every product is following the profit cycle, as described in Fig. 3. When a totally new crop is first marketed, no profit is expected, since the market has yet to accustom itself to the product. At this stage, low prices are set to attract consumers. In many cases, the market does not respond to the new product, and it simply vanishes without being noticed by most consumers. But if the market likes the new product (perhaps as a result of good marketing strategy), profits will rise as a result of increasing demand and improved production efficiency (Fletcher et al. 1995). Maximum profitability will be achieved by the first producer as long as he is the only suplier in the market. Competition will then start, first with the most efficient and aware producers and from many others. As a result, profitability will decline, and as with all common crops, it will fall to a maginal level. At this stage, only the big and efficient producers can survive. It is thus evident that Israel cannot compete in the market for common crops. A good example of the scenario described above is the "iceberg lettuce episode." In the late 1970s, Marks and Spencer (from the UK) approached the Negev R&D Organization to test the feasibility of growing iceberg lettuce in the Israeli Negev Desert for their chain. Farmers in the Arava valley (Moshav Ein Yahav and Hatzeva) produced the best iceberg lettuce that Marks and Spencer had ever received. The company, which was ready to pay these farmes higher prices than those given their American counterparts in California, was mystified by the refusal of the Israeli farmers to accept the contract. The buyers from Marks & Spencer simply did not understand that these farmers consisted of very small farms (4 ha!), expensive water, and very high energy, and labor costs. In no way, could they compete with the large American producers.

On the other hand, when we start with totally new product, the high profits obtained for small quantities of exotic fruits and vegetables, creates a natural niche for Israeli farmers. These farmers, being highly educated, can easily adopt new crops and new technologies. Israel is also blessed with research institutions and extension services capable of carrying an efficient R&D programs, which are essential for the introduction of new crops. In addition, Israel has a single efficient marketing arm of agricultural products (AGREXCO), which can easily adapt to such programs.

Unfortunately, such a strategy has not yet been adopted by the Israeli R&D authorities. The main objection to such R&D programs is the fact that the market size and the prices of the new products are unknown. Our feeling is that such a niche does exist, and the only way to confirm its existence is to test it. Even the return from R&D is expected to be higher when dealing with new crops. We may ask the question: how much can new R&D increase the profitability of well-established crop at the edge of their profit cycle? We claim that such an effort can yield much more when new crops are investigated.

Unfortunately, in Israel as in most other countries, most agricultural R&D is conducted with money raised as levies from sales. Thus apple growers for example, would like to see their money invested back into R&D on apples. The bigger the crop and the greater the body of knowledge about its biological and agricultural aspects, more R&D is applied. As a result, money is allocated mainly to the "good old crops," while the new crops of the future are neglected. A change in policy is needed to promote more research in the direction of new crops.

NEW CROPS INITIATIVE

In the light of the dilemma discussed above, we initiated in 1984 an R&D project for the "Introduction and domestication of rare and wild fruit and nut trees as new crops to the Israeli Negev Desert" (Nerd et al 1990; 1993). This project includes about 40 different fruit tree species (Table 1) from all over the world that are considered to be potential new export crops. For the project, four sites were selected in the Negev Desert and one location in the Judean Desert, each site differing from the others in terms of climate, soil, and water (Nerd et al. 1990, 1993). The first stage, which lasted about 10 years, was devoted to assessing the survival, growth, phenology, yields, and quality of seedlings of the investigated species. For all the species we preferred to start with seedlings, which provide wide base of genetic backgrounds, rather than to concentrate on a very narrow base of vegetatively propagated preselected genotypes. Many species did not survive, and others are still at various stages of R&D, far away from any onsiderations of economic potential. Four types of fruit have already been moved to the second stage of this program, which will enable us to provide economic evaluation, such as the cost of various inputs per unit area and the output during the years up to the time that the orchards will reach the full production stage. In this second stage of the project, vegetatively propagated specimens are also being tested in a cultivar trial. The expected small quantities that will be produced at this stage (20-30 t/year/crop) will also enable us to evaluate the marketing and find solutions to post-harvest problems. The market figures will enable farmers to take decisions whether or not to enter into the arena of these new crops.

The species that are currently in the second stage of the project include: (1) climbing trellised cacti growing in net houses--*Selenicereus megalanthus* and three species of *Hylocereus*; (2) the outdoor-grown cactus *Cereus peruvianus*, also known as apple cactus; (3) white sapote (*Casimiroa edulis*); and (4) Ber (*Ziziphus mauritiana*) also known as "desert apple," a species introduced from India. Two more species are under consideration for moving to the second R&D stage: (5) marula (*Sclerocarya birrea* subsp. *caffra*), for which 10 clones are currently being propagated and will be ready for planting next year, and (6) argan (*Argania spinosa*), a wild oil tree from Morocco, which will be promoted to the second stage after the selection of the current fruiting year.

Crawling Cacti

These species which are native to Central and north South America, climb on tree trunks in the tropics and may be epiphytic (Gibson and Nobel 1986). Their fruits have various sizes, tastes, shapes, and colors. Some have spines that abscise upon ripening and others have scales of various shapes and colors. The pulp also varies in color from white to various hues of red and purple, while the abundant seeds may be soft and edible (Mizrahi et al. 1996). The reproductive biology of these species is described in a review by Nerd and Mizrahi (1996). Five genotypes are already growing in an area of 2 ha, mainly in net houses since they require shade (Nerd et al. 1990; Raveh et al. 1993; Mizrahi et al. 1996). One clone of *Selenicereus megalanthus*, also known as yellow pitaya, is being cultivated (Weiss et al. 1995). Yellow pitaya is already an established crop that is being exported worldwide from Colombia (Arcadio 1986; Cacioppo 1990; Mizrahi et al. 1996). Other clones include one of *Hylocereus polyrhizus*, one of *H. undatus* and two of *Hylocereus* sp. (Barbeau 1990), all our selections. These clones have been planted in two plantations, each of 0.5 ha. Each clone was planted in a different row to allow cross pollination from the neighboring rows (Weiss et al. 1994b). All were planted in the late summer of 1993 as rooted cuttings removed from the same mother plants, and all started to fruit in 1994. In these plantations two net houses were planted, one with 50% shade in the Arava valley, having a hot climate and saline water (EC 4 dS/m), and the other with both 30% and 60% shade sections in the Besor area, which is characterized by good quality water (EC 1 dS/m) and moderate temperatures with only rare frosts (Nerd et al. 1993). The second hectare was planted in the Yad Mordekhay area, with sub-freezing temperatures as low as -4deg.C; here, plastic houses were planted to accommodate selected and non-selected plants. All started to fruit one year after planting.

Cactus Apple

Of many columnar cacti tested by us as potential new crops, one species--*Cereus peruvianus*--grew the fastest. It started to flower and fruit four years after seeding (Nerd et al. 1993; Weiss et al. 1993). Rooted cuttings of seven clones of this cactus, selected from over 300 seedlings, were planted in the Arava valley and the Besor, with a total area of 2 ha. All cuttings were planted as a mixture of clones, since this species demonstrates self-incompatibility (Weiss et al 1994a). The reproductive biology of this cactus is also described in the review of Nerd and Mizrahi (1996). All clones started to flower and fruit two years after planting. Over 1,000 seedlings have been planted for further selection.

White Sapote

White sapote (*Casimiroa edulis*, Rutaceae) is an evergreen medium-size tree native to the highlands of Mexico and Central America. The fruits are green-yellow, with a thin skin and a creamy white-yellow sweet flesh (Morton 1987). Selected clones are available, mainly in Southern California (Chambers 1984; Morton 1987), and some effort has been made to introduce the species into New Zealand and Australia (Dawes and Martin 1988; George et al. 1988). A small commercial plantation (16 hectares) with selected cultivars is being grown in Carpenteria near Santa Barbara, California and the fruits can be found as an exotic item in the United States and Australia. Early tests in the Israeli Negev Desert demonstrated partial tolerance to salinity (Nerd et al. 1992). In autumn 1992 and spring of 1993, 21 grafted clones were planted in Qetura and Besor; 16 were introduced as bud-wood from Fallbrook, Southern California (from R.R. Chambers orchard), while the remaining five were propagated as grafted bud-wood from our own selections. Nine replications from each clone were planted in three blocks at each location. In 1995 some clones started to flower and set fruits in these two locations.

Desert Apple

Desert apple (*Ziziphus mauritiana*, Rahmnaceae), also known as ber or Indian jujube, is an evergreen, medium-size, thorny tree believed to be of African origin (Alexander, 1979). The fruits can reach plum size, turning yellow from green as ripening starts, and becomes sweet and sour in taste, both the flesh texture and taste being reminiscent of apples. The fruit has a unique aroma, similar to that of carob, which becomes too strong for "Western" tasters when fully ripe, at which stage the color turns brown. The fruit can be consumed dry, similar to its relative the "Chinese date" *Z. jujube*. Ber is grown commercially as a desert crop (hence the name desert apple) in India. Seedlings and introduced cultivars from India developed and yielded very well (over 100 kg/tree annually) in all our introduction orchards, including areas with frequent sub-freezing temperatures and highly saline water (Nerd et al. 1990). Three Indian cultivars were planted at Neot Hakikar, the lowest point on earth -400 m below sea level with 3,960 mm evaporation/year and saline water (EC 4 dS/m) with Na and Cl as the major ions (Nerd et al. 1993). Most of our introduced fruit tree species did not survive under these conditions, but ber has fruited heavily from very early ages. A semi-commercial plantation was planted by a farmer in 1993, and the first yield was sold in 1995 in the local market, mainly to immigrants from India who are familiar with the fruit.

Marula

Marula (*Sclerocarya birrea* subsp. *caffra*, Anacardiaceae) is a large, dioecious, deciduous tree, which grows wild in southern Africa. Female trees bear plum-sized fruits with a thick yellow peel and a translucent, white, highly aromatic sweet-sour fruit, which is eaten fresh, like a small mango, or used to prepare juices, jams, conserves, dry fruit rolls, and alcoholic beverages. The seeds, which are eaten as a delicate nut, are highly appreciated by the locals and hence the name "the kings nut." The nut has high nutritive value and a high oil content (56%) with very good dietetic ratio of saturated to unsaturated fatty acids (Weinert et al. 1990). Trees were established very well at introduction sites in the Negev Desert and produced abundant fruits from early ages, mainly when grown in a hot area with saline water (Qetura) (Nerd and Mizrahi 1993). Trees were badly damaged after a spell of sub-freezing temperatures of -6° and -7°C; all recovered but never set fruits, and thus this species is not recommended for areas with such low temperatures. At Qetura, some pistillate trees are bearing well, over 400 kg/tree annually, and we have moved the species to the second stage of our R&D program to test selected clones on a semi-commercial basis. Ten selected clones are being propagated and will be ready for planting in 1996.

Argan

Argan (*Argania spinosa*, also known as *A. sideroxylon*, Sapotaceae) is a medium, thorny, evergreen tree native to south western Morocco. The tree bears plum-sized fruits, which are eaten by goats which often climb the trees. The fruits have a bitter pericarp around a stone-like structure, containing one to three kernels with a high oil content (over 50%). The oil has high dietetic value, total unsaturated fatty acids/total saturated fatty acids being around 4.5, a ratio similar to that of olive oil (Morton and Voss 1987; Prendergast and Walker 1992). The oil has a unique aroma and is considered as the best culinary oil by Moroccans, who are the only people familiar with the oil. In Israel, where 600,000 immigrants from Morocco reside, imported argan oil is sold for US$43/liter in comparison with $4/liter for olive oil. Attempts to domesticate this wild tree in Israel started about 10 years ago. The species demonstrated adaptability to the hot hostile environment of the Arava valley when irrigated with brackish water; yields of oil per tree at Qetura were double those at Ramat Negev, which has much milder environmental conditions (Nerd et al. 1994). The oil yield of best specimens was around 1 kg/tree annually. Some seedlings died as a result of infection with *Fusarium oxysporum*. Until tolerant rootstocks can be found, we decided to plant grafted trees from the best yielding ones and to plant additional seedlings from various habitats in Morocco. Even though this species is not in as advanced stage of introduction as the marula, we consider it to be a high-priority species because of its rarity and the high demand in Israel for its oil.

CONCLUSIONS

It is interesting to note that in our earliest publication (Nerd et al. 1990), we mentioned six species as promising, an evaluation based on their early development and growth. These species included white sapote and ber, which are still considered promising, and marula, which has been moved to the second stage of the R&D, but they also include yehib (*Cordeauxia edulis*), mongongo (*Ricinodendron rautanenii*), and pitaya agria (*Stenocereus gummosus*), which did not meet our early optimistic expectations. The latter three species proved to be late yielders (pitaya agria); or exhibited sensitivity to the desert conditions of our introduction sites, such as salinity or sub-freezing temperatures; or were not as abundant in fruiting as the promising species described in this presentation. Other promising species emerged, such as *C. peruvianus*, with its adaptability to a spectrum of conditions, including slight salinity and sub-freezing temperatures. The species produces early and heavily, giving good-quality, tasty fruits. The most surprising successes were the various crawling cacti (*Hylocereus* species and *S. megalanthus*), which did not survive the outdoor Negev Desert conditions (Nerd et al. 1990), but once trellised and protected from high radiation by net houses, started yielding precociously and early to give some of the most beautiful fruits on earth.

Of the six promising species from the first R&D stage, three were moved into the second stage (white sapote, ber, and marula), while others, the apple cactus and the crawling cacti, emerged as promising and already planted as vegetative clones (moved to second stage). This evaluation was based on fruiting (both as yields and fruit quality) and early selection of good-performing specimens.

We anticipate that at least some of these newly introduced species will become export items with profit levels that will be sufficiently high to revive the fruit export industry and replace the old "dying-out" export crops. The high profitability of new fruit crops was demonstrated for kiwi fruit by New Zealand in the world market and for avocado by Israel in the European market. There is no reason why such new exotic fruits will not be the commodities of the future. We should not forget that no crop can stay at its peak forever, and low profits always loom in the future. Mr. Dan Rymon (pers. commun.), found that it took 17 years from the first sales of flower crops in the European markets until Israel was chased out by its competitors. With fruit trees, it may be much much longer, as was the case with the kiwi fruit from New Zealand (47 years) and the `Shamuti' (`Jaffa') orange from Israel (80 years).

We should conclude with an evaluation of the benefits of our program to the world as a whole. Any species that can produce good yields in the Arava valley--the location of both Qetura and Neot Hakikar--can serve as a future crop species that can tolerate extremely high temperatures and salinity. Because of the unique situation in the Negev Desert of short distances between agriculturally different ecozones, we recommend that this area be used as a global laboratory for the introduction and acclimation of new desert crops. In 1994 the International Program for Arid Land Agricultural Crops (IPALAC) was initiated under the auspices of UNESCO. This program is aimed at R&D similar to that described in this paper, to be executed with all kinds of agricultural crops in representative desert areas around the globe.

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Table 1. List of candidate species.

Family Botanical name	Common name	Distribution
Apocynaceae		
Carissa grandiflora A. DC.	Carrisa	Southern America
Anacardiaceae		
Sclerocarya birrea subsp. *caffra* Sounder	Marula (Morula)	Southern Africa
Spondias cytherea (*Spondias dulcis*) Forst	Ambarella	Polynesia
Bombacaeae		
Bombax glabra	Malabar nut	Central America
Cactaceae		
Acanthocereus tetragonus (L.) Humlk.	Acanthocereus	Mexico
Cereus peruvianus (L.) Miller	Apple cactus (Pitaya)	North South America
Escontria chiotilla (Weber) Britt & Rose	Pitaya (Jiotilla)	Mexico
Hylocereus costaricensis (Weber) Br. & R.	Pitahaya	Central America
Hylocereus paolyrhi (Weber) Br. & R.	Pitahaya	Central America
Hylocereus polyrhizus (Weber) Br. & R.	Pitahaya	Central America
Hylocereus purpusii (Weber) Br. & R.	Pitahaya	Central America
Hylocereus undatus (Weber) Br. & R.	Pitahaya	Central America
Myrtilloactus geometrizans (Mart.) Cons.	Pitaya	Mexico
Nopalea cochenillifera (L.) Salm-Dyck	Nopalito, Nopalea	Mexico
Opuntia ficus-indica (L.) Miller	Prickly pear	Tropical America
Opuntia streptacantha Lem.	Prickly pear	Tropical America

Pachycereus pringlei (Berger) Britt & Rose	Cardon pelon	Sonoran Desert
Selenicereus megalanthus (Schum.) Br. & R.	Pitaya	Columbia
Stenocereus griseus (Haw.) Buxb.	Pitaya	Oaxaca Mexico
Stenocereus gummosus (Engelm.) Gilbs.	Pitaya agria	Sonoran Desert
Stenocereus stellatus (Pfeiff.) Riccob.	Pitaya	Mexico
Stenocereus thurberi (Engelm.) Buxb.	Pitaya dulce	Sonoran Desert
Stenocereus thurberi var. *litoralis* (E.) B.	Pitaya dulce	Sonoran Desert
Caesalpiniaceae		
Cordeauxia edulis Hemsl.	Yehib	Northeast Africa
Ebenaceae		
Diospyros digyna Jacq.	Black sapote	South America
Diospyros discolor Willd.	Mabolo (Velvet apple)	Philline Islands
Diospyros mespiliformis Hocht.	Mmilo namibia	South Africa
Euphorbiaceae		
Ricinodendron rautanenii Schinz	Mongongo	Southern Africa
Guttiferae		
Rheedia madruno Triana & Planch.	Madrono	Central America
Flacourtiaceae		
Dovyalis caffra Warb.	Kei apple	Southern Africa
Leguminosae		
Tamarindus indica L.	Tamarind	Tropical Africa
Loganiaceae		
Strychnos cocculoides Backer	Monkey orange	Southern Africa
Strychnos spinosa Lam.	Monkey orange	Southern Africa
Strychnos pungens Solereder	Monkey orange	Southern Africa
Mimosaceae		
Inga spp.	Ice cream bean	South America
Moraceae		
Artocarpus heterophyllus Lam.	Jackfruit	Asia
Rhamnaceae		
Ziziphus mauritiana Lank.	Ber	Old World Tropics
Rosaceae		
Prunus salicifolia H BK.	Capulin cherry	Mexico

Rubiaceae		
Vangueria infausta Burch.	Mmilo	Southern Africa
Rutaceae		
Casimiroa edulis Llave & Lex.	White sapote	Mexico, Central America
Santalaceae		
Santalum acuminatum (R. Br.) A. DC.	Quandong	Australia
Sapotaceae		
Argania spinosa L.	Argan	Morroco
Chrysophyllum cainito L.	Star apple	Central America
Manilkara zapota van Royen	Sapodilla	India, Africa, Central America
Mimusops angel Engler	Angel	Somalia
Mimusops zeyheri Sond.	Mmupudu	Southern Africa
Pouteria sapota (Jacq.) Merr.	Mammey sapote	Central America

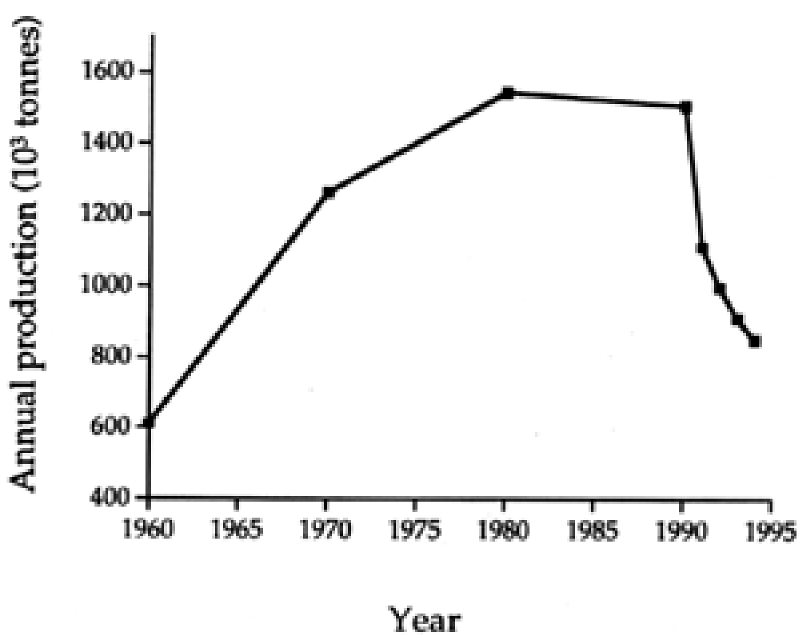

Fig. 1. Changes in annual citrus production in Israel 1960-1994. (Statistical Abstracts of Israel 1994).

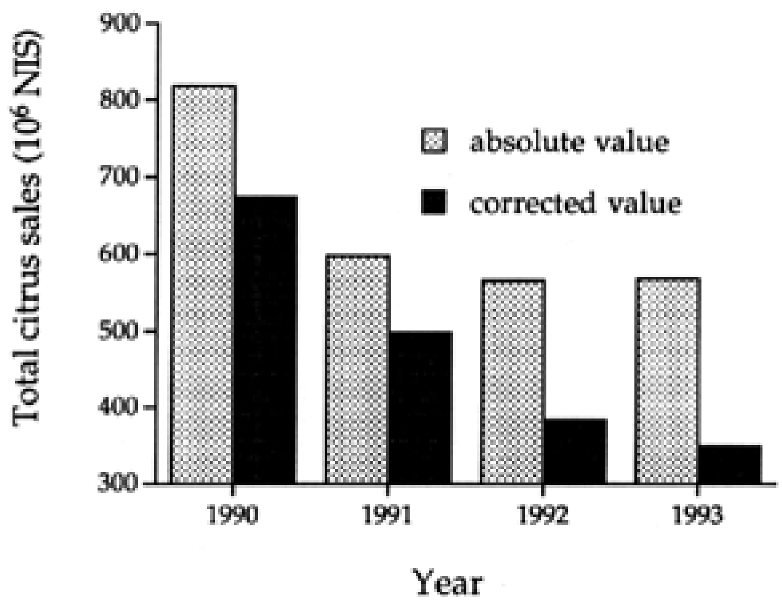

Fig. 2. Changes in sales volume and in buying power of citrus exporters in Israel 1990-1993. Data are taken from the Statistical Abstracts of Israel (1994). Production during this period decreased and prices increased but well below the consumer price index. The inflation rates were 17.6%, 18.6%, 9.4%, and 11.2% for 1990, 1991, 1992, and 1993, respectively (BDO Bavly Milner & Co. 1995). By the time farmers received their money, its value had been eroded due to inflation. The corrected value of their income is calculated from the actual value and the inflation rate.

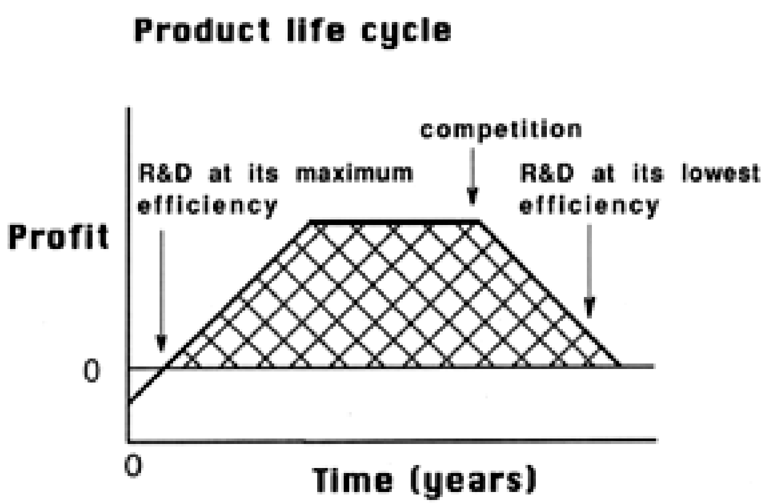

Fig. 3. Hypothetical product life cycle in a free market. For cut flowers exported from Israel to Europe the span is 17 years (D. Rymon, Agricultural Research Organisation, pers. commun.).

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Medicinal weed Satyanashi (*Argemone mexicana* Linn)

Contributor: Pankaj Oudhia

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English name: Mexican prickly poppy

Common (Indian) names

Hindi: Shialkanta, Satyanashi
Gujrati: Darudi
Danarese: Balurakkisa, Datturi, Pirangi, datturi
Marathi: Daruri, Firangi-kote-pavola, dhotara.
Sanskrit: Brahmadandi, Pitopushpa, Srigalkanta, Svarnakshiri.
Malyalam: Ponnummattu, Kantankattiri
Tamil: Kutiyotti, Ponnummuttai
Telugu: Brahmadandicettu

Family: Papaveraceae

Habitat: In India it is introducd and naturalised and occur as wasteland weed in almost every part of India. In many parts it is repoorted as crop weed also.

Related species: It is native of Tropcal America. The genus Argemone includes 12 species. Some major species are: *A. alba* Lestib. (used medicinally in North America), *A. platyceras* Link. & Otto., *A. grandiflora* Sweet.

Botany: It is a prickly, glabrous, branching herb with yellow juice and showy yellow flowers, The Sanskrit name svarnakshiri is given because of the yellow juice (Svarna - Gold; Kshiri - Juice). The height of this plant varies between 0.3 to 0.12 meters, Leaves are thistlelike. Stem clasping, Oblong, sinuately pinnatifid, spinous and viens are white. Flowers are terminal, yellow and of 2.5–5.0 cm diameter. Fruits are capsule. Prickly and oblong ovoid. Seeds numerous, globose, netted and brownish black. Flowering time is all round the year in Indian conditions. The plants is toxic to animals and cattle avoid grazing this plant. Harmful allelopathic effects of Argemone mexicana on germination and seedling vigour of wheat, mustard, fenugreek, sorghum, fingermillet, tomato, cucumber etc. (important crops in India) have been reported. The allelochemicals cinnamic and benzoic acid are identified as harmful chemicals responsible for inhibition of germination and seedling vigor.

Useful Parts: Roots, leaves, seeds and yellow juice.

Medicinal Properties and Uses: According to Ayurveda the plant is diuretic. purgative and destroys worms. It cures lepsory, skin-diseases, inflammations and bilious fevers. Roots are anthelmintic. Juice is used to cure ophthalmia and opacity of cornea. Seeds are purgative and sedative. Seeds resemble mustard seeds and in India it is used to adulterate mustard seed. Seed yield non edible toxic oil and causes lethal dropsy when used with mustard oil for cooking.

In Homoeopathic system of medicine, the drug prepared from this herb is used to treat the problem caused by tape-worm.

Popular Ayurvedic Formulations: Svarnakshiri churna and tail

Other uses: The plant is found suitable for the reclamation of alkaline soils.

Dried and powdered plants are recommended as green manure as it contain sufficient amount of Nitrogen, Phosphorus and Potassium.

Oilcake is used as manure.

Seed oil, popularly known as Satyanashi oil is used as an illuminant, lubricant, in soapmaking, and for protection from termites.

Chemical Constituents: The plant contains alkaloids as berberine, protopine, sarguinarine, optisine, chelerytherine etc. The seed oil contains myristic, palmitic, oleic, linoleic acids etc.

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Jack-In-The-Pulpit

Arisaema triphyllum (L.) Schott.

Synonym.—*Arum triphyllum* L.

Other common names.—Wild turnip, arum, three-leaved arum, Indian-turnip, wakerobin, wild pepper, dragon-turnip, brown dragon, devil's-ear, marsh turnip, swamp turnip, meadow turnip, pepper turnip, starchwort, bog onion, priest's-pintle, lords-and-ladies.

Figure 69.—Jack-in-the-pulpit (*Arisaema triphyllum*)

Habitat and range.—Jack-in-the-pulpit inhabits moist woods from Canada to Florida and westward to Kansas and Minnesota.

Description.—The jack-in-the-pulpit has one or two smooth leaves consisting of three leaflets from 3 to 6 inches long and from 1 1/2 to 3 1/2 inches wide. The flower, which is either all green or green with dark purple stripes, is readily recognized on account of the similarity of its form to that of the calla lily. In autumn the fruit ripens in the form of a bunch of bright, scarlet, shining berries. The underground portion, usually referred to as the root but botanically known as a corm, is shaped like a turnip. The lower part is flat and wrinkled, while the upper part is surrounded by coarse wavy rootless. It has an extremely burning taste.

Part used.—The dried corm, collected in the summer, is sliced crosswise and dried. Drying and heat diminish its burning taste, which disappears rapidly with age.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Snakeroot

(1) *Aristolochia serpentaria* L.; (2) *A. reticulata* Nutt.

Other common names.—(1) Virginia snakeroot, Virginia serpentaria, serpentary, snakeweed, pelicanflower, snagrel, sangrol, sangree-root; (2) Texas snakeroot, Texas serpentaria, Red River snakeroot.

Figure 99.—Snakeroot (*Aristolochia serpentaria*)

Habitat and range.—Virginia snakeroot is found in rich woods from Connecticut to Michigan and southward, principally among the Alleghenies, and Texas snakeroot occurs in the Southwestern States, growing along river banks from Arkansas to Louisiana.

Description of Virginia snakeroot.—This plant is nearly erect, the slender, wavy stem sparingly branched near the base growing usually to about a foot in height sometimes, however, even reaching 3 feet. It has thin leaves, heart-shaped at the base and pointed at the apex, about 2 1/2 inches long and from 1 to 1 1/2 inches wide. The dull-brown, somewhat leathery flowers are produced individually from near the base of the plant on slender stems. The fruit is round, about half an inch in diameter, and contains numerous seeds. Serpentaria has a short rootstock with many thin, branching, fibrous roots. The rootstock has a very agreeable, aromatic, camphorlike odor and a warm, bitterish, camphoraceous taste.

Description of Texas snakeroot.—This plant has a very wavy stem with oval, heart-shaped, clasping leaves which are rather thick and marked with a network of veins. The entire plant is hairy, with numerous long, coarse hairs. The small densely hairy, purplish flowers are produced from the base of the plant. The rootstock of this species is larger and has fewer small roots than that of the Virginia snakeroot.

Part used.—The roots of both species, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Arjun or Koha [*Terminalia arjuna* (Roxb.) W. & A.]

Contributor: Pankaj Oudhia

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English Name: White Marudah

Common (Indian) Names

Hindi: Arjun, Arjuna, Koha, Kahu, Arjan
Gujrati: Arjun - Sadada, Sadado
Canarese: Bili-Holo-Nir-Tora Matti, Maddi
Marathi: Arjuna, Arjun Sadada, Sadura
Sanskrit: Arjuna, Dhanvi, Indradruma, Kakubha, Karvirak.
Oriya: Arjuna, Sahajo
Tamil: Vellamatta
Telugu: Yerra maddi
Assam: Orjun
Bengali: Arjhan
Punjabi: Arjuna

Family: Combretaceae

Botany: Tree up to 25 meter hight; bark grey, smooth; leaves sub-opposite, 5–14 × 2–4.5 cm., oblong or elliptic oblong, glabrous, often inequilateral, margin often crenulate, apex obtuse or sub-acute, base rounded or sometimes cordate; petioles 0.5–1.2cm; glands usually two. Flowers small, white. Fruit 2.3–3.5 cm long, fibrous woody, glabrous with 5 hard wings, striated with numerous curved veins. Flowering time April–July in Indian conditions. Seeds hard germination 50–76 days (50–60%)

Related Species: The genus *Terminalia* consist large hard wooded trees. Over 100 species widely distributed in the tropices (*Terminalia* originated from Latin ward *Terminus*, alluding to the leaves being borne on the tips of the shoots). In India, *Terminalia chebula*, *T. bellrica* and *T. ciliata* are major related species.

Distribution: Common in almost every part of India. Grows well along bank of streams, rivers, ravines, dry water courses, reaching very large sizes on fertile alluvial loam.

Useful Parts: Every parts useful medicinal properties Arjun holds a reputed position in both Ayurvedic and Yunani Systems of medicine. According to Ayurveda it is alexiteric, styptic, tonic, anthelmintic, and useful in fractures, uclers, heart diseases, biliousness, urinary discharges, asthma, tumours, leucoderma, anaemia, excessive prespiration etc. According to Yunani system of medicine, it is used both externally and internally in gleet and urinary discharges. It is used as expectorant, aphrodisiac, tonic and diuretic.

Ayurvedic Formulations: Arujanarishta, Arjunghrita, Arjunakhsirpak, Arvindasava, Devadarvy - arishta etc.

Other Uses: Recommended for reclamation of saline, alkaline soils and deep ravines. Used for agro and social forestry. Timber is locally used for carts, agricultural implements, water troughs, traps, boat building, house building, electric poles, tool-handles, jetty-piles and plywood. Fodder is useful for tassar silkworm. It is one of the major tannin yielding trees. Bark (22–24%), leaf (10–11%) and fruit (7–20%) contains tannins.

Chemical Constituens: A glucoside - arjunetin - has been isolated from bark. Recently new flavance - arjunone has been isolated from fruits alongs with cerasidin, β-sitosterol, friedlin, methyl oleanolate, gallic, ellagic and arjunic acids.

Artificial Propagation: It can be artificially propagated through seeds, coppicing, pollarding, root-suckers, stumps and air-layering. It is initially slow-growing but later fast-growing. It attains 2–3 m height in 3 years. Arjun yields up to 45 kg dry bark chips on a three year cycle without injury.

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Armoracia rusticana P. Gaertn., B. Mey. & Scherb.

Brassicaceae (Cruciferae)

Horseradish, Creole mustard, German mustard, Horse-reddish root (archaic), Red horseradish

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Aronia melanocarpa Michx.

Rosaceae

Aronia, Chokeberry

We have information from several sources:

Temperate Berry Crops—Chad Finn

Outside links:

Aronia melanocarpa from Mallorn Computing

Arracacia xanthorrhiza Bancr.

Umbelliferae

Apio, arracach, arracacha, arracacia, fecula, Peruvian carrot, Peruvian parsnip, r'accacha, white carrot

We have information from several sources:

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Neglected Crops: 1492 from a Different Perspective.—1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy.

Outside links

Arracacha can be found in Lost Crops of the Incas—from National Academy Press

Andean roots and tubers: Ahipa, arracacha, maca and yacon—by M. Hermann, J. Heller (eds.) from the International Plant Genetic Resources Institute

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Tall oatgrass

Gramineae, Poaceae *Arrhenatherum elatius* (L.) Presl

Source: Magness et al. 1971

Tall oatgrass, native to Europe, was brought to the United States early in the last century. It is now grown widely in the central and northern states, and in the Pacific Northwest. It is a hardy, upright perennial bunchgrass reaching to 5 feet, with many leaves. The seed head resembles that of oats, hence the name. It tends to grow in bunches and is well adapted to light textured soils. It is suitable for pastures and yields a palatable hay. It is frequently seeded in combination with other grasses and legumes as sweet and red clovers. It is shorter lived than most bunchgrasses.

Last update June 28, 1996 bha

Eruca sativa Miller

Diplotaxis tenuifolia (L.) DC.

Diplotaxis muralis (L.) DC.

Brassicaceae = Cruciferae

Arrugula, arugula, garden rocket, jamba oil, Mediterranean rocket, rocket, rocket salad, roka, roquette, rucola, rugala, rugela, rugula

See:

Eruca sativa

Diplotaxis tenuifolia

Diplotaxis muralis

Index | Search | Home | Aromatic, Spice and Medicinal Plants

Artemisia abrotanum L.

Asteraceae (Compositae)

Southernwood, Old-man, southern wormwood

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, January 6, 1998 by aw

Artemisia dracunculus L.

Asteraceae (Compositae)

Tarragon, French tarragon, Russian tarragon, true tarragon

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Cynara scolymus L.

Compositae, or Asteraceae

Alcachofa, *archiciocco*, *artichaut*, Artichoke, *articiocco*, baby artichoke, *carciofo*, French artichoke, globe artichoke, Italian Green Globe, *karzochy*

We have information from several sources:

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Artichoke (and Lettuce & Endive) production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Artocarpus altilis (Parkinson) Fosberg

and

Artocarpus heterophyllus Lam.

syn. *Artocarpus integrifolia* L.

Moraceae

Breadfruit, *Fruit à pain, Pana de pepita, Sukun*, Breadnut, Panapen, Jack, Jackfruit, Jakfruit, Jack hirsutus Lam, *Jaca*, Jak, Nangka, Ramon, *Ramón*

NewCROP has Breadfruit & Jackfruit information at:

Breadfruit—Julia Morton, Fruits of warm climates

Jackfruit—Julia Morton, Fruits of warm climates

Magness—J.R. et al. 1971. Food and feed crops of the United States.

Outside links to more Breadfruit & Jackfruit info:

BREADFRUIT & JACKFRUIT "FRUIT FACTS"—(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Germplasm Catalogue of Jackfruit in Bangladesh—from Fruits for a Future

Breadfruit—by Diane Ragone, from the International Plant Genetic Resources Institute

---

Joshee, N., D.R. Bastola, V.P. Agrawal, and A.K. Yadav. 2002. Lakoocha: A multipurpose tree of warm climate. p. 405–406. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

Lakoocha: A Multipurpose Tree of Warm Climate

Nirmal Joshee, D.R. Bastola, V.P. Agrawal, and A.K. Yadav*

INTRODUCTION

Artocarpus lakoocha Roxb., Moraceae, is a valuable tropical tree species native to India and used for fruit, furniture, timber, and feed. The lakoocha fruits are generally eaten fresh. Each fruit contains 20–30 seeds that are fleshy with thin seed coat. The edible fruit pulp is believed to act as a tonic for the liver. Raw fruits and male flower spike (acidic and astringent) are utilized in pickles and chutney (sauce). The lakoocha tree is also valued for feed and timber. The hardwood sold as lakuch, is comparable to famous teak wood. Lakuch which is durable outdoors as well as under water, is used for construction, furniture, boat making, and cabinet work. Tree bark containing 8.5% tannin is chewed like betel nut, and is also used to treat skin ailments. It yields a durable fiber good for cordage. The wood and roots yield a lavish color dye. Lakoocha seeds and milky latex are purgative. Seeds contain artocarpins (ALA I and ALA II), the isolectins which exhibit high haemagglutination activity (Wongkham 1995). However, the agglutinin (ALA) from *Artocarpus lakoocha* is not organ specific. Moreover, the haemagglutination activity of ALA was demonstrated in various organs of the plant except fruit flesh. The highest and the lowest activities were found in the seeds (14,400 units/g fwt) and leaves (5 units/g fwt), respectively.

BOTANY AND DISTRIBUTION

The genus *Artocarpus*, Moraceae, which consists of jackfruit (*Artocarpus heterophyllus*), lakoocha or monkey jack (*A. lakoocha*), chempedak (*A. integer*), breadfruit or breadnut (*A. altilis*), and marang (*A. odoratissima*), comprises over 50 distinct species of monoecious evergreen trees (Drew 1997). Compound fruits are derived from swollen flower heads. *Artocarpus* species display high levels of genetic variability, both between and within species. This is evident from the wide range of locally distributed *Artocarpus* genotypes. Breadfruit cultivars are triploid and seedless. Lakoocha seedling trees take five years to come into bearing. The orange-yellow male flowers and reddish female flowers of lakoocha are borne separately on the same trees. Fruits are nearly round or irregular, from 5 to 12 cm in diameter and have a velvety surface (Fig. 1). The lakoocha fruits are dull-yellow with pink tinge and sweet-sour pulp. Fruit yield can be up to 80 kg/tree with fruit weight ranging from 200 to 350 g.

Fig. 1. A developing fruit (60%) of *Artocarpus lakoocha*.

The lakoocha is popularly known as "monkey jack" or "*lakuchi*" in India, "*badahar*" in Nepal, "*tampang*" in Malaya, and "*lokhat*" in Thailand. A native of the humid sub-Himalayan regions of India, it grows up to 1,200 m altitude. The lakoocha trees grow 6 to 9 m tall with large, leathery and deciduous leaves (Fig. 2).

Fig. 2. A mature tree of *Artocarpus lakoocha*.

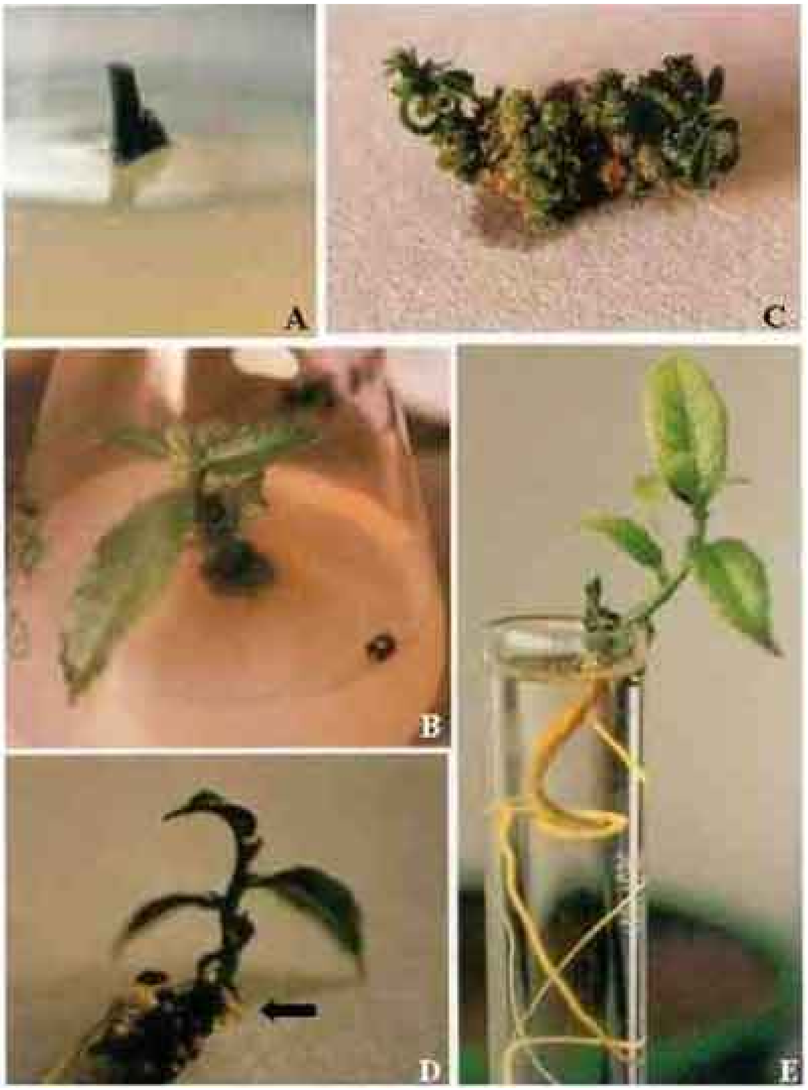
PROPAGATION

There are a number of Important problems associated with regeneration and propagation of lakoocha: (1) tree population of lakoocha is gradually decreasing due to poor seed viability and extensive exploitation for food, timber, and other uses; (2) seeds, once extracted from the fruit, quickly loose viability within a week, or sometimes even in few days; and (3) vegetative propagation methods such as rooting of hardwood or softwood stem cuttings have not been successful (Napier and Robbins 1989).

Protocols were developed for micropropagation of lakoocha seedlings. Lakoocha fruits were collected just before maturity and stored at 4°C. Fruits were washed under running tap water for 1 hr, then washed with detergent and rinsed 3 times with sterile distilled water. Fruits were dipped in 70% ethanol for 1 min, air dried and flamed to evaporate ethanol. Following this, fruits were cut open to remove seeds. Air dried seeds were germinated on sterile sand and slanted agar in test tubes. Germination medium contained 0.8% agar and 0.5% sucrose with pH adjusted to 5.7–5.8. Six-week-old seedlings were utilized to prepare leaf disc, nodal segment, and shoot tip explants.

Aseptic cultures using leaf discs, nodal segments and shoot tip explants were initiated on MS basal medium containing NAA and BA alone and in combination along with a control without growth regulators. Leaf discs did not show any response in different media. Nodal and shoot tip explants (Figs. 3A, C) initiated calli at cut ends. Shoot tips were more responsive and highly prolific in initiating shoot buds. Optimum results for multiple shoot induction were obtained with MS supplemented with 1.0 to 2.0 mg L^{-1} BA. Rooting was observed in 2 to 3 weeks in MS medium supplemented with 2.0 mg L^{-1} IBA (Fig. 3D).

Fig. 3. Sequential stages in the complete in vitro regeneration of lakoocha plantlets. A. Nodal explant. B. Elongation of axillary bud in nodal explant. C. Shoot tip producing callus and numerous shoot bud primordia. D. Elongated shoots initiate rooting in the induction medium, arrow points to a root. E. Complete plantlet developed with well defined shoot and root at the end of 4–5 months in culture.



CONCLUSIONS

In vitro micropropagation protocol for rapid multiplication of lakoocha is required to maintain an adequate supply of plants to establish new plantations and to conserve desirable genotypes. It is also considered important to develop somatic embryogenesis protocols for in vitro regeneration to enhance genetic improvement of desirable lakoocha genotypes.

REFERENCES

- Drew, R.A. 1997. The application of biotechnology to the conservation and improvement of tropical and subtropical fruit species. FAO, Rome p. 1–77.
- Napier, I. and M. Robbins. 1989. Forest seeds and nursery practice in Nepal. p. 94–95.
- Wongkham, S. 1995. Isolectins from seeds of *Artocarpus lakoocha*. Phytochemistry 40:1331–1334.

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Bamboo

Bambuseae *Arundinaria* sp., *Phyllostachys* sp., *Bambusa* sp., *Dendrocalamus* sp.

Source: Magness et al. 1971

According to Bailey (Stan. Cyclo. Hort.), more than 200 species of bamboo are recognized, varying in size from a few feet to more than 100 in height. The tender, young shoot growth of many of these species is used as food, in the United States mainly in Chinese dishes. Sprouts harvested in the United States are limited to Hawaii and Puerto Rico, but substantial quantities are imported. Since new sprout growth quickly becomes hard and woody, the maximum period of exposure of edible parts to direct pesticide application would be approximately a month.

Outside links for bamboo:

American Bamboo Society

Bamboo

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Arundo donax L.

Poaceae

Nalgrass, Giant reed, Spanish cane

We have information from several sources:

Nalgrass: A Nonwood Fiber Source Suitable for Existing US Pulp Mills—Mark Lewis and Michael Jackson

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Canada Wildginger

Asarum canadense L.

Figure 32.— Canada wildginger (*Asarum canadense*)

Other common names.—Asarum, Indian ginger, Canada snakeroot, Vermont snakeroot, heart snakeroot, southern snakeroot, black snakeroot, coltsfoot snakeroot, black snakeweed, broad-leaved asarabacca, false coltsfoot, colicroot.

Habitat and range.—This inconspicuous little plant frequents rich woods or rich soil along roadsides from Canada south to North Carolina and Kansas.

Description.—Canada wildginger, better known perhaps as Canada snakeroot, is a small plant, apparently stemless, and not more than 6 to 12 inches in height. It usually has but two leaves, which are borne on slender, finely hairy stems. The leaves are kidney-shaped or heart-shaped, thin, dark green above and paler green on the lower surface, and from 4 to 7 inches broad. The solitary flower is borne on a short, slender stalk produced between the two leaf stems, and on account of its closeness to the ground it is not readily noticeable. It is bellshaped and of a dull-brown or brownish-purple color, the inside being darker than the outside. The plant has a creeping, yellowish rootstock with thin rootless produced from joints which occur about every inch. It has a fragrant odor and spicy taste.

Part used.—The rootstock, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

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Asclepias syriaca L.

Asclepiadaceae

Milkweed, Silkweed

We have information from several sources:

The Milkweed Business—Herbert D. Knudsen and Richard D. Zeller

Milkweed Cultivation for Floss Production—Merle D. Witt and Herbert D. Knudsen

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Asclepias tuberosa L.

Asclepiadaceae

Butterfly weed, Indian posy, Orange milkweed, Orange root, Pleurisy root, Tuberroot

---

We have information from several sources:

The Herb Hunters Guide—Sievers, A.F. 1930.

New Flower Crops—Abraham H. Halevy

Asgandh or Ashwagandha (*Withania somnifera*)

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Family: Solanaceae
English Name: Indian Ginseng, Winter cherry, Withania root
Common Indian Names
Gujarati - Asam, Asoda, Ghodasoda
Hindi - Asgandh
Canarese - Amangura, Hirimaddina-gadde, Sogada-bery.
Marathi - Asgundh, Kanchuki, Askandha
Sanskrit - Ashvagandha, Balada, Gandhpatri, Kamrupini, Vajini
Bengali - Ashvagandh
Punjabi-Asgand
Tamil - Asuragandi
Telugu - Asvagandhi, Penneru
Urdu - Asgandanagaori

Botanical Description: Please see Table I

Useful Parts: Root, leaves, Green berries and seeds.

Medicinal Uses: According to Ayurveda, the root is bitter, acrid, heating, aphrodisiac, tonic, alternative, anthelmintic and useful in treatment of inflammations, psoriasis, bronchitis, asthma, consumption, ulcers, scabies, marasmus of children, insomnia, senile debility etc. According to Unani system of medicine, the root is bitter, tonic, aphrodisiac, emmenagogue, good in asthma, inflammations, leucoderma, bronchitis, lumbago, thirst etc.

Major Alkaloids: Somniferine, somnine, somniferinine, withananine, pseudo-withanine, tropino, pseudotropine, choline, cuscohygrine, isolettetierine, anaferine, anahydrine, 3-alpha-gloyloxy tropane, etc.

Reference

Agharkar, S.P. 1991. Medicinal plants of Bombay Presidency. Pbl. Scientific Publishers, Jodhurpur, India.

Krishnamurthy, T.1993. Minor forest products of India. Pbl. Oxford and IBH publishing Co. Pvt. Ltd., New Delhi, India.

Lindley, J. 1985. Flora Medica. Pbl. Ajay Book Service, New Delhi, India.

Singh, U; Wadhwani, A.M. and Johri, B.M. 1996. Dictionary of Economical Plants of India. Pbl. Indian Council of Agricultural Research, New Delhi, India.

Verma, D.M. Balakrishnan, N.P. and Dixit, R.D. 1993. Flora of Madhya Pradesh. Vol. I. Pbl. Botanical survey of India, Kolkata, India.

Common differences between *Withania somnifera* and *Withania coagulans*

	Withiania somnifera	*Withania coagulans*
Synonyms	Physalis somnifera	*Punneria coagulans*
Local name	*Asgandh*	Punir
Plant	A much branched, erect, perennial undershrub, from a more or less tuberous root	A rigid, ashy-grey undershurb
Branches	Terete, clothed with mealy, stellate-hoary tomentum, at length some what glabrous	Woody, terete, densely clothed with mealy, stellate tomentum, sulcate when dry
Leaves	5-10×3.6 cm, ovate, obtovate, or oblong, subacute or rarely obtuse, entire, rounded or somewhat produced at base, Pubescent on lower surface and glabrous on upper surface	2-7×1-2.5 cm, elliptic-lanceolate or oblanceolate, coriaceous, obtuse at apex, both surfaces uniformly grey-tomentose due to thick coating of minute, stellate hairs
Flowers	in sessile, axillary, 4-6 flowered cymes, greenish-yellow	Unisexual
Fruits	Orange-red berry, smooth, more or less globose	Globose, smooth
Seeds	Yellow, somewhat scurfy	Ear-shaped, glabrous

Rhizophora mucronata Lam.

Rhizophoraceae
Asiatic mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The wood (sp. grav. 0.81), durable except in the ground, and difficult to saw, is used for construction, fish traps, house frames, piling, and poles. Thousands of tons of mangrove woodchips are exported annually from Indonesia, Sabah, and Sarawak for pulp and for rayon manufacture (NAS, 1980a). Fruits may be eaten, after scraping off the outside and boiling with wood ashes, according to some skeptical accounts (Burkill, 1966). The Wealth of India describes the fruit as sweet and edible, the juice made into a light wine. Young shoots are cooked and eaten as a vegetable (C.S.I.R., 1948–1976). Bark, used for tanning and dye, may be removed from stems for sale as firewood. Leaves are the source of a black or chestnut dye (Burkill, 1966). Mangrove extract is used for maintaining oil-well drilling muds within a desired range of flow (C.S.I.R., 1948–1976). Planted along coastal fish ponds to stabilize the banks.

Folk Medicine

Reported to be astringent, Asiatic mangrove is a folk remedy for angina, diabetes, diarrhea, dysentery, hematuria, and hemorrhage (Duke and Wain, 1981). Leaves are poulticed onto armored fish injuries (Watt and Breyer-Brandwijk, 1962).Indochinese use the roots for angina and hemorrhage. Malayans use old leaves and/or roots for childbirth. Burmese use the bark for bloody urine, Chinese and Japanese for diarrhea, Indochinese for angina (Perry, 1980).

Chemistry

Wood contains 4.4% resin, 63.4% cellulose (List and Horhammer, 1969–1979) and 1.5% ash (Watt and Breyer-Brandwijk, 1962). Tannin may vary in dry bark from ca 13–50%, leaves contain 9.1%, green fruits 12.0%, and ripe fruits 4.2%. Spent mangrove bark, after tannin extraction, can be used as a source of furfural (C.S.I.R., 1948–1976). Spent bark from North Borneo yields an ash assaying 18% lime (70% $CaCO_3$).

Toxicity

Honey collected from the flowers is said to be poisonous (C.S.I.R., 1948–1976).

Description

Evergreen tree 25(–30) m high, 70 cm in diameter, with numerous branching arching stilt roots. Bark brown or blackish, smoothish, with horizontal fissures. Leaves opposite, elliptical to oblong, 8–15 cm long, 5–10 cm wide, acute, entire, without visible veins, thick and leathery, glabrous, black-dotted beneath. Petiole 3–5 cm long. Stipules paired, leaving ring scar. Flower clusters axillary, 2–3 times forked, with 3–8 flowers ca 15 mm long. Bell-shaped hypanthium with 4 pale yellow, pointed leathery sepals and 4 cream-colored petals 9 mm long. Stamens 8, stalkless, anthers 6–8 mm long, 4 opposite sepals and 4 opposite petals. Ovary half-inferior, conical, 2-celled, with 2 ovules in each cell, 2-lobed style. Berry ovoid or conical, 5–7 cm long, brown, leathery. Seed 1, viviparous, becoming cigar-shaped, to 40 cm long and 2 cm in diameter (Little, 1983).

Germplasm

Reported from the Africa, Hindustani, Indonesia-Indochina, and China-Japan Centers of Diversity, Asiatic mangrove, or cvs thereof, is reported to tolerate diseases, insects, pests, salt, and waterlogging (NAS, 1980a; Little, 1983). ($2n = 36$)

Distribution

Old World tropics from South and East Africa to Madagascar, Seychelles, Mauritius, southeastern Africa to southern China, Ryukyu throughout Malaysia to northeastern Australia, Melanesia, and Micronesia. Not widely introduced in Hawaii (Little, 1983).

Ecology

Estimated to range from Tropical Moist to Rain through Subtropical Moist to Rain Forest Life Zones, Asiatic mangrove is estimated to tolerate annual precipitation of 10 to 80 dm, annual temperature of 20 to 26°C, and pH of 6.0 to 8.5. Hou (1958) suggests that this is the only Malayan mangrove which can survive complete daily inundation. Little (1983) describes the habitat as brackish and saline salts of depositing shores and marshes. Of the Asian species this one is most likely to be found in deep soft mud.

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In Avicennia and Rhizophora, direct seeding results in ca 90% survival. Drying the seedlings in the shade a few days before planting seems to make them much less attractive to crabs, perhaps due to a buildup of tannin.

Harvesting

In Tamil Nadu, natural regeneration is abundant and plantations for fuel are managed on 30-year rotations. Clear fellings of Rhizophora may be replaced by Avicennia (Hou, 1958). Species of Rhizophoraceae, growing only from the tips of the branches, are often killed by indiscriminate lopping of branches(NAS, 1980a).

Yields and Economics

Virgin mangrove stands are reported from Mindanao, where there were 149 trees/ha over 25 cm DBH with 130 m^3/ha. Planted forests 40 years old are projected to yield 400 m^3/ha, an average of only 10 m/ha/yr (Hou, 1958). Cannell (1982) cites data on a mangrove forest dominated by Rhizophora, Ceriops, and Sonneratia, averaging 11 m tall, with an LAI (leaf area index) of 3.7–4.2. The stemwood and bark on a DM basis weighed 74.4 MT/ha, the prop roots 61.2 MT/ha, the branches 15.8, the foliage 7.4, the fruits 0.3, for a total standing aerial biomass of 157 MT/ha. The CAI (current annual increment) of stem wood, bark, and branches was 20 MT/ha/yr, foliage 6.7, fruits 0.3. These data, taken from a mangrove on Phuket Island, Thailand, regenerated following clear felling, Suggest annual productivity may attain 20 MT/ha/yr in Asian mangroves.

Energy

Mangrove was the main fuel in the Philippines until World War II (NAS, 1980a). One great advantage in the eyes of firewood dealers is the ease with which, the wood is split. With a calorific value higher than oak, it burns with even heat. Five tons of mangrove firewood is said to equal three tons of Malayan coal, two tons of Indian or Japanese. It makes an excellent charcoal, rather high in sulfur (Burkill, 1966). Wood affords good fuel with high calorific value (4,888 cal, 8,799 Btu) and makes high quality charcoal. In Bangkok, mangrove charcoal, which burns steadily, giving off intense heat without sparking, sells for twice the price of other charcoal (NAS, 1980a).

Biotic Factors

Crabs, great enemies of the seedlings, may damage starting plantations. Browne (1968) lists the following: Crustacea, *Sesarma* spp.; Coleoptera, *Poecilus fallax*; and Mammalia, *Macaca irus*.

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Last update Friday, January 9, 1998 by aw

Asimina triloba (L.) Dunal

Annonaceae

Pawpaw

Indiana Banana
Hoosier Banana
Poor Man's Banana

Pages on our server

Pawpaw FactSHEET contributed by Desmond R. Layne

Pawpaw (Asimina triloba): a "Tropical Fruit for Temperate Climates" by M. Brett Calloway. From: New Crops (Janick and Simon eds.) Wiley, New York, 1993.

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Nuts with Commercial Potential for America's Heartland

Pawpaws Provide Potential

Growing Pawpaws—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

The Pawpaw Regional Variety Trial—Kirk W. Pomper, Desmond R. Layne, and R. Neal Peterson

Articles on Insecticidal Acetogenins contained in Pawpaw Bark:

Evaluation of Various Parts of the Paw Paw Tree, *Asimina triloba* (Annonaceae), as a Commercial Source of the Pesticidal Annonaceous Acetogenins—Sunil Ratnayake, J. Kent Rupprecht, William M. Potter, and Jerry L. McLaughlin

Monthly Variations in Biological Activity of Asimina triloba—Holly. A. Johnson, J. Gordon, and Jerry .L. McLaughlin

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Outside links

The PawPaw Foundation Devoted to the Advancement of Asimina triloba, North America's Largest Native Edible Fruit

Kentucky State University Pawpaw Research Project

PAWPAW "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

About Pawpaws in Oregon

From the Northern Nut Growers Association, Articles about Pawpaw

Fruit Explorer's MidFEx Pawpaw page

The GardenWeb's page on Pawpaw

Peterson Pawpaws

Link to information and image of *Asimina tetramera* (Opossum Pawpaw), a rare and endangered species from southern Florida.

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Asparagus officinalis L.

Liliaceae, or Asparagaceae

Asparagus, asparagus fern, florist's fern, garden asparagus, green asparagus, special bean, white asparagus, wild asparagus

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Asparagus production links

Asparagus HO-96 Purdue University Cooperative Extension Service

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Vigna sesquipedalis (L.) Fruw.

Vigna unguiculata (L.) Walp. ssp. *sesquipedalis* (L.) Verd.

Fabaceae

Asparagus bean, Yard long bean, Changjiang dou, cheung kung tau, sitao, zuyu roku sasage

We have information from several sources:

Asian Vegetables—Mas Yamaguchi

New Opportunities in Vigna—Richard L. Fery

Effect of Southern Root Knot Nematode on Yield Components of Yardlong Beans (Abstract)—E.G. Rhoden, C.K. Bonsi and M.L. Ngoyi

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As hay, pasture, and soil improvement crop:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Galium odoratum L.

Rubiaceae

Woodruff, sweet woodruff, Waldmeister

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Astragalus species

(over 1500 species exist)

Fabaceae, or Leguminosae

Tragacanth, Gum Tragacanth

The gum group includes:
***Astragalus adscendens* Boiss**
***A. echinaeformis* Sirjaev**
A. gossypinus
***A. gummifer* Labill**
***A. microcephalus* Willd.**

Milk Vetches used for forage & groundcovers

forages and groundcovers
***Astragalus adsurgens* Pall**
A. cicer
***A. falcatus* L. Per.**
A. meliotoides

Other Astragalus species and their uses:
***Astragalus boetica* - Swedish Coffee (seeds roasted for a coffee substitute)**
***A. crassicarpus* Nutt.- Buffalo Pea, Ground Plum (unripe seed pods edible)**
***A. glycyphyllos* - (Used for a tea)**
***A. membranaceus* - Milk-vetch root, huang qi (a chinese medicine)**

Introduction of Chia and Gum Tragacanth in the U.S.—Howard S. Gentry, Marc Mittleman, and Peter R. McCrohan

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Garcinia hombrioniana: A Potential Fruit and an Industrial Crop

Hj. Serudin D.S. Hj. Tinggal*

Southeast Asia is regarded as a major center of origin and evolution of many cultivated crops particularly tropical fruits. A great variety of fruits, some wild, others cultivated are located in Brunei. Species of *Artocarpus*, *Durio*, *Garcinia*, *Mangifera*, *Musa*, and *Nephelium*, to mention only a few, occur as scattered species amidst forest trees or growing alongside homes, in backyards or mixed orchards. These indigenous species together with introduced cultivars represent invaluable genetic resources waiting to be collected, identified, and tested for commercial development.

One of these potential new fruit crops is *Garcinia hombrioniana* Pierre, locally called Assam Aur Aur, a close relative of the mangosteen, *G. mangostana* L. The attractive fruit contains white segmented luscious pulp, sweet with a pleasing fragrance similar to apricot (Fig. 1). The pulp has many uses. The dried crimson rind of the fruit for example, is commercially important and used extensively as sour relish in curries and culinary dishes requiring an acidulous base. Demand for this condiment is seemingly unsatisfiable and at every fruit season, housewives gather the fruits, remove the pulp, and sun-dry the rind (Fig. 2). The market price is attractive and keeping quality for properly dried pulp is good.

BOTANY

Origin

Assam Aur Aur is native to the Brunei Bay region of the states of Sabah and Sarawak of Malaysia and Brunei. The tree probably originated in the rainforests and was cultivated in the coastal and riverine regions to serve the culinary uses of the early settlers. Currently, the distribution is still restricted to the riverine and coastal alluvial regions. Some trees are found in the interior settlements, probably introduced, as coastal and riverine dwellers moved to settle inland. The fruit has never achieved the importance of mangosteen and early explorers and naturalists have largely neglected the small fruit for the larger, sweeter mangosteen.

Morphology

Assam Aur Aur is a handsome evergreen closely resembling the mangosteen in shape and canopy structure, except that Assam Aur Aur has smaller, more elliptical leaves. Mature trees can reach 10 m in height with numerous radially arranged spreading branches. Much of the leaves are held by tertiary branches. Inflorescence are borne on these branchlets in clusters of not more than five small flowers. Very little is known about the morphology of the flowers and owing to the smallness and almost fused structures, the flowers have received very little attention. It is likely that the flowers are hermaphroditic and the few seeds produced apomictic. Seedlings derived from seeds are always identical to the mother plant; there is no known genetic variation. Subtle differences in size (3 to 5 cm in diameter) and shape of fruits could be attributed to environmental influence. The population is generally homogeneous making selection for superior types difficult. However, this homogeneous attribute can be advantageous as fruit and fruit products derived from the fruits are fairly uniform.

HORTICULTURE

Culture

Assam Aur Aur is a tropical species requiring humid conditions of uniform annual rainfall exceeding 2,000 mm and mean temperature of 27°C. The tree shows a wide range of soil adaptability and will grow on damp alluvial soil as well as free draining upland soils. However, the preference is for well-drained fertile alluvial soil where water is not limiting.

Seeds, with the pulp removed, germinate within one week and can be shown direct into plastic bags. Early growth requires protection from full sunlight; 50% shading is recommended and progressively removed to harden the seedlings for field planing when 6 to 8 months old.

There is no commercial planting of Assam Aur Aur to provide cultural recommendations. However, based on observations and experiences, trees grow best at 5 m spacing. Nurse shade between 50 to 60% is essential at planting. Growth is rapid. Prunning of lower branches, weeding, and fertilization will bring the trees to bear after four years. Recommended fertilizers consist of

NPK (12-5-14) to enhance fruiting. Mulching with dry litter will help to retain soil moisture and prevent erosion which appears to be essential for healthy growth of the plant.

As long as the trees are healthy, problems of diseases appear minimal. However, ripe fruits are susceptible to infection by fruit flies (*Dacus* spp) causing damage to the pulp. The rind is unaffected and can still be processed into condiments. Fruit fly damage is more prevalent when few fruits are in season. Spraying with insecticides may reduce the damage, but, generally control of fruit fly is difficult in the tropics.

UTILIZATION

Bruneians, for centuries, have found many uses for the fruits. The young fruits that drop to the ground are collected and sliced into thin pieces or chunks and sun-dried. The final product is a fig brown condiment ready to give the needed tang to Brunei dishes. Currently, there is a limited amount in the market. The mature fruit has multiple uses with a fragrance reminiscent of apricot. Early Bruneians fermented the pulp into organic vinegar. The flavor is distinct, fruity, and strong. In recent years, efforts of the Department of Agriculture have produced suitable cordials and jams from the pulp (Fig. 3). The quality of the cordial is still questionable but the jams have penetrated a limited market. Research is still in progress.

The greatest commercial value of the fruit is the crimson rind. Dried in the sun, the shiny rind turns dull mauve in the process. Packed into small plastic bags, the rind is ready for sale as an essential ingredient for many Brunei dishes. The best condiment exudes some oil when pressed between fingers and quality rind, properly dried, will eventually turn black without being moldy (Fig. 4). Dark colored rind does not affect the culinary quality.

FUTURE PROSPECTS

Assam Aur Aur has tremendous opportunity as a specially fruit. Strong promotional support will strengthen marketing. The research programs of the Department of Agriculture can explore postharvest and handling technology to establish quality and standards. However, it is the inherent quality of fruit that will attract connoisseurs. The strategy is to introduce this fruit into specially markets.

Another area of interest is the acidulous quality of the rind. It is already in great demand. Opportunity exists for more systematic and scientific approach to rind processing, packaging, and marketing. Greater efforts will be required to evaluate value-added products such as jams, juices, and food colors.

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*There is no known published data on Assam Aur Aur. The information presented has been collected by the author during various field trips to the countryside and discussion with farmers and their families. Officers of the Department of Agriculture provided valuable information on its culture and food processing.

Fig. 1. Close up of the savory Assam Aur Aur fruit.

Fig. 2. Sun-drying of Assam Aur Aur rind with the pulp removed.

Fig. 3. Assam Aur Aur conserve produced by the Department of Agriculture, Brunei.

Fig. 4. Dried rind of Assam Aur Aur used as sour relish (left: freshly dried; right: after six months storage).

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Annona squamosa × *Annona cherimola* L.

Annonaceae

Atemoya

We have information from several sources:

Atemoya—Julia Morton, Fruits of warm climates

Commercialization of Carambola, Atemoya, and Other Tropical Fruits in South Florida—Jonathan H. Crane

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

South American Fruits Deserving Further Attention—Richard J. Campbell

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Atriplex hortensis L.

Chenopodiaceae

Garden orach, Green orach, Mountain Spinach, Orach, Orache, Red orach

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Solanum melongena L.

Solanaceae

Eggplant, Apple-of-love, Asiatic aubergine, Aubergine, Baby eggplant, *Brinjal*, Garden egg, Guinea squash, Gully bean, Italian eggplant, Japanese eggplant, Melanzana, Melongene, Oriental eggplant, Pea apple, Pea aubergine, Poor-man's-caviar, Susumber, *Terong*, White eggplant

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Specialty Mushrooms*

Daniel J. Royse

Total mushroom production world-wide has increased more than 10-fold in the last 25 years from about 350,000 t in 1965 to about 4,300,000 t in 1991. The bulk of this increase has occurred during the last 10 years. A considerable shift has occurred in the composite of genera that constitute the mushroom supply. During the 1979 production year, the button mushroom, *Agaricus bisporus*, accounted for over 70% of the world's supply. By 1991, only 37% of world production was *A. bisporus*. Mainland China is the major producer (2,200,000 t--or about 50% of the total) of edible mushrooms. In 1993 to 94, the United States produced 346,188 t (or about 8% of the total world supply) of mushrooms. *Agaricus bisporus* accounted for over 90% of total mushroom production value while *Lentinula*, *Flammulina*, *Pleurotus*, *Hypsizygus*, *Hericium*, *Morchella*, and *Grifola* were the main specialty genera cultivated. The value of the 1993 to 94 specialty mushroom crop in the U.S. amounted to $28.7 million--a 75% increase over the previous season (USDA 1994). Based on recent and historical trends, it is expected that diversification of the mushroom industry will continue in the United States and many other western countries. The development of improved technology to cultivate each species more efficiently, will allow consumer prices to decline.

PRODUCTION TECHNOLOGY

A list of cultivated species and their common English and Japanese names is given in Table 1. Twelve genera comprise the bulk of cultivated mushrooms as outlined below.

Auricularia spp.

Commonly known as wood ear, *Auricularia auricula* is the first recorded cultivated mushroom (Chang 1993). Total production of *Auricularia* spp. in 1991 exceeded 465,000 t (fresh weight; Table 2). This value is an increase of 346,000 t or 290% over 1986 levels (Chang 1993). *Auricularia* spp. production now represents about 11% of the total cultivated mushroom supply world-wide.

Auricularia auricula and *A. polytricha* commonly are produced on a synthetic medium consisting of sawdust, cotton seed hulls, bran, and other cereal grains or on natural logs of broad-leaf trees (Quimio 1982; Chang and Quimio 1982; Oei 1991). For cultivation on natural logs, members of the oak family (Fagaceae) are preferred, but many other species of both hard and softwoods may be used.

For synthetic medium production of Auricularias, the substrate may be composted for up to 5 days or used directly after mixing. In either case, the mixed substrate (about 2.5 kg wet wt) is filled into heat resistant polypropylene bags and sterilized (substrate temperature 121°C) for 60 min. Composted substrate is prepared by mixing and watering ingredients [sawdust (78%) : bran (20%) : $CaCO_3$ (1%) : sucrose (1%)] in a large pile. The pile then is covered with plastic and turned (remixed) twice at two-day intervals. For direct use of substrate, a mixture of cotton seed hulls (93%), wheat bran (5%), sucrose (1%), and $CaCO_3$ (1%) is moistened to about 60% moisture and then filled into polypropylene bags.

After the substrate has cooled, it is inoculated with either grain or sawdust spawn. The spawn then is mixed into the substrate either mechanically or by hand, and the mycelium is allowed to colonize the substrate (spawn run). Temperatures for spawn run are maintained at about 25°C±2°C for about 28 to 30 days. Light intensity of more than 500 lux during the spawn run may result in premature formation of primordia. Temperature, light intensity and relative humidity all interact to influence the nature and quality of the basidocarps.

In Fujian, China a system has been worked out to intercrop *Auricularia* spp. with sugar cane. Bags containing colonized substrate are suspended in mid air on a rope stretched between rows of sugar cane. The bags then are covered with a thin layer of plastic to help regulate relative humidity. Carbon dioxide generated from the growing mycelium apparently stimulates the growth of the sugar cane (Oei 1991).

Flammulina velutipes

Worldwide production of *F. velutipes* (enokitake) has increased from about 100,000 tonnes in 1986 to about 187,000 t in 1991 (an 87% increase). Japan is the main producer of enokitake (Furukawa 1987). In 1986, Japan produced 74,387 t; by 1991, production had risen to 95,123 t. In 1993, Japan produced 103,357 t--an increase of about 8%. From these data, it is evident that a faster growth rate, in terms of total production, is being enjoyed by other countries. In the United States, for example, enokitake production has increased at an estimated rate of 25% or more per year for the last four years.

Production of most enokitake in Japan is based on synthetic substrate contained in polypropylene bottles (Fig. 1). Substrates (primarily sawdust and rice bran; 4 : 1 ratio) are mechanically mixed and filled into heat resistant bottles with a capacity of 800 to 1,000 ml. Sawdust consisting primarily of *Cryptomeria japonica*, *Chamaecyparis obtusa* or aged (9 to 12 months) *Pinus* spp. appears to offer the best yields. In the United States, a bran-supplemented medium, consisting primarily of corn cobs, serves as the primary medium. After filling into bottles, the substrate is sterilized (4 h at 95°C and 1 h at 120°C), mechanically inoculated and incubated at 18° to 20°C for 20 to 25 days. When the substrate is fully colonized, the original inoculum is removed mechanically from the surface of the substrate and the bottles may be placed upside down for a few days. At the time of original inoculum removal, the air temperature is lowered to 10° to 12°C for 10 to 14 days.

To further improve quality during fruiting, temperatures are lowered to 3° to 8°C until harvest. As the mushrooms begin to elongate above the lip of the bottle, a plastic collar is placed around the neck and secured with a Velcroreg. strip. This collar serves to hold the mushrooms in place so that they are long and straight. When the mushrooms are 13 to 14 cm long, the collars are removed and the mushrooms are pulled as a bunch from the substrate. The mushrooms then are vacuum packed and placed into boxes for shipment to market.

Ganoderma lucidum

Known as reishi or mannentake to the Japanese and Ling Zhi to the Chinese, *G. lucidum* is renown for its medicinal properties (for an extensive review see Willard 1990). Reishi often is associated with health and recuperation, longevity, wisdom, and happiness (Stamets 1990, 1993). It is believed that certain triterpenes and polysaccharides may account for the multiple activities of Reshi. Thus, considerable time and effort has gone into the isolation and characterization of these compounds. About 100 triterpenes have been isolated from either the fruitbodies or mycelium but only a few have been tested for bio-activity (Mizuno et al. 1995).

Most cultivation of *G. lucidum* is on supplemented sawdust contained in heat-resistant polypropylene bottles (Fig. 2) or bags. Sawdust of hardwoods is supplemented with rice bran (10%) and $CaCO_3$ (3%), moistened with water and filled (700 g) into plastic bags. A plastic collar then is fitted onto each bag and stoppered with a cotton plug. After heat treatment (95° to 100°C for 5 h) the substrate is allowed to cool overnight and then inoculated with grain or sawdust spawn. The inoculated substrate is then incubated for 3 to 4 weeks or until the spawn has fully colonized the substrate.

Mushroom production is initiated by maintaining air temperature at about 28deg.C with relative humidity in the range of 85% to 90%. Basidiocarps begin to appear in about 1 to 2 weeks after initiation. Approximately 2 to 3 months after the appearance of primordia, mushrooms are ready to harvest. A mushroom is considered mature when the whitish margin around the edge of the basidiocarp has turned red. The substrate may yield another harvest of mushrooms after removal of the first flush.

Grifola frondosa

Japan is the major producer and consumer of *G. frondosa* (Maitake). Commercial production of maitake in Japan (325 t) began in 1981 (Takama et al. 1981). By 1986, production was 2,203 t and, by 1991, production reached 7,950 t (a 261% increase). Japanese production of maitake reached 9,617 t in 1993 (Table 3) and was produced primarily in the provinces of Niigata, Nagano, Gunnma, and Shizuoka.

Commercial production of most *G. frondosa* is on synthetic substrate contained in polypropylene bottles or bags (Fig. 3). A common substrate used for production is composed of sawdust supplemented with rice bran or wheat bran in a 5 : 1 ratio, respectively (Takama et al. 1981). For bottle production, the containers are filled with moistened substrate and sterilized or pasteurized prior to inoculation. Most growers use automated inoculation equipment thereby saving on labor costs. For production in bags, the moistened substrate (2.5 kg) is filled into microfiltered polypropylene bags and sterilized to kill unwanted competitive microorganisms. After cooling (16 to 20 h), the substrate is inoculated and the bags are heat sealed and shaken to uniformly distribute the spawn throughout the substrate. Spawn run lasts about 30 to 60 days depending on strain and substrate formulation. Temperatures then are lowered from about 22° to 14°C to induce fruiting and fruitbody maturation.

Most Maitake is marketed as food. However, Maitake has been shown to have both anti-tumor and anti-viral properties (Jong and Birmingham 1990; Jong et al. 1991; Mizuno and Zhuang 1995). Powdered fruitbodies are used in the production of many health foods such as Maitake tea, whole powder, granules, drinks, and tablets.

Hericium erinaceus

In the wild, *H. erinaceus* occurs on old logs and stumps and on wounds of living trees, especially, maple, beech, oak, and hickory. The fruiting body is formed as a large white mass (5 to 30 cm across) that is toothed in many small tufts. The Chinese were the first to domesticate the fungus and, in 1991, production reached 66,000 t (Table 1). In Japan, the mushroom is cultivated on synthetic substrate in bags and bottles and on logs. It is sold for 1,000 to 1,500 yen per kg ($5.25 to $7.87 per pound).

Polysaccharides in *Hericium* spp. are believed to inhibit a variety of cancers by enhancing the hosts' immune functions (Mizuno 1995b). It also has been suggested that the phenol-analogous compounds hericenone-C, -D, -E, and Y-A-8-c, which induce the synthesis of nerve growth factor, might be effective in treating patients suffering from Alzheimer's disease (Mizuno 1995b).

Hypsizygus marmoreus

Japanese are the main producers and consumers of *H. marmoreus*. Bunashimeji production has increased steadily over the last few years although not as fast as some other types of mushrooms (Royse 1995). In 1986, production of Bunashimeji was 11,439 t in Japan; by 1991 production reached 36,623 t--an increase of 220% (Table 3). Production of *H. marmoreus* increased 38% in the two year period 1991 to 1993.

Bunashimeji usually is produced in polypropylene bottles contained in plastic trays. After the completion of vegetative mycelial growth, bottle lids are removed and the colonized substrate subjected to environmental conditions known to stimulate fruiting. When the mushrooms are mature, the entire cluster of fruiting bodies are removed from the bottles. The mushrooms are packaged by placing an entire cluster (or multiple clusters) into each over-wrapped package. Only one flush of mushrooms is harvested prior to mechanical removal of the "spent" substrate from the bottles. The bottles then are refilled with fresh substrate and the process is repeated.

The antitumor polysaccharide, ß-(1-3)-D-glucan, isolated from *H. marmoreus* showed very high activity (Ikekawa 1995). The water solubility of the polysaccharide was much higher than the same polysaccharide isolated from other fungi. Dried mushroom powder from this mushroom is believed to stimulate the radical-trapping activity of blood (Ikekawa 1995). Excessive free radicals in the blood stream are believed to hasten the aging process.

Lentinula edodes

The cultivation of *L. edodes* (shiitake) first began in China about AD 1100 (Nakamura 1983; Royse et al. 1985; Chang and Miles 1987, 1989). It is believed that shiitake cultivation techniques developed in China were introduced to the Japanese by Chinese growers (Ito 1978).

Cultivation on natural logs. Various species of trees have been used for the cultivation of shiitake

(San Antonio 1981). One of the primary species used in one area of Japan in past years was the shii tree--thus the derivation of the name shii-take (Singer 1961). Most production today, however, is on various species of oak (Harris 1986; Stamets and Chilton 1982).

Natural logs usually are cut in the fall (after leaf drop) and may be inoculated within 15 to 30 days of felling. Trees that are cut in the fall also may be left intact through winter and, just before inoculation, cut into lengths of about one meter. Trees that are cut in the summer tend to have bark that is more loosely bound and sugar contents usually are lowest during this time. If trees are cut during the summer, the bark may strip off more easily, increasing the chances of contamination of the wood by competitive organisms. The most efficient log diameter appears to be in the 7- to 15-cm range (Ito 1978). Logs greater than 25 cm in diameter often are cut in half prior to inoculation (Royse et al. 1985).

Growers who inoculate the logs with wood-piece spawn drill holes in the logs with high speed drills to correspond to the diameter and length of the wood-piece spawn. Enough holes are drilled in the log to provide spacing of about one hole per 500 cm^2. The wood spawn then is driven into the holes with a hammer and then usually covered with hot wax to prevent excessive drying of the spawn. Sawdust spawn sometimes is used instead of wood-piece spawn.

Spawn run may last from 6 to 9 months, depending on the tree species, log size, spawn cultivar, moisture, temperature, and other variables (Leatham 1982). After the spawn run period the logs often are transferred to a "raising" yard. Raising yards usually are cooler and more moist than the spawn run area. The change in conditions provides an optimum environment for the growth and development of mushrooms. In the raising yard, the logs are arranged to provide for convenient harvesting of the mushrooms. Most production occurs in the spring and fall when conditions are most favorable. However, prices received by the growers usually are lowest during these periods.

Growers may use greenhouses for winter production of mushrooms (Przybylowicz and Donoghue 1988). More overall production is possible, and prices for fresh mushrooms are considerably higher, in winter than during the rest of the year. In the greenhouse method, logs usually are soaked in water (usually less than 48 h) and vibrated mechanically for various periods prior to placement in the greenhouse. After the mushrooms are harvested, the logs are incubated further (up to three months) and the process is repeated (up to five times).

Synthetic log production. Sawdust (Fig. 4a) is the most popular basal ingredient used in synthetic formulations of substrate used to produce shiitake (Miller and Jong 1987). Other basal ingredients that may be used include straw and corn cobs or mixtures thereof. Regardless of the main ingredient used, starch-based supplements such as wheat bran, rice bran, millet, rye, corn, etc. are added to the mix in a 10% to 40% ratio (dry wt) to the main ingredient. These supplements serve as nutrients to provide an optimum growing medium (Royse et al. 1990).

Once the proper ratio of ingredients are selected, they are combined in a mixer and water is added to raise the moisture content of the mix to around 60%. On large farms, the mix then is augured to a machine that fills and weighs the substrate so that a uniform amount is filled into each bag (Fig. 4b). The filled bags are stacked on racks, loaded into a industrial-sized autoclave, sterilized for 2 h at 121°C, cooled and inoculated with shiitake spawn.

After a 20- to 25-day spawn run (Fig. 4c) the bags are removed and the substrate blocks are exposed to an environment conducive for browning of the exterior log surfaces. As the browning process nears completion (4 weeks), primordia begin to form about 2 mm under the surface of the log indicating that the log is ready to produce mushrooms.

Primordium maturation is stimulated by soaking the substrate in water (12°C) for 3 to 4 h. Soaking allows water rapidly to displace carbon dioxide contained in air spaces, providing enough moisture for one flush of mushrooms. Approximately 9 to 11 days after soaking, mushrooms are ready to harvest (Fig. 4d).

The main advantages of using synthetic medium over natural logs is time and efficiency. The cycle for synthetic medium cultivation lasts approximately 4 months from time of inoculation to cleanout. Biological efficiencies for this method may average from 75% to 125%. In contrast, the natural log cultivation cycle usually lasts about 6 years with maximum efficiencies around 33%. The time required on synthetic substrate, therefore, only is about 1/15th that of the natural system with about 3 times the yield efficiency. As a result of these developments, shiitake production in the United States has increased dramatically in the last nine years (Fig. 5).

Shiitake is one of the best known and best characterized mushrooms used for medicinal purposes. Several medicinal properties have been attributed to shiitake in recent years. These properties include antitumor polysaccharides activity (Breene 1990; Mizuno 1995a) and glycoproteins, antiviral nucleic acids, platelet agglutination inhibitive substances, and anti-cholesterol active substances (Tokuda et al. 1974; Fujii et al. 1978; Suzuki et al. 1979; Tokuda and Kaneda 1978; Mizuno 1995a).

Morchella esculenta

Morels (Fig. 6) are some of the most highly prized mushrooms found in the wild. Researchers have long sought to consistently cultivate the morel; until recently this was not possible. In 1982, a report describing the successful production of ascocarps of *Morchella esculenta* under laboratory conditions appeared in the literature (Ower 1982). Since that first report, several patents (Ower et al. 1986, 1988) have issued describing a process for the commercial cultivation of these fungi. While patents have revealed some of the processes involved in predictable production of sporocarps, attempts to practice the invention have met only with limited success.

At present, one company in the United States is producing morels on a commercial scale. Commercial cultivation involves the production of sclerotia, an early overwintering stage of the mushroom. "Nutrient primed" sclerotia are produced in soil placed on a layer of sterilized wheat or rye grain. The production of nutrient primed sclerotia requires about 18 to 21 days under optimum conditions. The sclerotia are harvested, soaked in clean water for 24 h and distributed into a thin layer of pasteurized bark/soil mix. The sclerotia germinate via the production of mycelium. After the mycelium has spread throughout the soil mix, a continuous (12 to 36 h) fine mist of clean water is provided to stimulate the formation of ascocarps.

Several problems have yet to be solved in the commercial production of morels. Consistent fruiting, control of competitive weed molds, poor yields, and small mushroom size are just a few of the problems facing successful cultivation. A better understanding of the many factors contributing to increased yields and quality should lower the cost of commercially produced morels to consumers.

Pleurotus spp.

Oyster mushroom production has increased at rapid rate world-wide during the last few years (Table 2). From 1986 to 1991, oyster mushroom production increased from 169,000 t to 917,000 t (442% increase). China was responsible for most of the production increase. In the United States, production of oyster mushrooms was 882 t in 1994, up 94% from the previous year (USDA 1994). *Pleurotus* spp. (*P. ostreatus* and *P. cornucopiae*) production in Japan peaked in 1989 at about 36,000 t. Production was 24,000 t in 1993, a decrease of 33% in four years.

In the United States, the primary ingredients used for *Pleurotus* spp. production is chopped wheat straw or cottonseed hulls or mixtures thereof. For production on wheat straw, the material is milled to a length of about 2- to 6-cm. The pH of the material is adjusted with limestone to about 7.5 or higher to provide selectivity against Trichoderma green mold (Stolzer and Grabbe 1991).

After completion of pasteurization (60°C for 1 to 2 h) the substrate is cooled and spawned with the desired strain. At time of spawning, a delayed release supplement (rates of 3% to 10% of dry substrate wt) may be added to increase yield and size of the mushroom (Royse and Schisler 1987; Royse et al. 1991; Royse and Zaki 1991). Use of supplements, however, may cause overheating of the substrate if growers are not able to anticipate and control air temperatures to maintain a steady substrate temperature.

Production of *Pleurotus* spp. on cotton seed hulls has some advantages over straw-based production systems in that chopping of the hulls is not required (Royse 1995). The pasteurized, supplemented hulls are spawned and filled (12 to 15 kg) into clear or black perforated polyethylene bags and then incubated at 23° to 25°C for 12 to 14 days.

In Japan, bottle production of oyster mushrooms is most common (Fig. 7). Substrate is filled into bottles, sterilized and inoculated with *Pleurotus* spawn. Upon completion of spawn run, bottle lids are removed and mushroom emerge from the surface of the substrate. After the mushrooms are harvested they are weighed and packaged for shipment to market.

Pholiota nameko

Japan produced 21,738 t of *P. nameko* in 1991--an increase of only 1,700 t (8% increase) from 1986 levels (Table 2). World-wide production increases averaged 60% over the same time period. In 1991, Japan produced about 54% of the total world production of nameko compared to 80% of total production in 1986. Thus, production of nameko rapidly is gaining popularity in other Asian countries.

Nameko (Fig. 8) means "viscid mushroom" in Japanese. This mushroom is prized for its gelatinous viscosity and for its flavor and is generally used in miso soup, cooked fresh with grated radish, and steamed in pipkin.

Preparation of the medium for nameko production is similar to that for enokitake except that a higher moisture content of the substrate is desirable. A substrate of broad leaf tree sawdust is preferred but research has shown that sawdusts from conifers such *Pinus* spp. and *Cryptomeria japonica* are suitable for growth. Rice bran usually is added as a supplement in the ratio of 15% for conifer sawdust and 10% for broad-leaf sawdust.

Mushrooms are harvested from the substrate by cutting the stems near the base with scissors. The harvested mushrooms are washed and packed for shipment to market.

Tremella fuciformis

Known as the white jelly fungus or silver ear, *T. fuciformis* has been used as a delicacy food in China for many years. This mushroom can be cultivated on natural logs or on synthetic medium (Quimio et al. 1990). Cultivation techniques used to produce the mushroom on natural logs is similar to that used for shiitake production. In recent years, most production of *T. fuciformis* has been on synthetic substrate using a mixed culture inoculum technique first developed in Fujian, China (Huang 1982).

The mixed culture technique involves the use of "helper" mycelium of *Hypoxylon archeri*, an ascomycete commonly associated in nature with decaying wood. *Hypoxylon archeri* increases the ability of *T. fuciformis* to digest the substrate thereby increasing mushroom yields. Exploitation of this mycelial association is accomplished through use of dual cultures to make mother spawn (Quimio et al. 1990).

Substrate used for mushroom production is the same as that used for spawn production. The supplemented substrate is packed into plastic bags (50 cm long; 9 cm diameter) and ends of the bags are tied with cotton string. Six holes (1 cm diam) then are punched in the filled bags and covered with a breathable fabric. The substrate is sterilized for 6 to 8 h, cooled and inoculated with the mother culture.

After about 30 days of vegetative mycelial growth, the hole covers are removed and the exposed substrate is exposed to conditions favorable for primordia formation (Huang 1982). If optimum conditions are maintained in the growing houses, clusters of jelly fungus should be ready for harvest within 12 to 15 days. Yield for each bag of substrate is in the range of 350 to 500 g fresh weight (35 to 50 g dry weight).

Volvariella spp.

The straw mushroom derives its name from the substrate on which it originally was grown (San Antonio and Fordyce 1972). Cultivation of *Volvariella* was believed to have begun in China as early as 1822 (Chang 1977). In the 1930s, straw mushroom cultivation began in the Philippines, Malaysia, and other Southeast Asian countries (Chang 1982). Production of the straw mushroom increased from 178,000 t in 1986 to about 253,000 t in 1991--a 42% increase. *Volvariella* accounts for approximately 6% of the total world-wide production of edible mushrooms (Table 2).

Many agricultural by-products and waste materials have been used to produce the straw mushroom. These include paddy straw, water hyacinth, oil palm bunch, oil palm pericarp waste, banana leaves and sawdust, cotton waste, and sugarcane waste (Chang 1982; Ho 1985). *Volvariella* is well suited for cultivation in the tropics because of its requirement for higher production temperatures. In addition, the mushroom can be grown on nonpasterized substrate--more desirable for low input agricultural practices.

In recent years, cotton wastes (discarded after sorting in textile mills) have become popular as substrates for straw mushroom production (Chang 1982). Cotton waste give higher and more stable biological efficiencies (30% to 45%), earlier fructification (four days after spawning) and harvesting (first nine days after spawning) than that obtained using straw as a substratum. Semi-industrialization of paddy straw cultivation on cotton-wastes has occurred in Hong Kong, Taiwan, and Indonesia as a result of the introduction of this method (Chang 1979).

MARKETING

Marketing of specialty mushrooms in the United States is a relatively new enterprise. Since 1984, some farms have seen their production rise as prices have fallen. For example, Donovan (1991) indicates that production of shiitake on their farm has increased from slightly less than 1 t per week in 1984 to over 7 t per week in 1990. At the same time, the price has decreased from US $12.50/kg ($5.50 per pound) to about US $ 8.80/kg ($4.00 per pound). In the 1993 to 94 growing season, the price growers received for shiitake was about $8.14/kg ($3.70 per pound; USDA 1994). Over the past seven years (1987 to 1994) the price of shiitake has declined an average of $0.19/kg ($0.09 per pound) per year (USDA 1994).

In recent years, the trend for specialty mushroom sales has been toward the retail market (Gunn 1992; Sorenson 1992). This trend is driven partly by an increased interest in specialty mushrooms and by the convenience packaged products offer to the consumer. In some retail markets, only 10% of the customers buy 90% of the specialty types (Gunn 1992).

Some merchandisers have projected a steady growth in consumption of specialty mushrooms. As consumers become more aware of specialty mushrooms, demand is expected to increase. Aggressive marketing will help to find new markets for these relatively new products. Therefore, specialty mushroom producers seeking new outlets for their mushrooms may want to check sources listing reputable produce industry firms (Anon. 1995a, b).

Specialty mushrooms are sold fresh, dried, or processed in Japan and China. Most fresh shiitake is collected and shipped to central wholesale markets where brokers and other participants buy the mushrooms through a bidding process in Japan (Hara 1988). Mushrooms then are distributed to retailers for consumer purchase. Other mushrooms, such as *Pleurotus*, may be packaged at the farm and shipped directly to brokers or to retailers.

Dried shiitake is distributed through traders specializing in this mushroom (Hara 1988). These traders (about 400 in Japan in 1988; data not available for China) buy shiitake at special bidding markets and then distribute the product to retailers for in country consumption or to trading firms for overseas export. In recent years, however, exports of shiitake from Japan have declined as the number of shiitake producers have declined and shiitake production has decreased (Anon. 1992; Royse 1995). On the other hand, Chinese production of shiitake and exportation of the product to Japan have increased dramatically in the last five years.

FUTURE OUTLOOK

Production and consumption of specialty mushrooms in the United States and other western countries is expected to increase at an accelerated rate in the years to come (Farr 1983; Royse 1995). As production technology is improved through interdisciplinary efforts, the retail price for specialty mushrooms should decrease. As economies improve in Latin America, production of specialty mushrooms could increase at an even faster rate than in the United States. The culinary advantages offered by specialty mushrooms bode well for the continued growth and development of the specialty mushroom industry worldwide.

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Table 1. Scientific and English and Japanese names for some cultivated specialty mushrooms.

Scientific Name	English name	Japanese name
Agrocybe cylindracea (DC.: Fr.) Maire	South Popular	Yangimatusutake
Armillaria mellea (Vahl:Far.) Kummer	Chiodini, Honey	Naratake
Auricularia auricula (Hook) Underw.	Black ear, Wood ear	Kikurage
Auricularia polyticha (Mont.) Sacc.	Cloud ear, Tree ear, Wood ear	Angekikurage
Coprinus comatus (Mull.:Fr.) S.F.Gray	Shaggy ink cap, Lawyer's wig	
Cordyceps sinensis (Berk.) Sacc.	Chinese catepillar fungus	
Creolophus pergamenus Karsten	Bear's head	Banshariake
Dictyophora indusiata (Vent.:Pers.) Fisch.	Bamboo sprouts, Collared stinkhorn	
Flammulina velutipes (Curt.:Fr) Karst.	Winter, Velvet stem, Golden, snow puff	Enokitake
Ganoderma lucidum (Leyss.:Fr.) Karst.	Ling-Zhi, Reishi	Reishi
Grifola frondosa (Dicks.:Fr.) S.F.Gray	Hen of the woods	Maitake
Hericium erinaceus (Bull.:Fr.) Pers.	Monkeyhead, Bear's head	
Hypsizygus marmoreus (Peck) Bigelow	Shimeji	Bunashimeji
Lentinula edodes (Berk.) Pegler	Black forest, Black, Oak	Shiitake
Lepista nuda (Bull.:Fr.) Cook	Blewit	
Lyophyllum decastes (Fr.:Fr.) Sing	Fried chicken	Hatakeshimeji
Morchella esculenta Pers. ex St. Amans	Morel	
Naematoloma sublateritivum Karsten	Bricktop, Chestnut	Kuritake
Pleurotus abalonus Han et al.	Abalone	Kuroawabitake
Pleurotus cornucopiae (Paul.) Roll.	Golden oyster, Horn of plenty	Tamogitake
Pleurotus cystidiosis O.K. Miller	Ohritake	

Pleurotus djmour (Fr.) Boedijn	Rose, Pink oyster	
Pleurotus ostreatus (Jacq.:Fr.) Kumm	Oyster, White oyster, Gray oyster	Hiratake
Pleurotus pulmonarius (Fr.) Quel.	Phoenix-tail	
Panellus serotinus (Fr.) Kuh.	Green oyster, Late fall oyster	Mukitake
Pholiota nameko (T.Ito) S.Ito *et* Imai	Viscid, Nameko	Nameko
Pholiota adiposa (Fr.) Quel	Fat pholiota	Numerisugtake
Tremella fuciformis Berk.	Snow fungus, Silver ear, White jelly	Shirokikurage
Tricholoma matsutake (Ito *et* Iman) Sing.	Pine	Matsutake
Tuber aestivum Vitt.	Summer truffle	
Tuber magnatum Pico ex Vitt.	Piedmont white truffle	
Tuber melanosporum Vitt.	Perigord black truffle	
Volvariella diplasia (Berk & Br.) Sing.	Banana, Straw	
Volvariella volvacea (Bull.:Fr.) Sing.	Straw, Paddy straw	Fukurotake

Table 2. World production of cultivated edible mushrooms in 1986 and 1991 (Chang 1993).

	Fresh wt (x 1,000 t)				
Species	1986		1991		Increase (%)
Agaricus bisporus	1,215	(55.8%)	1,590	(37.2%)	30.9
Pleurotus spp.	169	(7.8%)	917	(21.5%)	442.6
Lentinula edodes	320	(14.7%)	526	(12.3%)	64.4
Auricularia spp.	119	(5.5%)	465	(10.9%)	290.8
Volvariella volvacea	178	(8.2%)	253	(5.9%)	42.1
Flammulina velutipes	100	(4.6%)	187	(4.4%)	87.0
Tremella fuciformis	40	(1.8%)	140	(3.3%)	250.0
Hericium erinaceus	--	--	66	(1.5%)	--
Pholiota nameko	25	(1.1%)	40	(0.9%)	60.0
Hypsizygus marmoreus	--	--	32	(0.7%)	--
Grifola frondosa	--	--	8	(0.2%)	--
Others	--	--	49	(1.2%)	--
Total	2,176	(100.0%)	2,176	(100.0%)	96.4

Table 3. Japanese production of *Grifola frondosa* (Maitake), *Hypsizygus marmoreus* (Bunashimeji), *Flammulina velutipes* (Enokitake) and *Pholiota nameko* (Nameko) from 1981 through 1993 (Ohmasa 1994).

	Production (t fresh wt)

Year	*H. marmoreus*	*G. frondosa*	*F. velutipes*	*P. nameko*
1981	1,885	325	53,282	16,348
1983	4,666	699	55,769	18,141
1985	9,157	1,501	69,530	19,793
1986	11,439	2,203	74,378	20,079
1987	13,688	3,015	78,129	21,054
1989	22,349	6,167	83,200	21,125
1991	36,623	7,950	95,123	21,738
1993	48,479	9,617	103,357	22,613

Fig. 1. Production of enokitake (*Flammulina velutipes*) on synthetic substrate contained in polypropylene bottles; collar removed to show maturing mushrooms.

Fig. 2. Production of reishi (*Ganoderma lucidum*) in bottles.

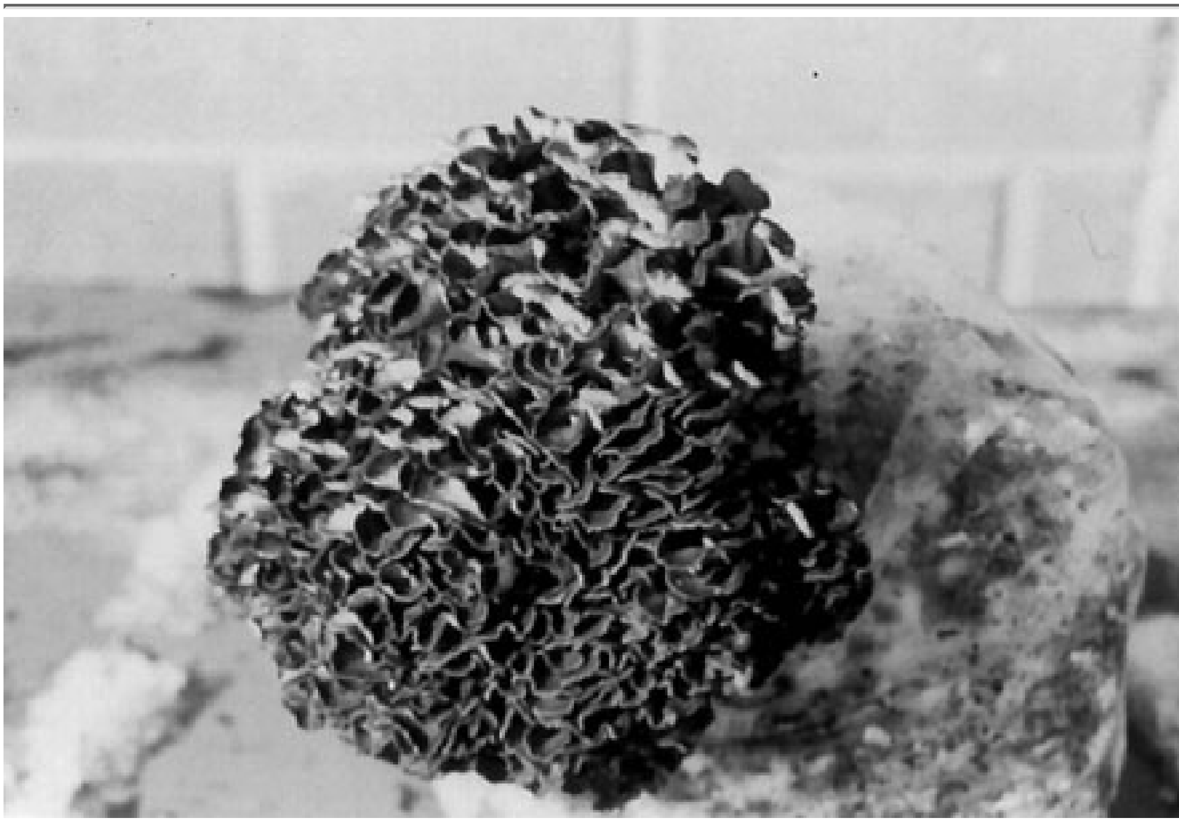

Fig. 3. Maitake (*Grifola frondosa*) fruiting on substrate contained in plastic bags.

Fig. 4. Shiitake production on synthetic substrate: a) loading sawdust for use as an ingredient,

b) filling polypropylene bags with nutrient supplemented sawdust,

c) spawn run in plastic bags, and

d) shiitake fruiting from synthetic logs.

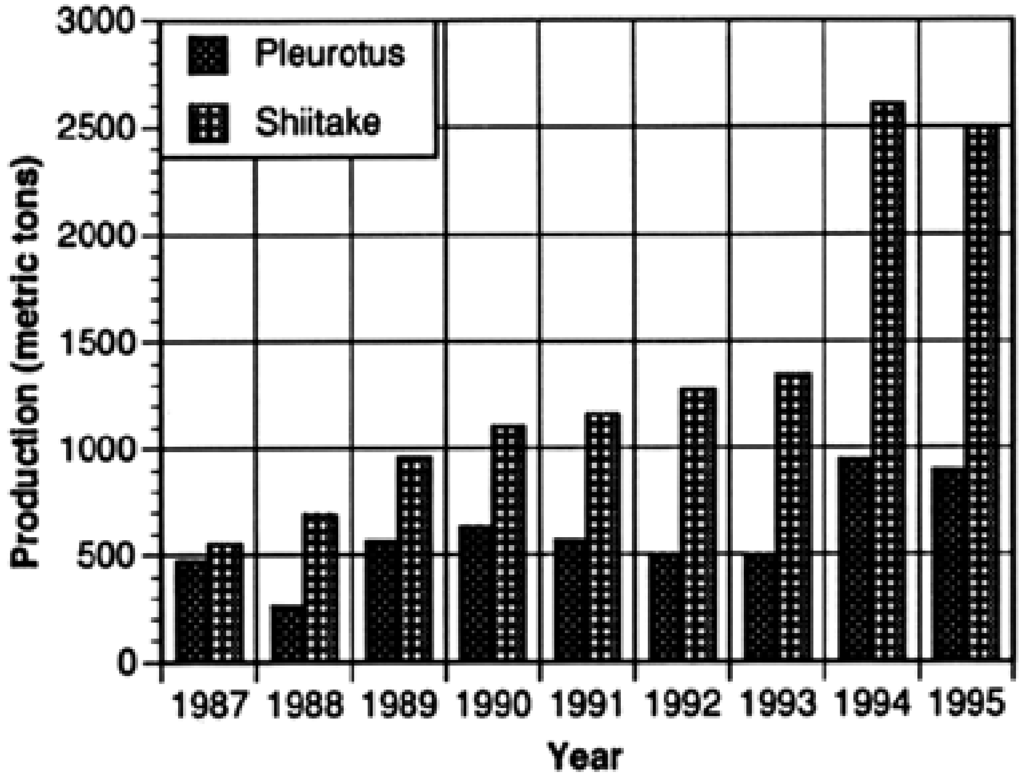

Fig. 5. Shiitake and *Pleurotus* spp. production in the United States from 1987-1994.

Fig. 6. *Morchella esculenta* (morel) fruiting in the wild.

Fig. 7. *Pleurotus* spp. production from polypropylene bottles.

Fig. 8. Nameko (*Pholiota nameko*) production on substrate contained in polypropylene bottles.

Last update Augsut 22, 1997 aw

Casuarina equisetifolia J.R. & G. Forst.

Syn: *Casuarina litorea* L.
Casuarinaceae
Sheoak, Beefwood, Australian pine, Polynesian ironwood, Horsetail tree

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Extensively cultivated for fuel, erosion control, and as a windbreak. It can be trimmed and used as a hedge. The bark, used for tanning, penetrates the hide quickly, furnishing a fairly plump, pliant, soft leather of pale reddish-brown color. With the neutral sulfite semichemical process, wood yields a good pulp. The wood is used for beams, boatbuilding, electric poles, fences, furniture, gates, house posts, mine props, oars, pavings, pilings, rafters, roofing shingles, tool handles, wagon wheels, and yokes. The needles have been employed in preparing active carbon by the zinc chloride method (C.S.I.R., 1948–1976). Hill tribes of New Guinea use *Casuarina* in rotation to restore nitrogen to the soil. They even use *Casuarina oligodon* as a cover crop for coffee.

Considering its unique ability to grow well, even in highly eroded areas, Aspiras (1981) recommends it for Philippine barren hills and watersheds. "It is not known to deplete the soil of important nutrients unlike other fast-growing species now being grown in the countryside. Aside from its ability to raise the N status of the soil when grown in rotational agriculture or in stabilizing road embankments, it also produces good quality timber of high energy value. It may even be raised as a nurse plant to pine, just like *Myrica*, or planted between coconut trees for its nitrogen and timber." (Aspiras, 1981). In the Philippines, this is recognized as one of the best trees for planting in sites covered by Imperata grass (NAS, 1983e). In Thailand it is planted along coastlines to produce the poles used in building fish traps as well as fuelwood. In the Dominican Republic, it has been used to reclaim stripmine lands. Egyptians plant the trees along the coast to Protect houses from the wind and salt spray.

Folk Medicine

Reported to be astringent, diuretic, ecbolic, emmenagogue, laxative, and tonic, beefwood is a remedy for beri-beri, colic, cough, diarrhea, dysentery, headache, nerves, pimples, sores, sorethroat, stomachache, swellings, and toothache (Duke and Wain, 1981). In Ternate, the seeds are used for passing blood in diarrhea (Burkill, 1966).

Chemistry

Asparagine and glutamine accounted for 92% of the total amino acid in the nodules. The bark contains 10% catchol tannin, the root 15%.

Description

Tall evergreen tree to 30 m, the branches often drooping, sulcate, green, with 6–8 scalelike leaves. Internodes 5–7.5 mm long on the branchlets, only 2.5 mm on main shoots. Main shoots minutely hairy, with small recurved scales ca 2.5 mm long, usually 8 in a whorl. Male spikes usually numerous, terminating the branches on which the female "cones" are borne lower down, cylindric to fusiform 12–24 mm long. Female "cones" subglobose to ellipsoid, 10–20 mm in diameter. Seeds ca 660,000–990,000/kg.

Germplasm

Reported from the Australian Center of Diversity, beefwood, or cvs thereof, is reported to tolerate calcareous soils, drought, granitic soils, poor soil, salt and salt spray, sand, waterlogging, and wind. In Kenya, it grows around cement works, in Hawaii in sterile pumice, in Malaysia on sterile tin tailings, near Hilo Bay on tidal rocks with its roots in salt water (NAS, 1983e). It is sensitive to fire, grazing, and, in early stages, weed competition. Older trees are problems in hurricanes. It is one of the most fire-sensitive of the *Casaurina* species. Subspecies incana is a small tree possibly useful for low growing shelter belts (NAS, 1983e) ($2n = 18$).

Distribution

Said to be indigenous from Indonesia and Malaysia to India and Sri Lanka and to north and northeast Australia, the Australian Pine is now one of the most common trees on frost-free beaches anywhere in the world.

Ecology

Ranging from Subtropical Thorn Woodland to Wet through Tropical Thorn to Wet Forest Life Zone, *Casuarina* is reported to tolerate annual precipitation of 6.4 to 43 dm (mean of 49 cases = 16.0) (but 2–50 possible, NAS, 1983e), annual temperature of 22.1 to 26.9°C (mean of 34 cases = 25.2), and pH of 5.0 to 7.7 (mean of 2 cases = 6.4) (Duke, 1978, 1979).

Cultivation

Seeds have been successfully stored for 24 months at ca -7°C to 2°C with moisture content of 6–16% (Ag. Handbook 450). In Hawaii seeds are broadcast in spring and covered with less than 1 cm soil. Seedling density should be about 21–32/1000 sq cm. Mulching is not required. Normally seedlings are raised in nurseries to outplant taking advantage of the rainy season, 4–18 months after sowing. Irrigation may be needed during dry periods over the first three years. In new areas, seeds have to be inoculated. They should also be treated to repel ants. Cuttings strike root readily. Trees are usually spaced 2–4 m apart. WARNING: *Casuarina* can exhaust the soil moisture, lower the water table, and restrict understory growth, leaving the soil exposed. Some species are agressive weed species. Trees may die young under unfavorable circumstances (C.S.I.R., 1948–1976). According to the National Academy of Sciences, this has become an undesirable weed in Florida (NRC, 1982).

Harvesting

Although other *Casuarinas* coppice readily, this one does not. *Casuarina* plantations are worked under a clear-felling system, with a rotation of 7–35 years. Some estimates showed a long rotation (33 years) gave greatest volume, but a shorter rotation (15 years) is preferred. In Madras State, the plantations are worked with a short rotation of 7–15 years (usually 10 years), while in North Kanara a 30-year rotation is followed. From a purely silvicultural consideration, the proper rotation appears to be 7 years. In parts of the Philippines, this has outgrown *Gmelina arborea* and *Leucaena* (NAS, 1983e).

Yields and Economics

With plants spaced 2 m apart, on a 7–10-year rotation, the trees may yield 75–200 MT wood/ha, i.e. 10–20 MT/ha/yr. Higher yields have been reported. Citing literature yields of 58–229 kg/ha/yr nitrogen, Aspiras (1981) notes that *Casuarina equisetifolia* fixes 1,742 nmoles C_2H_4/24 hrs/g dry weight, compared to 4,479 for *Casuarina rumphiana,* 4,545 for *Casuarina montana*, 2,267 for *Elaeagnus philippensis,* 225 for *Alnus maritima*, 626 for *Alnus hepalensis,* 7,242 for *Coriaria intermedia*, and only 13 for *Myrica javanica.*

Energy

Litter fall from *Casuarina littoralis* is said to run 29 MT/ha/yr. However, in China litterfall from *C. equisetifolia is* 4 MT/ha/yr with a mean annual wood increment of 4–5 m^3/ha (NRC, 1982).

In India:

5 year-old trees averaging ca 22 cm DBH, 6+ m tall yielded ca 14 m^3/ha
10 year-old trees averaging ca 42 cm DBH, 11+ m tall yielded ca 28 m^3/ha
15 year-old trees averaging ca 56 cm DBH, 16+ m tall yielded ca 54 m^3/ha
20 year-old trees averaging ca 70 cm DBH, 24+ m tall yielded ca 94 m^3/ha
25 year-old trees averaging ca 80 cm DBH, 31+ m tall yielded ca 140 m^3/ha
30 year-old trees averaging ca 90 cm DBH, 35 m tall yielded ca 190 m^3/ha
35 year-old trees averaging ca 96 cm DBH, 36+ m tall yielded ca 210m^3/ha
40 year-old trees averaging ca 100 cm DBH, 37+ m tall yielded ca 240 m^3/ha
indicating yields of ca 6 cubic meters per year. *Casuarina equisetifolia* fixes ca 60–230 kg N/ha/yr (Aspiras, 1981). The wood, burning with immense heat, even when green, has been called the best firewood in the world. In India, it is used to fuel locomotives. It makes a good charcoal. In China the wood is used for firing brick kilns. With a specific gravity of 0.8–1.2, the wood has a calorific value of 4,959 kcal/kg (8,910 Btu). The charcoal has a calorific value of 7,181 kcals/kg, one of the highest reported values. The yields of 10–20 MT/ha/yr are roughly equivalent to 25–50 barrels of oil/ha/yr.

Biotic Factors

In Puerto Rico, natural regeneration is rare because ants consume nearly all the seeds; many trees are killed by disease. The Puerto Rican dieback of 1940, followed by stemcanker, has been blamed on *Diplodia natalensis*. Nursery seedlings in India are attacked by crickets (*Brachutripes achatinus*). Other insect pests, e.g., *Arbela tetraonis*, the bark-eating caterpillar, *Celosterna scabrator*, a longicorn, and grubs of the rhinoceros beetle, *Oryctes rhinoceros,* also cause considerable damage to plantations. Infection by the root fungus *Trichosporium vesiculosum* is among the more serious diseases affecting *Casuarina* (favored by excessive watering and congestion). Early thinning checks it to some extent. Trees infected by insects and fungi should be removed and the stumps grubbed up. Keeping an interval of two years between felling and replanting, and planting of other trees such as *Anacardium occidentale, Azadirachta indica, Pithecellobium dulce, Pongamia glabra, Sapindus laurifolius,* and *Syzygium cumini,* along with *Casuarina* are recommended to segregate the plants, minimizing the spread of infection. It also helps attract insectivorous birds which are remarkably scarce in *Casuarina*. A symbiotic fungus *Phomopsis casuarinae* F.Tassi has been recorded in all organs of *Casuarina* (C.S.I.R., 1948–1976). Browne (1968) lists quite a few diseases. Bacteria: *PseudoNonas solanacearum.*

Fungi: *Armillaria mellea, Corticium salmonicolor, Fomes badius, Fomes durissimus, Fomes fastuosus, Fomes senex, Ganoderma lucidum, Macrophomina phaseoli, Phoma casuarinae, Phytophthora cambivora, Poria hypolateritia, Schizophyllum commune, Sclerotium rolfsii, Trichosporum versiculosum, Ustulina deusta, Xylaria hypoxylon.* Nematodes include *Helicotylenchus cavenessi, Radopholus similes, Rotylenchulus reniformis, Tylenchus* sp., *Xiphinema ifacolum.* Angiospermae: *Cuscuta campestris, Dendrophthoe falcata, Dendrophthoe lanosa.* Coleoptera: *Amblyrrhinus poricollis, Anoplophora chinensis, Celosterna scabrator, Ceresium furtivum, Cratopus punctum, Cryptocephalus sehestedti, Doliopygus chapuisi, Doliopygus serratus, Hamartus instabilis, Hypomeces squamosus, Hypothenemus birmanus, Lixus camerunus, Lixus spinimanus, Myllocerus curvicornis, Myllocerus fabricii, Myllocerus sabulosus, Myllocerus undecimpustulatus, Platypus hintzi, Sthenias grisator.* Hemiptera: *Anoplocnemis tristator, Ceroplastes ceriferus, Clastoptera undulata, Delococcus tafoensis, Duplaspidiotus tesseratus, Ferrisia virgata, Halys dentatus, Icerya aegyptiace, Icerya formicarum, Icerya nigroareolata, Icerya purchasi, Icerya seychellarum, Naiacoccus serpentinus, Nipaecoccus vastator, Parthenolecanium persicae.* Isoptera: *Glyptotermes dilatatus, Neotermes greeni, Odontotermes obesus, Odontotermes wallonensis, Postelectrotermes militaris.* Lepidoptera: *Acanthopsyche reimeri, Ascotis selenaria, Eumenodora tetrachorda, Eumeta crameri, E. variegata, Indarbela quadrinotata, Indarbela tetraonis, Labdia xylinaula, Maruca testulalis, Melasina energa, Metarmostis asaphaula, Sahyadrassus malabaricus, Spodoptera litura, S. mauritia, Zeuzera coffeae.* Orthoptera: *Brachytrupes portentosus, Gymnogryllus erythrocephalus, Gymnogryllus humeralis, Schistocerca gregaria.*

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 19.44 to 18.26 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the wh. plant contained 78.94% volatiles, 1.40% ash, 19.66% fixed carbon, 48.61% C, 5.83% H, 43.36% O, 0.59% N, 0.02% S, 0.16% Cl, and undertermined residue.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, December 30, 1997

Euphorbia tirucalli L.

Euphorbiaceae
Petroleum plant, Aveloz, Milk bush

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Probably most familiar as a subtropical and tropical ornamental, aveloz has recently made popular headlines as a potential "cancer cure" and more important, as an energy source. Growing in rather arid zones as well as more mesophytic zones, the species makes a good living fence post. A large shrub, *Euphorbia tirucalli*, is used as a hedge in Brazil. According to Calvin, these plants grow well in dry regions or land that is not suitable for growing food. He estimates that the plants might be capable of producing between 10 and 50 barrels of oil per acre. Cut near the ground, they would be run through a mill like a cane crushing mill, while the plants would regrow from the stumps. Crude obtained from these plants would run $3.00 to $10.00 per barrel. Calvin discussed this concept with Petrobas, the Brazilian national petroleum company, which is investigating. Calvin's most exciting statement, if true, would be a boon to Brazil and the United States. "He estimates, assuming a yield of 40 barrels per acre (100 barrels per hectare) that an area the size of Arizona would be necessary to meet current requirements for gasoline" (in the U.S.). (Science 194: 46, 1976). The latex is toxic to fish and rats. Africans regard the tree as a mosquito repellent. In Ganjium, rice boiled with the latex is used as an avicide. Aqueous wood extracts are antibiotic against *Staphylococcus aureus*. The wood, weighing 34 pounds per cu. ft., is used for rafters, toys, and veneer. The charcoal derived therefrom can be used in gun powder. Since the latex contains rubber, whole plant harvesting seems most advisable from an energy point-of-view (if the tree coppices well) with rubber, petroleum, alcohol as energy products, and resins, which may find use in the linoleum, oil skin, and leather industries. In Brazil, *Euphorbia gymnoclada*, very similar to *tirucalli* (both are called aveloz), is much used for firewood. One cu. m. of wood yields 2 kg latex with the fibrous residue usable for paper pulp.

Folk Medicine

Recently (SPOTLIGHT July 14, 1980) Alec de Montmorency kindled long-sleeping interests in aveloz (*Euphorbia* spp. including *tirucalli*) inferring that it "seems to literally tear cancer tissue apart." Several Brazilian Euphorbias, *E. anomala, E. gymnoclada, E. heterodoxa, E. insulana, E. tirucalli,* known as aveloz, have local notoriety as cancer "cures," and often find their way into the U.S. press as cancer cures. I fear they are more liable to cause than cure cancer. Still the following types of cancer are popularly believed in Brazil to be alleviated by aveloz: cancer, cancroids, epitheliomas, sarcomas, tumors, and warts. Hartwell (1969) mentions *E. tirucalli* as a "folk remedy" for cancers, excrescences, tumors, and warts in such diverse places as Brazil, India, Indonesia, Malabar and Malaya. The rubefacient, vesicant latex is used as an application for asthma, cough, earache, neuralgia, rheumatism, toothache, and warts in India. In small doses it is purgative, but in large doses it is an acrid irritant, and emetic. A decoction of the tender branches as also that of the root is administered in colic and gastralgia. The ashes are applied as caustic to open abscesses. In Tanganyika, the latex is used for sexual impotence (but users should recall "the latex produces so intense a reaction ... as to produce temporary blindness lasting for several days." In Zimbabwe, one African male is said to have died of hemorrhagic gastroenteritis after swallowing the latex to cure sterility.) The root is used as an emetic for snakebite. In Malabar and the Moluccas, the latex is used as an emetic and antisyphilitic. In Malaya, the stems are boiled for fomenting painful places. The pounded stem is applied to scurf and swelling. In the Dutch Indies, pounded stems are used as a poultice for extracting thorns. The root infusion is used for aching bones, a poultice of the root or leaves for nose ulcers and hemorrhoids. The wood decoction is used for leprosy and for paralysis of the hands and feet following childbirth. Javanese use the latex for skin complaints and rub the latex over the skin for bone fractures.

Chemistry

The latex contains 53.8–79.9% water and water solubles and 2.8–3.8% caoutchouc. Fresh latex contains a terpenic alcohol, isoeuphoral ($C_{30}H_{50}O$) identical with euphol from *Euphorbia resinifera*. Dried latex contains no isoeuphorol but a ketone euphorone ($C_{30}H_{48}O$). Taraxasterol ($C_{30}H_{50}O \cdot CH_3OH$) and tirucallol ($C_{30}H_{50}O$) have also been isolated. Resin, however, is the principle constituent (75.8–82.1%) of the dried latex. According to Hager's Handbuch (List and Horhammer, 1969–1979), the stem contains hentriacontene, hentriacontanol, the antitumor steroid β-sitosterol, taraxerin, 3,3'-Di-O-methylellagic acid, ellagic acid, and a glycoside fraction which hydrolyses to give kampferol and glucose, and a ca 0.1% sapogenin acetates. The whole plant contains 7.4% citric acids with some malonic and some bernstein (succinic) acids.

Description

Dioecious, succulent, cactus-like milky tree, devoid of spines, to 10 m tall, the branches often arranged in pseudowhorls. Leaves small, early deciduous, alternate, 1–2.5 cm long, ca 3–4 mm broad, oblanceolate, acute at tip, tapered to the sessile base. Flowers in yellow head, stalkless at the end of twigs.

Germplasm

Reported from the African Center of Diversity, aveloz, or cvs thereof, is reported to tolerate drought, poor soil, sand, and slope.($2n = 20$)

Ecology

Ranging from Tropical Thorn to Moist through Subtropical Thorn to Moist Forest Life Zones, the milkbush is reported to tolerate annual precipitation of 2.5 to 40 dm (mean of 6 cases = 11), and estimated to tolerate annual temperature of 21 to 28°C, and pH of 6 to 8.5. Calvin suggests that it grows well where annual precipitation is 2.5 to 5 dm and where there is no frost. Ive seen it as a cultivar in almost every tropical site I have visited.

Cultivation

According to Melvin Calvin, *Euphorbia tirucalli* "will grow in the same soils sugarcane will grow in, even without irrigation" (Gogerty, 1977). Calvin notes that 5 cm cuttings take readily and increased one-thousand fold in one growing season, attaining more than 50 cm height in the first growing season (Calvin, 1980).

Harvesting

Harvested in 1978, the 5 cm cuttings that grew to more than 50 cm, weighed roughly 2 kg and produced the equivalent of 15 barrels of oil per acre. It could be mowed, or possibly after reaching full size, tapped (Calvin, 1980). For energy purposes, Calvin suggests they be "cut near the ground and run through a crushing mill in much the same fashion as if done with sugarcane... The plants themselves would regrow from the stumps, so replanting might be necessary only once every 20 years or so." (Maugh, 1976).

Yields and Economics

As early as 1941, French scientists (Steinheil, 1941) reported yields of 3 MT oil per hectare from a similar Moroccan species, *Euphorbia resinifera* (10,000 liters latex/ha). In 1976, Calvin "optimistically estimates that the cost of crude hydrocarbons obtained in this manner would be somewhere between $13 and $10 per barrel. The oil furthermore, would be practically free of sulphur and other contaminants." (Maugh, 1976). California associates of Calvin have since projected $150 to $200 per barrel for *Euphorbia* oil. Philip Leakey, from Kenya, claims to be getting 400 MT biomass (fresh weight = 85% moisture) per ha in Kenyan areas with a rainfall of ca 20 inches per year. I can see 60 MT DM in a several year old stand but do not think Dr. Leakey meant to imply that these were annual yields. Leakey claims to be getting, now, 20 MT/ha charcoal from similar plantations, renewably. Such figures, if replicated, should be very encouraging to arid land inhabitants (Philip Leakey, personal communication, September 28, 1981).

Energy

Back in 1976, Melvin Calvin was quoted as saying the plants might be capable of producing 10 and 50 barrels of oil per acre per year (Maugh, 1976). Back in 1977, Melvin Calvin was quoted as saying, "A cultivated field would yield the equivalent of 2 to 20 barrels of crude oil per acre per year, possibly for as little as $3 per barrel. OPEC oil costs three times that much." (Gogerty, 1977). Back in 1979, Calvin was quoted as saying the growth was 1,000 fold when 5 cm cuttings were inserted in the field. Calculations by a Japanese firm, based on plantings in Okinawa, showed the possibility of producing 5–10 barrels of oil per acre per year. Calvin (1980), however, quotes these same sources as 10–20 barrels per acre.

Biotic Factors

Dehgan and Wang describe the plant as having "no natural enemies". Golden (p.c. 1984) notes that *Meloidogyne* may affect the plant.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, January 6, 1998 by aw

Index | Search | Home

Avena sativa L.

Poaceae

Common oats, Rolled oats, Steel-cut oats

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

New Crops for Canadian Agriculture—Ernest Small

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Index | Search | Home

Averrhoa bilimbi L.

Oxalidaceae

Bilimbi

We have information from several sources:

Bilimbi—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Tuesday, February 09, 1999 by ch

Averrhoa carambola L.

Oxalidaceae

Starfruit, Carambola, Bilimbi, Belimbing, Chinese Star Fruit, Five-angled Fruit, Star Apple

NewCROP has starfruit information at:

Carambola—Julia Morton, Fruits of warm climates

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Commercialization of Carambola, Atemoya, and Other Tropical Fruits in South Florida—Jonathan H. Crane

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more starfruit info:

CARAMBOLA "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Starfruit Nutritional Facts provided by Friedas.

Avicennia germinans L.

Syn: *Avicennia nitida* Jacq.
Avicenniaceae
Black mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Information on *Avicennia* species is confused, due to the difficulty, historically at any rate, of distinguishing the species. Regarding the timber useage, Burkill quotes Foxworthy, "altogether it a very unsatisfactory wood—the least useful of the mangrove-swamp woods—and the tree is usually considered as a weed in the swamps." Little (1983) says it is used for crossties, marine construction, piers, posts, utility poles, and wharves. Ashes are added to water as a soap substitute. Bark is used for tanning. Smoke from the wood is said to constitute an effective mosquito smudge (Duke, 1972). Flowers are a major source of honey.

Folk Medicine

According to Hartwell (1967–1971), the resin is used in folk remedies for tumors in the West Indies. Reported to be astringent, insect repellent, rubefacient, and tonic, black mangrove is a folk remedy for diarrhea, dysentery, hemorrhage, hemorrhoids, rheumatism, swellings, throat ailments, tumors, and wounds (Duke and Wain, 1981; Garcia-Barriga, 1975). Salvadorans use the resin for chest complaints and sore throat. Bahamans believe it restores lost vitality (Morton, 1981) and use it in baths for rheumatism. Colombians say gargling with the bark decoction alleviates cancer of the larynx and malignant ulcers of the throat (Garcia-Barriga, 1975).

Chemistry

Per 100 g, the seed is reported to contain 354 calories, 9.8 g H_2O, 5.6 g protein, 0.5 g fat, 81.3 g total carbohydrate, 4.0 g fiber, 2.8 g ash, 207 mg Ca, and 117 mg P. Leaves contain on a zero-moisture basis, 10.7% protein, 4.0% fat, 69.2% total carbohydrate, 23.9% fiber, and 15.7% ash (Duke and Atchley, 1983).

Toxicity

Fruits, though edible after processing, are said to be toxic raw (Little, 1983).

Description

Evergreen shrub or small tree 3–12(-25) m high; trunk 30–60 dm in diameter. Masses of small air roots 15–45 cm long sometimes hang from upper part of large trunks. Pneumatophores often rise 5–10 cm from the long horizontal roots. Bark dark gray or brown and smooth on small trunks, becoming dark brown, fissured, scaly, and thick. Leaves opposite, lanceolate or narrowly elliptical, 5–11 cm long, 2–4 cm wide, acute or blunt at tip, entire, thick, leathery. Fine hairs giving a grayish hue to foliage; both surfaces often with scattered salt crystals and salty taste. Petiole 3–15 mm long. Spikes or panicles headlike, upright at and near ends of twigs. Flowers several, crowded, sessile, 6 mm long, 10 mm across. Calyx cup-shaped, deeply 5-lobed; corolla tubular, hairy, white but yellowish at base, with 4 slightly unequal spreading, rounded, or notched lobes, stamens 4, 5 mm long in notches of corolla tube near base; pistil with imperfectly 4-celled ovary, slender style, and 2-forked stigma. Capsule elliptical, flattened, 2.5–3 cm long, often splitting into 2 parts. Seed 1, large, flattened, often germinating on tree (Little, 1983).

Germplasm

Reported from the Middle and South American Centers of Diversity, black mangrove, or cvs thereof, is reported to tolerate disease, insects, pests, salt, and waterlogging. Seems to tolerate prolonged flooding.

Distribution

Along coasts of tropical America. Atlantic Coast; Bermuda, Bahamas, West Indies, southeastern US, northern Florida, southeastern Texas, northern Mexico southward on Atlantic Coast to Brazil and on Pacific Coast to Ecuador including Galapagos Islands and northwestern Peru. The same or very closely related species on coasts of western Africa. Not widely planted or introduced elsewhere (Little, 1983).

Ecology

Estimated to range from Tropical Dry to Wet through Subtropical Dry to Wet Forest Life Zones, black mangrove is reported to tolerate annual precipitation of 8.7 to 20.6 dm (mean of 4 cases = 14.1) and annual temperature of 25.3 to 26.6°C (mean of 4 cases = 25.9). Common in mangrove swamp forests, mainly on the landward side in brackish water in mud flats of tidal zones of protected silty shores and at the mouths of rivers.

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In Avicennia and Rhizophora, direct seeding result in ca 90% survival.

Harvesting

Since this mangrove can regrow rapidly from buds beneath the bark along the trunk and branches, it is said to suffer little from removal of much of the branchwood (NAS, 1980a).

Yields and Economics

Good mangrove stand can show annual productivity of 10–20(-25) MT/ha/yr, but for firewood purposes, I would reduce that to 10–20(-25) m^3/ha/yr, figuring that at optimal rather than average. Litterfall may account for 1/3– 1/2 of above ground productivity. Because of the heaviness of the wood, a cubic meter of mangrove is generally more valuable than other species.

Energy

Generalizing about the genus *Avicennia*, Burkill (1966) notes that when freshly cut, the heartwood floats, but the sapwood sinks. "It gives indifferent firewood...not liked because it cannot be split. It is used, however, when better is not easily procurable. It burns smoulderingly. The fisher-folk like it for smoking fish, to which it is said to give an agreeable flavor. It is used, also, for smoking rubber" (Burkill, 1966). Still in Latin America the wood is valued "mainly for fuel, charcoal" (Morton, 1981). "Wood used for fuel and charcoal, burning with intense heat" (Little, 1983).

Biotic Factors

No data available.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update December 29, 1997

Avicennia marina (Forsk.) Vierh.

Avicenniaceae
Grey mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Heavy even-textured wood used for poles and ribs of boats. Bark yields a brown dye. Leaves are used for camel fodder around the Red Sea. Branches are lopped and fed to cattle in India and Australia.

Folk Medicine

According to Lewis and Elvin-Lewis (1977), the tree possesses a bitter aromatic juice, used as an abortive in tropical Africa and Asia. Root and bark are used as aphrodisiac, the wood for snakebite, the aqueous extract of the seed for sores. Unripe fruits are poulticed onto wounds and leaves onto skin ailments (List and Horhammer, 1969–1979).

Chemistry

Bark and roots contain tannin, the bark with lapachol ($C_{15}H_{14}O_3$) the compound supposedly responsible for the overblown virtues of "lapacho" (*Tabebuia* spp. from Brazil).

Toxicity

Lapachol is an allergic sensitizer.

Description

Evergreen shrub or small tree 1–10 m high, trunk to 40 cm in diameter. Numerous upright pneumatophores 10–15 cm high and 6 mm in diameter. Trunk often with masses of small air roots but no prop or stilt roots. Bark whitish to grayish or yellow-green, smooth, often powdery with raised dots, scaly, exposing greenish inner bark. Leaves opposite, ovate, lanceolate to elliptical, 3.5–12 cm long, 1.5–5 cm wide, mostly acute at both ends, entire, thick leathery, shiny green and hairless upper surface, pale whitish-gray and finely hairy underneath. Petiole 5–10 mm long, hairy. Heads or cymes ball-like, upright on long stalks at ends and sides of twigs. Flowers few to many, sessile, 4 mm long, 5 mm across. Calyx 5-lobed, green, hairy, persistent; corolla tubular, white.turning yellow or orange with 4 nearly equal, short lobes (Little, 1983).

Germplasm

Reported from the African, Australian, Indonesian-Indochina Centers of Diversity, grey mangrove, or cvs thereof, is reported to tolerate disease,insects, light frost, pests, salt waterlogging (NAS, 1980a; Little, 1983). Little mentions five varieties, differing in leaf, flower, and geography.

Distribution

Coasts of East and South Africa, southern Asia, Australia, and Oceania. From Egypt and Arabia along shores of Red Sea and western Indian Ocean, eastward along shores of Arabian Sea, Bay of Bengal, southeastern and eastern Indian Ocean, South China Sea north to Hong Kong and Taiwan, and islands of the Philippine Sea, Coral Sea, and South Pacific to Western Australia and New Zealand. Not widely introduced (Little, 1983).

Ecology

Estimated to range from Tropical Moist to Wet through Subtropical Moist to Wet Forest Life Zones, grey mangrove is estimated to tolerate annual precipitation of 10 to 45 dm, annual temperature of 17 to 26°C, and pH of 6 to 8.5. Often a pioneer in muddy areas, this species, intolerant of shade, cannot succeed itself. Mostly on saline silts of depositing shores and marshes (Little, 1983).

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In *Avicennia* and *Rhizophora*, direct seeding results in ca 90% survival.

Harvesting

Since this mangrove can regrow rapidly from buds beneath the bark along the trunk and branches, it is said to suffer little from removal of much of the branchwood (NAS, 1980a).

Yields and Economics

This small tree could not be quite so productive as other mangroves, though I estimate 10 MT/ha year is possible.

Energy

Used for firewood and fuel for lime kilns.

Biotic Factors

No data uncovered.

References

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Complete list of references for Duke, Handbook of Energy Crops

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Last update December 30, 1997

Avicennia officinalis L.

Avicenniaceae
Indian mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The wood, used to construct boats, houses, and wharves has been studied as a pulp source, and the bark and roots are used for tanning. The bark is used for dying cloth, the ash for washing it in India (Watt and Breyer-Brandwijk 1962). Javanese and others may consume the bitter fruits and seeds after rather elaborate processing. Branches are lopped and given to cattle for fodder. The wood has been recommended for creosoted paving blocks. Its wood is attractive enough of grain to be useful in cabinetry.

Folk Medicine

According to Hartwell (1967–1971), the fruits are plastered onto tumors in India. Indian mangrove is a folk remedy for boils and tumors (Duke and Wain, 1981). Kirtikar and Basu (1975) suggest that the roots are aphrodisiac. Unripe seeds are poulticed onto abscesses, boils, and smallpox sores.

Indochinese use the bark for skin afflictions, especially scabies. According to Perry (1980), quoting other sources, "A resinous substance exuded from the bark acts as a contraceptive, and apparently can be taken all year long without ill effects. Philippines use the seed for ulcers, the resin for snakebite."

Chemistry

Tanganyikan wood specimens (zero moisture basis) contained 54.7% cellulose, 2.3% ash (C.S.I.R., 1948–1976). The wood ash is said to be rich in alkali. A green, bitter, medicinal resin oozes from the bark. Bark contains tannin and lapachol (Perry, 1980), but the tannin content may be only 2.5% (C.S.I.R., 1948–1976).

Description

Evergreen tree, sometimes to 25 m, trunk to 1 m in diameter. Numerous upright pneumatophores rise above soil from long shallow, horizontal roots. Bark brownish-gray, thin, becoming rough and blackish, or outer bark yellowish-green and inner bark whitish. Leaves opposite obovate or broadly oblong, 4–12 cm long, 2–6 cm wide, rounded at tip, acute or rounded at base, thick, leathery, edges slightly rolled under, upper surfaces shiny green and hairless, underneath with fine gray-green hairs and resin dots. Cymes headlike in panicles, upright near ends of twigs, to 15 cm long and wide. Flowers many 2–12 together, sessile, malodorous, 7–10 mm long, 12–15 mm across. Calyx 5-lobed, hairy on edges, with resin dots; corolla bell-shaped, tubular, yellow or yellow-brown, turning orange, with 4 unequal spreading lobes, stamens 4, inserted in notches of corolla tube; ovary conical, hairy, imperfectly 4-celled with 4 ovules, style threadlike; stigma 2-forked. Capsule broadly ovoid, flattened, 2.5 cm long. Seed 1, large, flattened, without seed coat, germinating in water (Little, 1983).

Germplasm

Reported from the African, Australian, Hindustani, and Indonesian-Indochina Centers of Diversity, Indian mangrove, or cvs thereof, is reported to tolerate alkali, disease, insects, high pH, pest, salt, and waterlogging (NAS, 1980a; Little, 1983).

Distribution

Coasts of southern Asia to Australia and Oceania. From East Pakistan, Tanasserim, Andaman Islands, and Sri Lanka through coasts of Vietnam, Thailand, and Peninsular Malaysia to the Philippines, Sumatra, Madura, Java, Borneo, Celebes, Sunda Islands, Molucca Islands, and New Guinea; south in Australia to New South Wales. Near sea level, to 50 m in Papua. Not widely introduced elsewhere (Little, 1983).

Ecology

Estimated to range from Tropical Moist to Wet through Subtropical Moist to Wet Forest Life Zones, Indian mangrove is estimated to tolerate annual precipitation of 10 to 45 dm, annual temperature of 20 to 26°C, and pH of 6 to 8.5. Mostly on brackish or saline silts of depositing shores and marshes.

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In *Avicennia* and *Rhizophora* direct seeding result in ca 90% survival.

Harvesting

Since this mangrove can regrow rapidly from buds beneath the bark along the trunk and branches, it is said to suffer little from removal of much of the branchwood (NAS, 1980a).

Yields and Economics

Good mangrove stands can show annual productivity of 10–20(-25) MT/ha/yr, but for firewood purposes, I would reduce that to 10–20(-25) m^3/ha/yr, figuring that at optimal rather than average. Because of the heaviness of the wood, a cubic meter of mangrove is generally more valuable than other species. Litterfall may account for 1/3–1/2 of aboveground productivity.

Energy

Brittle wood used for firewood.

Biotic Factors

No data uncovered.

References

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Avocado oil

Lauraceae *Persea americana* Mill.

Source: Magness et al. 1971

The edible pulp of the avocado, which surrounds the seed, contains from 8 to 30% of a non-drying oil. Oil is separated by dehydrating the pulp, then pressing or extracting with solvents. The oil is used in cosmetics, and to some extent in salad dressings.

Last update February 18, 1999 by ch

Axonopus affinis Chase

Poaceae

Carpetgrass

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update July 3, 1996 by aw

Carica × heilbornii var. *pentagona* Heilborn

syn. *Carica pentagona* Heilborn

(natural hybrid between *C. pubescens* and *C. stipulata*)

Caricaceae

Babaco

NewCROP has babaco information at:

Regeneration of *Carica pentagona* (Babaco) (Abstract)—Rebecca Vega de Rojas and Sherry Kitto

New Horticultural Crops in New Zealand—Errol W. Hewett

South American Fruits Deserving Further Attention—Richard J. Campbell

Outside links:

Babacocan be found in Lost Crops of the Incas from National Academy Press

BABACO "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

NewCROP information on the Common Papaya (*Carica papaya*)

Last update Friday, February 19, 1999 by ch

Halevy, A.H. 1999. Ornamentals: Where diversity is king—the Israeli experience. p. 404–406. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Ornamentals: Where Diversity is King—the Israeli Experience

Abraham H. Halevy

In the increasingly competitive international cut flower and pot-plant market, novelty of crops plays an important role in maintaining and expanding market share. The ornamental industry is unique among the agricultural industries in that novelty is an important attribute. Customers always seek "something new." Although the standard major ornamental crops will continue to constitute an important part of the market, a distinct trend towards increasing the share of "new crops" is clearly evident in recent years. These new products normally fetch higher prices than the traditional crops for a certain period, but quite often the prices drop when the market is saturated, and the attraction novelty lessens. By that time new products should be ready to enter the market. Research on introduction of new ornamental crops is therefore an endless project.

The floriculture industry in Israel is relatively new. Until about 30 years ago cut flowers and pot-plants were only produced on low-scale for the limited domestic market. In recent years ornamental plants became a major agricultural exportable product of over 250 million US$ per annum. Israel is now second only to Holland in flower export in Europe.

Initially Israel produced and exported mainly the major traditional cut flowers, such as carnations, roses, and gladiolus. Gradually the share of these crops declined and those of new minor crops increased, so that the "new crops" now constitute over 60% of the exportable cut flowers (Fig. 1). None of these "new crops" has become a major crop as roses or carnations, but together they are and will certainly continue to be the major part of our exportable ornamental products.

Introduction of new crops includes many research stages that begins with the initial search and screening and is concluded when the product is introduced commercially.

The introduction and adaptation of new exportable crops normally includes the following stages:

1. Searching for optional crops.
2. Selection and improvement.
3. Developing propagation methods.
4. Studying the growth and flowering physiology and developing practical means for their control.
5. Evaluation of horticultural practices.
6. Studying postharvest physiology and developing practical methods for postharvest handling, transport, and storage.
7. Semi-commercial export shipments to markets abroad.

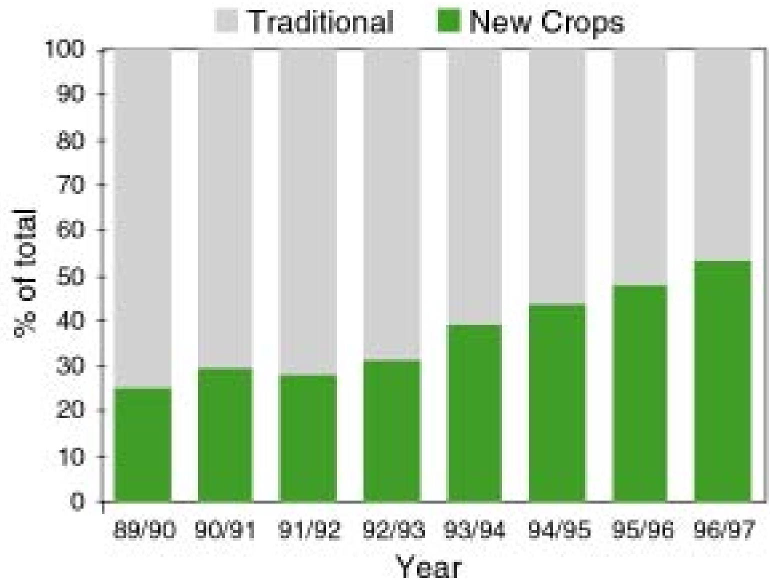

Fig. 1. Relative percentage of "traditional" and "new" cut flowers exported from Israel from 1989/90 to 1996/67.

Some important cut flowers (in European markets), which we introduced and developed in Israel, were "new crops" about 25 years ago such as Gypsophila and Geraldton wax flower. The development of these and other crops are described in the following examples of successful introduction projects.

GYPSOPHILA (BABY'S BREATH)

Gypsophila (*Gypsophila paniculata* L., Caryophyllaceae) is really not a new crop. It has been cultivated for many years as a minor field crop for harvesting in the natural summer flowering season. Today, Gypsophila is a major cut flower in Israel, grown in over 200 ha of greenhouses for the autumn to spring export season. It is now the main flowering shoot used as a "filler" in flower arrangements, in both Europe and the US.

The introduction and development of this crop involved many aspects (Shillo and Halevy 1982; Shillo 1985b; Shillo et al. 1985).

1. Selection of superior clones for controlled cultivation.
2. Development of in vitro meristem culture method to obtain disease-free mother plants.
3. Propagation of clean, uniform commercial cuttings in controlled insect-free greenhouses.
4. Study the physiology of flowering and development of practical methods to control flowering. It was found that Gypsophila is an absolute long day plant, with quantitative response to vernalization. The methods developed to control flowering include cold storage of rooted cuttings prior to planting and supplementary night illumination. Spraying with gibberellic acid is also used to promote flower and shoot breaking and elongation.
5. Development of specific cultivation methods, such as pruning, watering, and feeding.
6. Study the postharvest physiology of the flower and development of methods for postharvest treatment of the flowers prior to shipment, to ensure their longevity and quality. When 15% to 30% of the florets are open, flowering shoots are harvested, treated with silver thiosulfate

(STS) to protect them from internal and external ethylene, followed by pulsing the flowers in sugar (7% to 10%) and germicides until about 2/3 of the florets are open.

The flowers of commercial *G. paniculata* plants are sterile and do not produce seeds. This prevented real breeding of this plant. Recently this obstacle was overcome and real new varieties were introduced by Dan Nursery in Israel. A major success is the cultivar Million Stars that was introduced last year, and is already grown this year on over 40 ha in Israel and over 100 ha worldwide.

GERALDTON WAX-FLOWER

Geraldton wax-flower (*Chamaelaucium uncinatum* Schauer, Myrtaceae) is a native shrub in Western Australia. It was introduced to southern California and grown outdoors as a minor cut flower. Most of the initial physiological and horticultural research was carried out in Israel, a fact that facilitated the rapid development of the plant as an important commercial crop (Shillo 1985a; Shillo et al. 1985; Halevy 1994). More recently important research is also conducted in its native country, Australia. In Israel this plant is currently a major commercial ornamental crop, grown on ca. 300 ha. It is used mainly for cut flower production, but also for cut shoots with flower buds, cut foliage, and flowering pot plants. Israel became the main exporter of wax flowers to Europe in the winter.

Plant material of native plants in Australia, as well as breeding, enabled the establishment of a wide assortment of various plant colors (pink, purple, white, lilac, and bicolors), which bloom from November to May. The selected plants are propagated by semi-woody vegetative cuttings in order to form uniform varieties. Recently, virus-free mother plants have been produced by meristem in vitro culture.

Studies on the physiology of flowering revealed that the wax flower is an absolute short-day plant under conditions of mild temperatures. At very high and very low temperatures no flowers are produced. At medium-low temperature some flowers are formed regardless of photoperiod. To advance flowering in the autumn, plants of several cultivars are covered in the field at the end of the summer to create artificial short days. An interesting physiological phenomenon, revealed for the first time in this plant, was that the young flower buds produce a factor that inhibits the formation of new flowers, even under inductive conditions (Shillo et al. 1984).

For production of flowering pot plants, plants are heavily pruned to promote branching and then treated with growth retardants (CCC or paclobutrazol). Controlled photoperiod is employed to extend the flowering period.

Abscission of individual flowers during shipment and handling is a problem of the cut flowering shoots. This problem can be ameliorated by dipping the cut flowering shoots in auxin (NAA) solution and hydrating them in cold water.

PEONY

Peony (*Paeonia lactiflora* Pall., Paeoniaceae) has been in cultivation in China for thousands of years, and have been grown as garden and outdoor cut flower plants in Europe and the US for many years. Cut flowers were, however, available only for a few weeks a year during the natural flowering season in late spring. Until recently, however, very little was known on the flowering physiology of the plant. We have found that flower bud initiation starts after the old leaves senescence in the summer and continues until late autumn when they become dormant. Release from dormancy requires a period of low temperatures, and can be accelerated by GA treatment. After the release from dormancy the plants may start growing and blooming under mild-warm temperatures (Wilkins and Halevy 1985; Byrne and Halevy 1986). This basic information enabled the development of a practical method for extending the flowering season and obtaining cut flower production in the winter, 2–3 months before the natural flowering season (Halevy et al. 1995). Plants are grown under ambient natural cold temperatures of the early winter. After sufficient cold units are accumulated, the structures are covered with polyethylene at mid-winter and the plants are drenched with GA solution. Sprouting and flowering soon follow.

The introduction and improvement of this "new crop" is actually developing new horticultural techniques for flowering control of a very old ornamental plant. One of the obstacles of rapid development of peony as a commercial crop is the slow rate of natural propagation by division of crowns. We are now developing a tissue culture propagation method that should solve this problem.

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Rambai

Baccaurea motleyana Hook. f.

A fruit somewhat resembling the **langsat** (q.v.) but belonging to a different family, Euphorbiaceae, is the rambai, *Baccaurea motleyana* Hook. f., called *rambi* in the Philippines, *mai-fai-farang* in Thailand.

Description

The slow-growing tree, ordinarily to 30 or 40 ft (9-12 m), occasionally up to 60 ft (18 m), has a short, thick trunk, broad, dense, rounded crown and silky-hairy new branchlets. The leaves are evergreen, spiralled, 6 to 13 in (15-33 cm) long, 3 to 6 in (7.5-15 cm) wide; dark-green, glossy, with conspicuously indented veins on the upper surface; greenish-brown and hairy below. The small, fragrant male and female flowers are borne on separate trees. They are petalless, with 4 to 6 chartreuse, velvety sepals, the female arranged in racernes 10 to 30 in (25-75 cm) long; the male in racemes 3 to 6 in (7.5-15 cm) long. The fruits, in showy strands dangling from the older branches and trunk, are oval, 1 to 1 3/4 in (2.5-4.5 cm) long and 1 in (2.5 cm) thick, with thin, salmon-colored or brownish-yellow, velvety skin becoming wrinkled after ripening. The translucent, white, sweet-to-acid pulp is in 3 to 5 segments which separate readily, each segment containing a brown, flat seed about 1/2 in (1.25 cm) long, adherent to the pulp.

The rambai is native and commonly cultivated in the lowlands of Malaya, grows wild in Bangha and Borneo and is occasionally cultivated in Java. It is valued for its shade as well as its fruits, which are eaten raw, stewed or made into jam or wine.

The wood is of low quality but used for posts. The bark serves as a mordant for dyes and is employed to relieve eye inflammation.

The very similar *kapoendoeng*, *B. racemosa* Muell. Arg., native to West, Central and East Java, is commonly cultivated and is budded onto its own rootstocks or those of *B. motleyana*.

A lesser-known species, the so-called Burmese grape, *B. sapida* Muell.-Art., called *tempui* in Malaya, *lutqua* in India, and *mai fai* in Thailand, grows to 30 or even 70 ft (9-21 m). The leaves are rarely, and then only slightly, hairy; the fruit, in strands 6 to 12 in (15-30 cm) long, is smooth, nearly round or oval, 1 to 1 1/4 in (2.5-3.2 cm) long. The skin turns from ivory to yellowish or pinkish-buff or sometimes bright-red. The pulp is not translucent; is whitish, occasionally deep-pink near the seeds; varies from acid to sweet.

The tree grows wild from southern China, Thailand and Cambodia to Malacca and it is occasionally cultivated in northern Malaya and Thailand.

B. dulcis Muell.-Arg., the *tjoepa*, *toepa* or *ketoepa* of southern Sumatra, has relatively large, sweet fruits which are abundant on local markets. It is sometimes cultivated in West Java.

Bactris gasipaes Kunth

syn: *Guilielma gasipaes*

Arecaceae (Palmae)

Pejibaye, Peach palm

We have information from several sources:

FactSHEET contributed by: Charles R. Clement

Introduction and Evaluation of Pejibaye (*Bactris gasipaes*) for Palm Heart Production in Hawaii—Charles R. Clement, Richard M. Manshardt, Joseph DeFrank, Francis Zee, and Philip Ito

Pejibaye Heart-of-Palm in Hawaii: From Introduction to Market —Charles R. Clement, Richard M. Manshardt, Catherine G. Cavaletto, Joseph DeFrank, John Mood, Jr., Natalie Y. Nagai, Kent Fleming, and Francis Zee

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.).

New Crops from Brazil—David Arkcoll

New Crops: Solutions for Global Problems—Noel Vietmeyer

Pejibaye—Julia Morton, Fruits of warm climates

Handbook of Energy Crops—James A. Duke (unpublished)

Outside Links

Peach palm—by Jorge Mora-Urpi, John C. Weber, Sharles R. Clement—Link to the publication on the International Plant Genetic Resources Institute web site

Campbell, R.J. 1996. South American fruits deserving further attention. p. 431-439. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

South American Fruits Deserving Further Attention

Richard J. Campbell

Considerable attention has been given in recent years to fruits with potential for further economic development (Clement 1983; Donadio 1983; Arkcoll 1990; Ferguson and Arpaia 1990; Lamberts and Crane 1990; Nerd et al. 1990; Campbell 1990; Silva 1991; Crane 1993). South America has been the focus of many of these previous studies due to the sheer number of edible fruit crops originating on the continent, which is considered an important center of diversity for fruit crops. Our study takes another look at South American fruit crops with potential for further economic development, emphasizing fruit crops not previously discussed in recent studies. Discussions for each individual fruit are preceded by a general overview of the family to which each fruit belongs, highlighting the characteristics of the family and some of its commercial members. The fruit crops discussed include crops presently grown on a limited commercial scale, as well as minor fruit which at present are of importance only on a subsistence level within their native range.

SPECIFIC FRUIT CROPS

Anacardiaceae

This family consists of 850 species, including fruit crops of great economic importance throughout the tropical and subtropical regions of the world. The mango, *Mangifera indica* L. (Asia) and the cashew, *Anacardium occidentale* L. (South America) are produced in most tropical and subtropical countries. Another genus, *Spondias*, consisting of 8 to 10 fruit species of American and Asian origin (Popenoe 1979) is also prevalent throughout the tropics. *Spondias purpurea* L. and *Spondias cytherea* Sonn. are both commercial fruit crops in the American and Asian tropics. Other *Spondias* species native to South America are of great local importance as subsistence crops.

Spondias tuberosa Arruda. Umbú. The umbú is native to the dry plains of northeastern Brazil. This fruit has been described as perhaps the best flavored among all of the *Spondias* species by Popenoe (1920). The tree can attain a height of 6 m, although it usually forms a low, spreading tree when left unmanaged (Martin et al. 1987). Fruit are oval, averaging 4 cm in length, with a 2 cm stone. When fully ripe the flesh is almost liquid, with a sweet, aromatic flavor. The fruit are sour if eaten before they are fully ripe. In its native region the umbú is consumed fresh, used in preserves, made into juices, or sweetened and mixed with milk to make "imbuzada," a typical drink of the region. Popenoe (1920) discussed the importance of this fruit to the people of northeastern Brazil, who consumed vast numbers of umbú during the fruiting season. The same can be said in the region today, as wild umbú trees are protected and visited by local residents while the trees are fruiting.

The umbú offers potential for arid tropical regions due to its production in the harshest of conditions. Annual production has been up to 300 kg/tree with good selections (Cavalcanti and Abilio de Queiroz 1992). There has been limited work on the identification and selection of superior clones of umbú; however, within Brazil clones have been identified which weigh nearly 90 g and have a pulp to seed ratio of 80% (Cavalcanti and Abilio de Queiroz 1992). Popenoe (1920) questioned why the umbú had not yet attained a greater status in the world due to its superior flavor, and today the same sentiment is commonly expressed. However, due to its short shelf life and delicate texture when mature, it is doubtful that the umbú could be a viable consideration as a fresh fruit beyond the local level. However, as a flavoring and/or juice crop for the arid, hot tropics, the potential is much greater.

Little is known about its adaptability to different climates. Young trees have been killed by freezes in the state of Sao Paulo, Brazil (Donadio 1983) and in Florida (Campbell et al. 1977). The growth of seedling umbú trees in the calcareous soils of South Florida has also been poor (Campbell and Sauls 1980). Umbú is graft compatible with other *Spondias* species (Popenoe 1920), possibly widening its adaptation to other climates and soil conditions.

Spondias mombin L. Yellow mombin. The yellow mombin is native to Central America and northern South America (Popenoe 1979) and can be found under semi-wild cultivation in most lowland areas of the American Tropics. The tree can attain a height of 10 m and is tolerant of most soil types and rainfall patterns. The fruit are ellipsoid about 2.5 to 4 cm in length and hang singly on the tree (Martin et al. 1977). There is great variation in quality among fruit from region to region, some being sweet and pleasant and others quite disagreeable in flavor (Martin et al. 1977;

Popenoe 1920). The fruit can be eaten fresh, used in preserves or as a flavoring. Although common in most of the lowland tropics, the yellow mombin has not been highly commercialized. It is generally considered inferior in quality to *S. purpurea*, which is grown in the same environments. Yellow mombin has been introduced to most tropical locations and performs well under varied conditions. Trees are severely damaged by freezing temperatures (Campbell et al. 1977). Trees are generally grown from vegetative cuttings, but patch budding has been used as well (Coelho Pedrosa et al. 1991). The fruit are consumed fresh on a local level; however, its potential is more as a processed fruit. It offers an adaptive advantage over other species of *Spondias* in some climates and soil types.

Annonaceae

This family is comprised of 2,050 species, many of which are cultivated for their fruit, both on a commercial and subsistence level (Leon 1987). The cherimoya (*Annona cherimola* Miller), guanabana (*A. muricata* L.), sugar apple (*A. squamosa* L.) and atemoya (*A. cherimola* x *A. squamosa*) are the major commercial members of the family in tropical and subtropical regions. Due to their unique appearance and flavor, many other members of this family from Central and South America have potential for further commercialization.

Rollinia deliciosa A. DC. Biribá. The biribá is native to northern South America and the Caribbean (Leon 1987). The tree is small, usually reaching a height of 6 to 10 m, with a dense, multiple-branched growth habit. Biribá is one of the most common home garden trees in the state of Para, Brazil (Clement 1983), where there is also limited commercial production (Cavalcante 1974). Biribá fruit from this region can sometimes be found in markets as far away as Rio de Janeiro. The fruit are globose and can weigh up to 1350 g (Cavalcante 1974). The mature fruit is yellow with multiple protuberances, which turn black as the fruit are handled. The flesh is translucent, juicy, and sweet with a somewhat mucilaginous consistency, which is objectionable to many. It is usually consumed fresh, but it is also used as a juice, a preserve, or a flavoring. Within its native region it is considered to be of the highest quality among the Annonaceae. Outside of northern Brazil, however, the biribá is much less common and not as highly esteemed. It can be found in germplasm collections throughout the lowland tropics, but the fruit encountered are generally of inferior-quality seedlings.

Production of biribá is limited to the hot, humid lowland tropics. Temperatures of -1° to -2°C can kill young trees (Campbell et al. 1977). The trees grow quickly and bear fruit from seed in 4 to 6 years. There is great variation in fruit quality among seedling trees. Biribá trees produce well without hand pollination, which is an advantage over many other Annonaceae. In order to increase the commercialization of the biribá, superior cultivars would need to be identified and selected. Research would also be required on storage, shipping, and handling procedures.

Caricaceae

In terms of fruit production, the Caricaceae is a small (31 species), yet important family throughout both the American and Asian tropics (Badillo 1993). The most widely known member of the family is the papaya (*Carica papaya* L.), which is cultivated commercially throughout most of the lowland tropics. There are, however, other species currently produced on a limited commercial scale in the South American highlands which have potential for greater exploitation, both within their present production areas and beyond.

Carica pubescens (A. DC.) Solms-Laub. Chamburo. This fruit is native to northern South America and is cultivated from Panama to Bolivia at elevations above 1,000 m. The plants often attain a height of more than 10 m and have a similar appearance to papaya. They can be distinguished by their variable leaf shape and pubescence, which covers the leaves and flowers. The fruit are from 5 to 20 cm in length, turning yellow or orange at maturity. The flesh is yellow and tart, even when fully ripe. Trees are grown from seed, and there are no widely recognized superior selections. The fruit are usually not consumed fresh; instead, they are processed into juices or preserved. Thinly-sliced chamburo flesh is preserved in sugar solutions and eaten as an accent at meals (e.g. with cheese) or used in cooking. Lizana et al. (1978) conducted experiments with the production of dehydrated slices of chamburo as a potential new product in Chile.

Carica xheilbornii var. *pentagona* Heilborn. Babaco. The babaco is a sterile hybrid between *C. pubescens* and *C. stipulata*. It is cultivated mostly in Ecuador at elevations above 1,000 m. The fruit range in diameter from 6 to 12 cm and can reach a length of 30 cm. The plants are precocious in cultivation and usually remain less than 4 m in height. The pulp is white, and like the chamburo is tart when ripe. Babaco is important locally as a juice or preserve and is extensively used in cooking. For commercial production, cuttings are used, as no seed are available due to sterility of the clone. There are only a few recognized cultivars of babaco and these selections are not widely distributed. Annual production at elevations of 1,500 to 2,000 m is up to 46 t/ha, with production beginning 10 months after planting (Camacho and Rodriquez 1982).

Throughout the highlands of South America, products made from chamburo and babaco are readily available in markets. Also, local residents use these fruit in all forms of cooking. Babaco has been tested as a commercial fresh fruit throughout the American tropics and in New Zealand, but consumer acceptance has been poor. The preserved products made from both fruit have a mild, widely acceptable flavor. If these two fruit are to significantly expand in production, these processed products will need to be successfully marketed; however, some competition can be expected from similar, readily available products such as green papaya preserves. However, given the precocity and heavy production of these fruit at elevations above 1,000 m, they remain candidates for further development in the highland tropics. Also, these two fruit are resistant to the papaya ringspot virus, a major limiting factor for papaya production in the tropics. The chamburo has been investigated as a potential source of resistant genes for imparting virus resistance to papaya (Moore and Litz 1984).

Chrysobalanaceae

This family has over 460 species, but few among them yield edible fruit. The icaco (*Chrysobalanus icaco* L.) is perhaps the most widely grown, with subsistence production throughout the lowland tropics, particularly in coastal regions.

Licania platypus Fritsch. Sunsapote. The sunsapote is native throughout the moist lowlands of Central America and northern South America. It forms a large tree up to 30 m and is usually found in secondary forests under semi-wild cultivation, or in small plantings of a few individual trees. The trees produce 1 to 5 large, oblong fruit per panicle that range from 10 to 15 cm in diameter and 15 to 20 cm in length, and weigh up to 900 g (Leon 1987; Martin et al. 1977). The fruit has a fibrous skin that is easily removed. The pulp is dry and sweet. The seed is large in most clones, often with fibers that protrude into the flesh. The fruit are generally consumed fresh, but can also be used as a flavoring. The fruit are highly esteemed in localized areas of Central and South America, but in northern Brazil, they are not preferred (Cavalcante 1974).

Trees are grown from seed and can require up to 10 years to come into production. There have been only limited trials of this fruit in orchard conditions within the lowland tropics. Trees grew well in Florida until damaged by freezing temperatures (Campbell et al. 1977). Fruit quality within the markets of Central and South America is highly variable because the fruit are often collected from seedling trees maintained in semi-wild cultivation. Martin et al. (1977) considered this fruit to have little potential for further commercialization. However, the fruit are large and can withstand handling, making them a candidate as a fresh fruit for the lowland humid and seasonally dry tropics. In order to improve the commercialization of this fruit, a concerted effort into the selection of superior cultivars would be needed, as well as research on production, and handling procedures.

Guttiferae

This is a large family (1350 species) that contains many fine-flavored fruit crops. Popenoe (1920) went so far as to proclaim one member of this family, the mangosteen (*Garcinia mangostana* L.), as perhaps the finest flavored of all of the fruit in the world. Other species in the family from South America also possess a superior flavor and may actually have greater potential for further commercialization than the mangosteen due to superiority in adaptation to diverse climates.

Platonia esculenta (Arruda) Rickett and Stafleu. Bacurí. The bacurí is native to northern South America and is now grown extensively throughout the Amazonian lowlands. The tree can attain a height of 25 m under optimal conditions. Fruit production is reported to be quite heavy in comparison to other Guttiferae (Cavalcante 1974), although specific yield records are not available. The fruit are yellow, with a leathery shell enclosing a creamy white flesh, which is usually divided into 6 sections (similar to mangosteen). The flavor is excellent, being sweet and aromatic and highly appreciated. Care must be taken when eating the fruit because the leathery shell contains a yellow latex that is quite bitter. The fruit range from 300 to 900 g and are 10 to 12 cm in diameter (Donadio 1983). There can be up to 6 seeds per fruit, weighing about 20 to 40 g each. Often the seeds abort, and edible flesh fills the space which would otherwise be occupied by the normal-sized seed. In contrast to mangosteen, the tree is tolerant of many different environmental conditions, including poor drainage (Martin et al. 1987). Trees are quite sensitive to temperatures below 0°C and to desiccating winds. Propagation is usually by seed, but bacurí is graft compatible with other *Garcinia* and *Rheedia* species.

Rheedia macrophylla Planch. et Triana. Bacuripari. The bacuripari is native to the Amazonian lowlands, where it grows as an understory tree. The tree can grow to 9 m, forming an attractive, pyramidal canopy (Campbell 1983). Trees are propagated by seed and may require 7 to 10 years to come into production. Fruit are variable in shape, averaging 4 to 5 cm in diameter and 5 to 6 cm in length. The fruit have a thick, hard outer wall containing a bitter latex, as in bacurí. Inside the hard shell is a white, creamy flesh surrounding 3 to 4 large seeds. The flesh is scanty in comparison to mangosteen or bacurí. The bacuripari is outstanding because it grows and produces a significant crop in shaded conditions (Campbell 1983). The trees are also tolerant of full sun and wind exposure, making them more adaptable to varied climates than the mangosteen. There is considerable variation in fruit quality among bacuripari from different regions of South America, and there may be different species involved.

Wherever bacurí, bacuripari or other *Rheedia* sp. are grown, the flavor is considered excellent. Although not superior to mangosteen in terms of flavor or edible flesh percentage, these other species have better adaptation to varied climatic and edaphic conditions, allowing for their production in many regions. The latex in both of these fruit can be a major obstacle to commercialization, because those unfamiliar with the consumption of these fruit are likely to ingest it, leading to an unpleasant taste experience. Silva (1991) reports that bacurí fruit can be stored a few days after harvest to reduce the amount of latex in the fruit. There has been little selection for superior clones among either bacurí or bacuripari, although there is considerable variation present among seedling trees.

Malpighiaceae

This family of 1100 species is best represented in fruit crops by the acerola (*Malpighia glabra* L.) which is widely cultivated on a commercial scale throughout the tropics as a fresh fruit, juice, and natural source of vitamin C. Other members of this family from South America are also widespread throughout the tropics as food sources on a local scale.

Byrsonima crassifolia (L.) H.B.K. Nance. This fruit is native from the Caribbean through Central America and throughout most of South America. It has one of the widest native ranges of all fruit crops in Tropical America. Trees are tolerant of a wide range of environments, from the coastal Caribbean, the semi-desert regions of northeastern Brazil, the humid tropical lowlands and the middle elevations (1,000 m) of Central and South America. Throughout their range, nance trees are left when forests are cleared, and maintained in a state of semi-wild cultivation. The fruit from these trees are harvested by local residents, consumed, preserved, or sold to local markets.

The tree can attain a height of 10 to 15 m. While in flower the tree is quite ornamental, with showy orange and yellow inflorescences. The fruit are variable, ranging in size from 2 to 5 cm throughout its range. The skin is usually yellow, with a yellowish, translucent flesh and a single seed. The flavor is sweet and aromatic, sometimes with an oily or musky flavor. The nance is consumed fresh, as a preserved product, a juice or a liquer. In the markets of the lowland tropics, it is commonplace to find nance packed in water in glass containers.

Propagation is generally by seed, but the trees are easily grafted and in some locations (Yucatan, MX) superior clones are commercially propagated by veneer or cleft grafting. Fruit of superior clones may be yellow or red, and up to 6 to 7 cm in diameter. These clones typically have a superior flavor to the wild types, and are commonly consumed as a fresh fruit. The trees are sensitive to cold, but have survived repeated freezes in South Florida (Campbell et al. 1977). Due to the wide-spread familiarity with this fruit there is the potential for the marketing of fresh fruit of superior cultivars. In addition, with its adaptation to varied climates, the nance could become an important processed fruit for the lowland tropics if it could be successfully marketed.

Bunchosia armeniaca Rich. The bunchosia is native to South America, and is uncommon in most other locations. The trees are found from low to middle elevations, producing a small, attractive tree up to 10 m. The trees are precocious, fruiting within 3 years from seed. The trees flower and fruit throughout most of the year. Fruit are ellipsoid and borne in clusters. The red or yellow fruit are from 3 to 4 cm in length with a cream-colored flesh. The flavor is sweet, but often astringent. Even in areas where the tree is common, the fruit are not highly esteemed for fresh consumption. They are more commonly used as a flavoring. Bunchosia is a common addition to the home garden, but only rarely used as a commercial crop. The trees are tolerant of freezes, being slightly damaged by temperatures of -2°C in Florida (Campbell et al. 1977).

Martin et al. (1977) finds the bunchosia to have little potential for further commercialization. However, it could have potential, given its precocity and adaptive nature if superior cultivars could be identified. New cultivars not withstanding, the tree has good potential as an ornamental in the low to middle elevations throughout the tropics (Donadio 1983), where it would be a pleasant addition to the home garden landscape. With the commercial importance of ornamental horticulture throughout the world, this aspect of the tree should not be ignored.

Myrtaceae

Of all of the tropical fruit families, the Myrtaceae has attracted perhaps the most attention for possible increased commercialization (Campbell 1977; Clement 1983; Donadio 1983; Arkcoll 1990). Among the 3,850 species within this family, many produce edible fruit of superior quality. These same species often possess unusual growth forms, making them good candidates for ornamentals as well. The guava (*Psidium guajava* L.) and the jaboticaba (*Myrciaria cauliflora* Berg) are two of the best known members of this family in terms of commercial use. There are, however, many others (particularly from South America) that deserve greater attention.

Eugenia luschnathiana Klotzsch ex. O. Berg. Pitomba. The pitomba is native to Brazil and is relatively uncommon outside of this region. As with many of the Myrtaceae, its growth rate is slow, particularly in calcareous soils, where micronutrient deficiencies are often problematic (Campbell 1977). In acid soils, the growth is much faster, and plants generally have a better nutritional status. The pitomba forms a bush or a small tree to 8 m. The fruit are yellow or orange, 2 to 3.5 cm in diameter, with orange flesh. The flavor is sweet and aromatic. The fruit can be eaten fresh, but more commonly are made into preserves or juices. Dorsett et al. (1917) commented that the tree had value as an ornamental in the correct environment, although Campbell (1977) noted that in Florida the tree is not as attractive as many other members of this family. Trees are grown from seed and can require 7 to 10 years to produce fruit. Grafting can be used to reduce the time to fruiting. The pitomba is not as productive as some Myrtaceae (Dorsett et al. 1917).

Marliera edulis Cambess. Cambucá. The cambucá is native to the coastal rain forests of Sao Paulo and Rio de Janeiro states, Brazil. It has long been known and consumed locally, but is uncommon today within its native region, and even lesser known outside of Brazil. The tree is attractive, but slow growing, eventually reaching heights of 5 to 12 m depending on the environmental conditions. The bark has the same attractive mottled appearance as a jaboticaba tree. The fruit, from 50 to 70 g in weight, are born on the trunk and larger limbs of the tree. They are yellow, with longitudinal ridges. The skin is leathery with a translucent and juicy flesh and 1 to 2 large seeds, leaving little flesh to eat. The flavor is excellent. In recent years this fruit has been described by many as superior to jaboticaba in flavor, but Dorsett (1917), describing the diversity of fruit available at that time in Brazil, considered the taste inferior to jaboticaba. There has been, however, little work done on selection due to the slow growth of the tree and the narrow genetic base.

The pitomba and the cambucá are both good examples of fruit which have truly excellent flavors, but are not likely to be developed in the future as fresh fruit. Instead, development will depend on some form of a niche market, taking advantage of their excellent flavor for ice creams, or juices. As with most of the Myrtaceae, the fruit of these two species are small and easily damaged by handling. Even if their excellent flavor can be exploited, their commercial future will depend on the selection of better clones and improvements in propagation and production techniques, allowing for feasible economic production.

Sapotaceae

The Sapotaceae, with 1,000 species, is a prevalent fruit crop family, particularly in the Caribbean. The sapodilla [*Manilkara zapota* (L.) P. Royen] and the mamey sapote [*Pouteria sapota* (Jacg.) H. Moore and Stearn] are commercial fruit crops throughout the Caribbean and Central America. In South America there are also representatives of this family which have potential for much wider cultivation than at present.

Pouteria caimito Radlk. Abiu. The abiu is native to the warm, moist lowlands of South America. Trees have been introduced to many other locations, but they are still relatively uncommon. The trees attain a height of 12 m under optimal conditions. The fruit are ellipsoid to spherical and can range from 4 to 10 cm in length. The skin color is yellow when ripe, with a translucent flesh surrounding 1 to 5 seeds. The skin is leathery, containing a sticky white latex. The abiu is common in local markets throughout South America, where fruit quality is highly variable, with round, oblong, pointed, and dorso-ventrally flattened fruit types.

The abiu has good potential for commercial development in warm, moist tropical climates due to its precocity and heavy production. Yet, propagation of this crop is still predominantly by seed. In order to further develop this crop there will need to be selection of superior clones. Clement (1983) discussed clones in the eastern Amazon of up to 1,000 g, but these are not widely available. In Australia several named varieties have recently been selected which are precocious and productive, and have good fruit quality. These new selections have been accepted in the Southeast Asian marketplace, and should also have potential in the American Tropics. As with the Guttiferae, the latex of the abiu could be a hindrance to the development of this fruit.

Pouteria obovata Baehni. Lucuma. The lucuma is native to the cool highlands of South American, above 1,000 m. Lucuma grows best in cool climates, and is difficult to cultivate in the lowlands. The trees attain a height of 12 m and yield an ovoid to ovate fruit 4 to 8 cm long. The fruit are yellow at maturity with a dry, yellow flesh. While the fruit are immature, it contains a bitter white latex. The fruit can be eaten fresh when ripe, but is generally consumed as a drink or a flavoring. In Chile and Peru the lucuma is a significant commercial crop (Lizana et al. 1986), and specialized grafting techniques to improve precocity are practiced by some nurseries. Within Chile and Peru, the lucuma fruit are usually dehydrated and ground into a fine powder and used as an additive to milk.

This fruit does have some potential for fresh consumption, and there has been research conducted on the harvest indices and storage characteristics (Lizana et al. 1986). The lucuma could fill the same niche in the tropical highlands as the canistel [*Pouteria campechiana* (Kunth) Baehni] does in the lowlands. However, canistel has not been successful as a fresh fruit in the U.S. market to date. There is little reason to assume that the lucuma would succeed as a fresh fruit when the canistel has failed. The greater potential for lucuma is probably as a processed product, such as the powder used as an additive to milk.

Sterculiaceae

This family with over 1500 species is best known for cacao (*Theobroma cacao* L.), used for chocolate and the cola nuts (*Cola* sp.) used for caffeine production. Within South America there are several other members of this family with potential. One of these species, the cupuaçu (*Theobroma grandiflorum* Schumann) was previously discussed in detail by Arkcoll (1990) and Cabral Velho et al. (1990).

Theobroma bicolor Bonpl. Mocambo. This fruit is commonly used as a beverage fruit within its native range of Central and South America, but is uncommon outside of this area. The trees are propagated by seed and can attain a height of 12 m, although they are usually found as smaller understory plants. The fruit are ellipsoid from 15 to 20 cm long and 10 to 15 cm wide, with a felty brown exterior. The pulp is sweet and pleasant and the seeds can be roasted for consumption. The odor of the fruit can be disagreeable to many. In Central America it is traditionally mixed with achiote (*Bixa orellana* L.) and sugar to make a sweet desert. As with cupuaçu, the mocambo will never have potential as a fresh fruit, but the flesh could be marketed as an additive for beverages as proposed for cupuaçu (Cabral Velho et al. 1990).

CONCLUSIONS

The commercial status of many of the fruit described in this paper has not changed dramatically from when they were described over 75 years ago by Dorsett et al. (1917) and Popenoe (1920). A narrow range of environmental adaptations, the lack of superior selections, difficulties in propagation, exotic looks and tastes, and ignorance about the proper use of the fruit may have doomed these fruit to obscurity to date. They were then, and remain today as "under-exploited" fruit crops.

Regardless of the reason for their continued obscurity, it is clear that a superior taste and an exotic appearance alone was not enough to insure greater economic development of these crops. There was not sufficient economic incentive for their development. It may require innovative methods of marketing and promotion to introduce the new tastes and sights, and gain greater acceptance of these products. Perhaps the time is right to market these fruit crops and their products as the "fruits of the rainforest," taking advantage of the present sentiment that they are the salvation of these endangered ecosystems (Schemo 1995).

The greatest challenge lies in the promotion of fruit that are not consumed "out-of-hand," but are better used as a juice or flavoring. A change is needed in the consumption habits of consumers to further develop these markets. Fresh or frozen juices will have to at least partially replace soft drinks and juices which include only small percentages of fruit juice. Prices of fresh fruit or frozen pulp will have to be affordable to allow the economical use of the fruit within the home. The promotion of these products as "all-natural" could also be a plus for their marketing.

The potential value of fruit crops in the home landscape should also not be ignored, providing both beauty and a nutritious product for the home. Campbell (1973) discussed the use of fruit trees in the home garden within metropolitan areas. South Florida is an excellent model of how fruit crops can be used profitably in this manner (Crane 1993; Lamberts and Crane 1990). With the continuing economic development of Latin America, the use of fruit crops as ornamentals and home landscape components will become more important.

Increased demand through the promotion of these fruits must be accompanied by the selection of clones that meet the needs of the market. Whether it is size, color, self-fruitfulness, or precocity, a concerted effort into the genetic improvement of these crops is vital. Finally, there must also be an effort put forth for trials in other locations and research into propagation and production for the fruit crop. Regardless of the fruit crop considered, further development will depend on sound economic principals (Campbell 1990). If the production of the fruit is not profitable within a particular region, its development will not proceed.

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Last update June 23, 1997 aw

Paspalum notatum Flugge

Poaceae

Bahiagrass, Common bahai, Pensacola bahai

We have information from several sources:

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Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update September 26, 1996 by aw

Morton, J. 1987. Bakupari. p. 309–310. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Bakupari

Rheedia brasiliensis Planch. & Triana

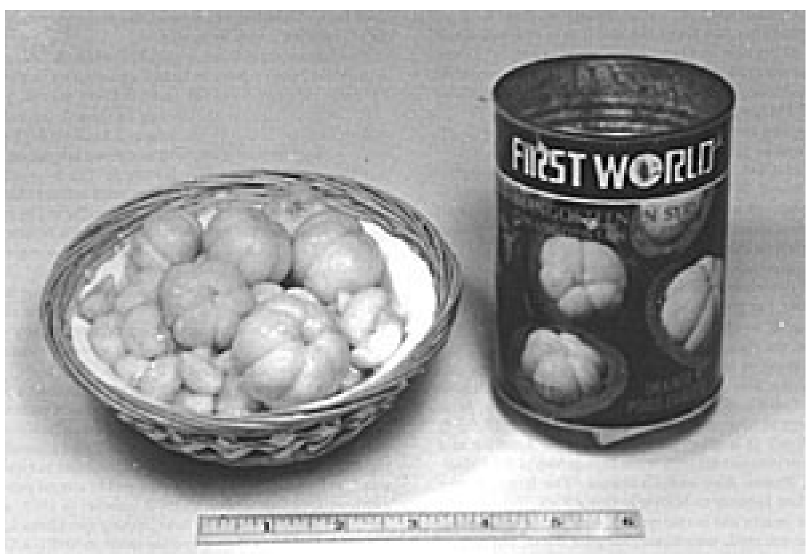
Of the approximately 45 species of *Rheedia* (family Guttiferae), several have edible fruits. Perhaps the best-known is the bakupari, *R. brasiliensis* Planch. & Triana, which is also known as *bacupary* or *bacoropary* in Brazil; as *guapomo* in Bolivia.

The very attractive tree is pyramidal like that of the bakuri but smaller; is equally rich in yellow latex. The leaves are short-petioled, ovate, oblong-ovate or lanceolate, narrowed at the base, blunt or slightly pointed at the apex, and leathery. The flowers, profuse in axillary clusters, are polygamous. The fruit, ovate, pointed at the apex, may be 1 1/4 to 1 1/2 in (3.2-4 cm) long, with orange-yellow, pliable, leathery, tough skin, 1/8 in (3 mm) thick and easily removed. The aril-like pulp is white, translucent, soft, subacid, of excellent flavor, and encloses 2 rounded seeds.

The tree grows wild in the state of Rio de Janeiro in southeastern Brazil and adjacent Paraguay; is rarely cultivated. It blooms in December and matures its fruit in January and February. The ripe fruit is mostly used in making sweetmeats or jam.

The seeds contain 8 to 9% oil (by weight) which is used in Brazil in poultices on wounds, whitlows, tumors and, externally, over an enlarged liver. An infusion of the pulp has a narcotic action with an effect like that of nicotine. The root bark extract contains rheediaxanthone and a polyprenylated benzophenone, other lesser constituents, and 3 new prenylated xanthones.

Related Species



The **mameyito,** *R. edulis* Triana & Planch. (syn. *Calophyllum edule* Seem.), is also known as *arrayan* and *palo de frutilla* in Guatemala; waiki plum in Belize; *chaparrón* in El Salvador; *caimito* or *caimito de montaña* in Honduras; *jorco* in Costa Rica; *sastra* in Panama; *berba* in the Philippines.

The elegant, erect tree, ranging up to 100 ft (30 m), has copious gummy, yellow latex and opposite, short-petioled, thick, leathery, elliptic-oblong or elliptic-lanceolate leaves, 3 3/16 to 6 in (8-15 cm) long, 3/4 to 2 in

(2-5 cm) wide, or much larger, with numerous lateral veins conspicuous on both surfaces; dark-green above, pale or brownish on the underside. Young foliage is reddish. The small, greenish-white or ivory flowers, densely clustered below the leaves, are 4-petalled, the male with 25 to 30 stamens, the perfect with 10 to 12. The fruit is oval or oblong, 3/4 to 1 1/4 in (2-3.2 cm) long, smooth, orange or yellow, the thin, soft skin easily peeled. There is a little flesh, sweet or acid, adhering to the 1 or 2 seeds.

Fig. 83-b: Peeled mangosteens, in light sirup, canned in Thailand, are appearing in Asiatic food outlets in the United States.[1] According to the *Wall Street Journal*, April 7, 1987, fresh fruits, cut open, inspected, sealed with tape, and quick-frozen, are exported from Malaysia to Japan where they sell readily at nearly $4 each. They are defrosted in boiling water for 2 minutes before eating.

The tree is native and common in humid forests on both the Atlantic and Pacific sides of Central America, from southern Mexico to Panama, up to an elevation of 4,000 ft (1,200 m). It is often planted in Central America as a shade or ornamental tree. It has been grown in the Philippines, Puerto Rico and California. The fruits mature from late January to March in Costa Rica.

The heartwood is rose-yellow, hard, medium-heavy, coarse-textured, with numerous gum ducts, but tough, strong, easy to work, fairly durable, and valued for construction because it is nearly immune to insects. It is also used for tool handles, fenceposts, and temporary railroad ties. The bark is rich in tannin.

The **bacuripari,** *R. macrophylla* Planch. & Triana, is also called *bacury-pary* in Brazil; *charichuela* in Peru.

It is a pyramidal tree, 26 to 40 ft (8-12 m) tall, with stiff, leathery, lanceolate-oblong or broad-lanceolate leaves, 12 to 18 in (30-45 cm) long and 3 to 7 in (8-18 cm) wide, pointed at both ends, with numerous lateral, nearly horizontal veins. New foliage is maroon. The 4-petalled, male and female flowers are home in small axillary clusters on separate trees, the male on delicate stalks to 1 1/2 in (4 cm) long and having numerous stamens, the female on thick, short stalks and sometimes having a few stamens with sterile anthers.

The fruit is rounded-conical, pointed at one or both ends, about 3 3/16 in (8 cm) wide, with thick yellow rind, usually smooth, sometimes rough, containing gummy yellow latex. The white, aril-like pulp, agreeably subacid, encloses 3 to 4 oblong seeds.

The tree is native to humid forests of Surinam and Brazil to northern Peru. The fruit is not much esteemed but widely eaten and sold in native markets. The bacuripari was introduced into Florida in 1962 and planted at the Agricultural Research and Education Center in Homestead, at Fairchild Tropical Garden and in several private gardens. One tree fruited in 1970, another in 1972, and the latter has continued to bear. Young specimens have been killed by drops in temperature to 29º to 30º F (-1.67º--1.11º C). Older trees have been little harmed by 27º to 28º F (-2.78º--2.22º C). The tree is accustomed to light-to moderate-shade. Seeds have remained viable for 2 to 3 weeks but require several weeks to germinate.

In Brazil, the tree blooms from August to November and the fruits mature from December to May. In Florida, flowers appear in April and May and a second time in August and September, and the fruits are in season from May to August and again in October and November. Some 15-to

20-year-old trees have produced 100 to 200 fruits when there have been no adverse weather conditions.

The **madroño,** *R. madruno* Planch. & Triana, may be called *machari* or *fruta de mono* in Panama; *cerillo* in Costa Rica; *cozoiba* in Venezuela; *kamururu* in Bolivia.

The tree is erect, lush, compact, with pyramidal or nearly round crown, 20 to 65 ft (6-20 in) high, and has much gummy yellow latex. The opposite leaves are elliptic to oblong, wedge-shaped at the base, rounded or pointed at the apex, 2 3/8 to 8 in (6-20 cm) long, 3/4 to 3 in (2-7.5 cm) wide; dark green above, paler beneath, with numerous veins conspicuous on both surfaces and merging into a thick marginal vein. The fragrant male and female flowers are borne on separate trees in clusters of up to 14 in the leaf axils; have 4 reflexed, pale-yellow petals; the male, 25 to 30 light-yellow stamens. The fruit is round or ellipsoidal, sometimes with a prominent nipple at each end; 2 to 3 in (5-7.5 cm) long, with thick, leathery, warty, greenish-yellow rind containing a deep-yellow, resinous latex. The white, translucent, juicy, sweet-acid, aromatic pulp adheres tightly to the 1 to 3 ovate or oblong seeds which are about 3/4 in (2 cm) long.

The tree is native to the Golfo Dulce region of Costa Rica, the Atlantic slope of Panama, and northern South America–Colombia and Ecuador through Venezuela to Guyana and Bolivia. It is particularly common in the Cauca Valley of Colombia where the fruits are marketed in quantity. It is limited to elevations below 4,000 ft (1,200 in). Dr. Wilson Popenoe collected seeds for the United States Department of Agriculture near Palmira, Colombia, in 1921 (S.P.I. #52301). The tree was introduced into Puerto Rico in 1923 and into the Philippines at about the same time. A few old trees have been fruiting more or less in southern Florida for many years, in midsummer. In Costa Rica, flowers are borne from December to February and fruits from May to August.

The yellow latex of the tree is used in Panama to treat ulcers and other sores. The wood is pinkish and hard but not commonly used.

Fig. 83-b: Peeled mangosteens, in light sirup, canned in Thailand, are appearing in Asiatic food outlets in the United States.[1] According to the *Wall Street Journal*, April 7, 1987, fresh fruits, cut open, inspected, sealed with tape, and quick-frozen, are exported from Malaysia to Japan where they sell readily at nearly $4 each. They are defrosted in boiling water for 2 minutes before eating.

Morton, J. 1987. Bakuri. p. 308. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Bakuri

Platonia insignis Mart.

Aristoclesia esculenta Stuntz

A relatively obscure member of the Guttiferae, the bakuri, *Platonia insignis* Mart. (syn. *Aristoclesia esculenta* Stuntz), is also called *bacurí*, *bacurí assu*, *bacurí do Pará*, *bacury*, *pacuri* or *pacoury-uva* in Brazil; *pakuri*, *pakouri* or *maniballi* in Guyana; *pacouri* in French Guiana; *packoeri*, *pakoeri* or *geelhart* in Surinam; *goherica* or *ko* by the Indians in Amazonian Colombia. It is, unfortunately, sometimes referred to as *bakupari,* a name better limited to *Rheedia brasiliensis*, q.v. In Brazil the tree is called *bacurizeiro.*

Description

The tree is erect, to 80 ft (25 m) high, with pyramidal crown and copious yellow latex in the bark. The leaves are deciduous, opposite, oblong or elliptic, to 6 in (15 cm) long, dark-green and glossy above; leathery, with wavy margins. Borne singly or in 3's, the flowers are 2 3/4 in (7 cm) long, rose-colored, 5-petalled, with many stamens. The fruit is nearly round or ovoid, 3 to 5 in (7.5-12.5 cm) wide, weighing up to 32 oz (900 g); yellow when ripe. The rind is yellow, hard, fleshy on the inside, 3/8 to 3/4 in (1-2 cm) thick, and contains gummy, yellow, resinous latex. The white, pithy pulp, of pleasant odor and agreeable, subacid flavor, contains 1 to 4, rarely 5, oblong, angular seeds, dark-brown and 2 to 2 3/8 in (5-6 cm) long. The infertile seed compartments are filled with pulp called *'filho* "which is the part preferred.

Origin and Distribution

The bakuri was first reported in European literature in 1614. The tree is common, wild, in the Amazon region of northern Brazil from Maranhao, Goias to Paraguay. It is abundant in the State of Para, especially around Marajo and Salgado. Its native territory extends across the border into Colombia and northeast to the humid forests of Guyana. It is seldom cultivated but when the Indians clear the land for planting or pastures, they always leave this tree standing for the sake of its fruits. In Marajo, it is viewed as a weed because it proliferates from fallen seeds and, if felled, produces abundant suckers from the roots. In the district of Marapanim, there is a hamlet called Bacurteua because of its many bakuri trees.

Climate

The bakuri requires a moist, lowland, tropical habitat.

Season

In Brazil, the tree flowers in June and July, after the shedding of the leaves. The first fruits mature in early December and the season extends to the following May, the peak of the crop ripening in February and March.

Food Uses

The pulp is much eaten raw but is mainly used to make sherbet, ice cream, marmalade or jelly.

Food Value Per 100 g of Edible Portion*	
Calories	105
Moisture	72.3 g
Protein	1.9 g
Lipids	2.0 g
Glycerides	22.8 g
Fiber	7.4 g
Ash	1.0 g
Calcium	20.0 mg
Phosphorus	36.0 mg
Iron	2.2 mg
Vitamin B,	0.04 mg
Vitamin B,	0.04 mg
Niacin	0.50 mg
Ascorbic Acid	33.0 mg
Amino Acids (mg per g of nitrogen [N = 6.25])	
Lysine	316 mg
Methionine	178 mg
Threonine	219 mg
Tryptophan	57 mg

*Analyses made in Brazil.

Other Uses

The sapwood is yellowish-white; the heartwood dull-yellow to orange-brown with many fine, dark, often black streaks. It is hard but easy to work and fairly durable. It is valued for construction, furniture, flooring, ship-building and general carpentry.

Medicinal Uses: The latex derived from the bark is used in veterinary practice in Guyana. The seeds contain 6 to 11% of an oil that is mixed with sweet almond oil and used to treat eczema and herpes.

Khareti or Bala (*Sida cordifolia* Linn.)

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Khareti or Bala (*Sida cordifolia* Linn.)

Scientific Name: *Sida cordifolia* Linn.
Family: Malvaceae
English Name: Country Mallow
Hindi Name: Khareti, Bala, Barial, Kumghi.

Botanical differences among the major species of *Sida* in India.

	S. cordifolia	*S. acuta* syn. *S. carpinifolia*	*S. alba* syn. *S. spinosa*	*S. ovata* syn. *S. grewioides*	*S. rhommbifolia*	*S. tiagii*
Plant	An erect, perennial undershrub, upto 1m. Tall	A much branched undershrub, 1-2 m tall	An erect undershrub, densely stellately pubescent all over	An erect shrub or undershrub,	An erect undershurb	A low, much branched, perennial undershrub, densely stellately-tomentose all over
Stem	Ascending, terete or sulcate, softly villious and densely stellate-pubescent all over	Glabrous or minutely stellately hairy, usually woody at the base		grey, tomentose, with stellate hairs	Stellately hairy, sulcate	Terete or sulcate, woody at base
Leaves	Ovate or ovate-oblong, obtuse or subacute at apex	Lanceolate or elliptic lanceolate, base obtuse or roundish, apex acute	Elliptic oblong, lanceolate or ovate, obtuse or rounded at apex	Elliptic-oblong or oblong-ovate, obtuse at apex	Oblong to lanceolate, rhomboid, cunneate, obtuse or rarely acute at apex	Ovate-oblong to obovate, roudned, entire, rounded or truncate at apex

Flowers	Yellow, peduncles, axillary, jointed much above the panicles, upper flowers nearly sessile and fasciculate towards the tip of the branches forming subspicate inflorescence	Petals pale yellow, ciliate	Fascicled in the axil of leaves, rarely solitary, Corolla white	Petals yellow	Petals yellow	Pale yellow
Fruits	Subdiscoid, 6-8 mm across, mericarps 10, 3 sided	Mericarps 5-6, 4 mm long, reticulately serrate	Mericarps 5, more or less finely reticulate	Mericarps 7-8, nearly glabrous	mericarps 8-12, pubescent	Pentagular ovoid, Mericarps 7-8
Seeds	Trigonous, glabours, tufted-pubescent near the hilum	Smooth glabrous, but pubscent around hilum	Smooth, dark brown, rounded at back, trigonous, glabous	Brown, smooth, with stellate hairs near the hilum	Smooth, glabrous, except for the pubescent area near the hilum	Black, glabrous with tufts of stellate hairs at hilum
Flowering & Fruiting Time	Sept.-Dec. in Indian conditions	Sept-Oct. in Indian conditions	Sept.-Jan. in Indian conditions	Oct.-Jan. in Indian conditions	Aug.-Oct. in Indian conditions	Aug.-Dec. in Indian conditions

General Description: It grows as wasteland weed. It is in use as folk medicine in India since time immemorial.

Useful Parts: Root, bark, leaves, flowers and seeds.

Traditional Medicinal Uses: According to Ayurveda, the plant is tonic, astringent, emollient, aphrodisiac and useful in treatment of respiratory system related troubles. Bark is considered as cooling. It is useful in blood, throat, urinary system related troubles, piles, phthisis, insanity etc.

Ayurvedic Preparations: Maha baladi Kvatha, Bala Taila etc.

Internet Resources

Traditional medicinal knowledge about common herbs and insects: Interactions with the natives of village Khudmudi, Chhattisgarh, India http://botanical.com/site/column_poudhia/24_interactions_natives.html

Interactions with the traditional healers of Dashapal and Mudpar villages of Chhattisgarh, India http://botanical.com/site/column_poudhia/228_dashapal.html

Traditional Medicinal knowledge about excreta of different animals used to treat many common diseases in Chhattisgarh, India http://botanical.com/site/column_poudhia/40_animal_excreta.html

Herbal dishes of Chhattisgarh, India VI. Paushtic Laddu
http://botanical.com/site/column_poudhia/346_hd_paushtic_laddu.html

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Agharkar, S.P. (1991). Medicinal plants of Bombay presidency. Pbl. Scientific publishers, Jodhpur, India : 194-195.
Bhandari, M.M. (1990). Flora of Indian desert. Pbl. MPS Repros, Jodhpur, India : 66-69.

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Melissa officinalis L.

Lamiaceae (Labiatae)

Balm, Balm mint, Bee herb, Harden balm, Gentle balm, Lemon balm, Melissa, Sweet balm

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Herbs Affecting the Central Nervous System—Varro E. Tyler

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Balm-Of-Gilead Poplar

Populus candicans Ait.

Other common names.—Balsam poplar, balm buds.

Habitat and range.—The balm-of-Gilead tree, which has mostly escaped from cultivation, is found along roadsides or streams from Newfoundland to Minnesota and Georgia.

Description.—This is a large tree reaching a height of 100 feet with a maximum trunk diameter of about 6 1/2 feet with spreading branches, the young twigs slightly hairy, and with very resinous, fragrant buds. The broad, pointed leaves, 2 1/2 to 6 inches long, are somewhat heart-shaped at the base, fine toothed, dark green above, pale beneath, and hairy when young. The male and female flowers are borne in separate catkins 6 inches or less in length, which appear before the leaves.

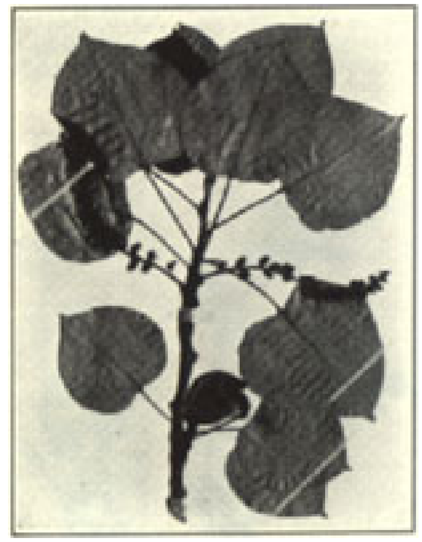

Figure 11.—Balm-of-Gilead poplar (*Populus candicans*)

Part used.—The leaf buds.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Wednesday, March 16, 1998 by aw

Balsam pear

Bitter melon, Cundeamor, La-kwa

Cucurbitaceae *Momordica charantia* L.

Balsam apple

***M. balsamina* L.**

Source: Magness et al. 1971

The balsam pear plant is an annual running vine, to 10 feet or more, with near round, lobed leaves. The fruit is 4 to 6 inches long, oblong, pointed and furrowed lengthwise. When full ripe it splits into 3 divisions. The immature fruit is boiled as a vegetable. A pulpy aril surrounds the seeds, which is esteemed by Orientals. In culture, similar to cucumber. The related balsam apple has a smaller, egg-shaped fruit, and is used in a similar manner.

Season, **seed to harvest**: 3 to 4 months.

Production in U.S.: No data. Mainly oriental gardeners.

Use: As boiled vegetable. Seed arils eaten out of hand.

Part of plant consumed: Whole immature fruits. Seed arils.

Last update February 18, 1999 by ch

Momordica Species

Cucurbitaceae

Momordica balsamina L.

Balsan apple

Momordica charantia L.

Bitter melon, Balsam pear, Bitter cucumber, Bitter gourd, *kerela*

Momordica grosvenorii (Swingle) C. Jeffrey *ex* Lu & Zhang

syn. *Siraitia grosvenorii* Swingle

syn. *Thladiantha grosvenorii* (Swingle) C. Jeffrey

Lo Han Guo, Lo Han Kuo, Monk Fruit

We have information from several sources:

Asian Vegetables: Selected Fruit and Leafy Types—Marita Cantwell, Xunli Nie, Ru Jing Zong, and Mas Yamaguchi

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Lo Han Guo—Croom, E.M.

Momordica grosvenorii—Swingle, W.T.

Karela (*Momordiaca charantia* Linn.) Pankaj Oudhia

Vigna subterranea (L.) Verdc.

syn: *Voandzeia subterranea* (L.) Thouars

Leguminosae

Bambara groundnut, bambarra, bambarra nut, Congo goober, ground pea, voandzou

We have information from several sources:

New Opportunities in Vigna—Richard L. Fery

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Bambara groundnut—*Vigna subterranea* (L.) Verdc.
Proceedings of the Workshop on Conservation and Improvement of Bambara groundnut 14–16 November 1995, Harare. Zimbabwe—Link to the publication on the International Plant Genetic Resources Institute web site

International Bambara Groundnut Database

Bamboo Greenbrier

Smilax pseudo-china L.

Other common names.—Bamboo brier, long-stalked greenbrier, American chinaroot, false chinaroot, bullbrier.

Habitat and range.—This plant occurs in dry, sandy thickets from New Jersey to Florida and west to Texas and Nebraska.

Description.—Bamboo greenbrier is a smooth vine with a tuberous rootstock and with the lower part of the stem smooth or sometimes beset with straight, needle-shaped prickles. The leaves, 2 1/2 to 5 1/2 inches long and 1 1/2 to 3 1/2 inches wide, are egg-shaped or sometimes narrowed at the middle, usually rough on the margin, and somewhat leathery when old. The greenish flowers, 12 to 40 in number, are borne in round clusters on flattened stalks 1 to 3 inches long. These are followed in autumn by one to three seeded black berries up to one-quarter inch in diameter.

Figure 12.—Bamboo greenbrier (*Smilax pseudo-china*)

Part used.—The root.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

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Bambusa arundinacea (Retz.) Willd.

Poaceae
Spiny bamboo, Thorny bamboo, Tziu chu, Kalak, Bans

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Very young shoots are consumed as food in some parts of India and China. In raw state, shoots (ca 8 cm in diameter and 37.5 cm long) are very acrid, but with two changes of water in cooking and with addition of salt and butter, they make a pleasant vegetable. Young shoots pickled or made into curries. Wood used by Chinese in household carpentry, furniture, boxes, ornamental vases, scaffolding, etc. Leaves used as fodder. Stems in great demand for manufacture of paper pulp of good quality. Seeds edible and used in times of scarcity of food. Other species of Bambusa, found in various parts of the tropics, are used for similar purposes: those used for the young shoots or buds as a vegetable include *B. cornuta* Munro, *B. multiplex* Raeusch, *B. oldhami* Munro, *B. spinosa* Roxb., *B. tulda* Roxb., and *B. vulgaris* Schrad.; species used for construction and other such purposes include *B. balcooa* Robx. (one of the best and strongest bamboos for building purposes), *B. multiplex* Raeusch (culms used for paper), *B. nana* Roxb. (fishing poles), *B. pervariabilis* McClure (heavy construction), *B. polymorphs* Munro (roofs of houses, floors and walls), *B. sinospinosa* McClure (sheaths made into sandals), *B. spinosa* Roxb. (timber bamboo), *B. texilis* McClure, *B. tulda* Roxb., and *B. tuldoides* Munro (weaving mats, hats, baskets and ropes), *B. vulgaris* Schrad. (paper pulp), *B. beecheyana* Munro [*Sinocalamus beecheyanus* (Munro)McClure] is an important source of commercial edible bamboo shoots.

Folk Medicine

An ointment from the root is said to be a folk remedy for cirrhosis and hard tumors, especially tumors of the abdomen, liver, spleen and stomach (Hartwell, 1967–1971). Tabasheer, a siliceous secretion (up to 97% SiO_2), considered aphrodisiac, cooling, and tonic, is used in asthma, cough and debilitating diseases (C.S.I.R., 1948–1976). Leaves given to horses suffering coughs and colds.

Chemistry

The stem consists almost entirely of cellulose and hemicellulose (xylans, arabans, polyuronides, etc.) and lignins, with a small amount of resins. Oven-dried stems contain 3.3% ash, 1.8% silica, 6.0% hot water solubles (see above), 19.6% pentosans, 30.1% lignin, and 57.6% cellulose. Analyses from paper pulping showed 8.5% water extract, 1.2% fat, wax, etc., 24.4% pectose, 15.6% lignin, 50.3% cellulose, and 1.6% ash. Per 100 g, the seeds are reported to contain 11.0% H_2O, 11.8 g protein, 0.6 g fat, 75.4 g total carbohydrate, 1.7 g fiber, and 1.2 g ash (C.S.I.R., 1948–1976). On a zero moisture basis the fresh leaves (57.1% DM) contain 18.6% CP, 24.1% CF, 11.8% ash, 4.1% EE, 41.4% NFE. With sheep the CP exhibits 72.4% digestibility, CF 49.1%, EE 10.8%, and NFE 48.8% (Gohl, 1981). Per 100 g, the shoot is reported to contain 29 calories, 90.7 gH2 0, 2.3 g protein, 0.2 g fat, 6.6 g total carbohydrate, 0.5 g fiber, 0.7 g ash, 33 mg Ca, 41 mg P, 0.4 mg Fe, 20 meg β-carotene equivalent, 0.15 mg thiamine, 0.7 mg riboflavin, 0.6 mg niacin, and 4 mg ascorbic acid (Food Comp. Table Latin America).

Toxicity

Eight grams of raw shoots or slightly more improperly cooked shoots can cause death. Young shoots contain 0.03% HCN (C.S.I.R., 1948–1976). Hairs on various bamboos, and fungi which live thereon, may cause dermatitis (Mitchell and Rook, 1979). Benzoic acid and traces of cyanogenic glucoside present in shoots have lethal effect on mosquito larvae (has antiseptic and larval properties).

Description

Tall woody bamboo, stems thorny, numerous, tufted, up to 40 m tall, curving at top; branches numerous, internodes 30–45 cm long, prominent, bearing in lower parts of stems dense half whorls of stiff, naked, horizontal branches, armed with 2–3 recurved, stout spines; lowest nodes rooting; stem-sheaths leathery, orange-yellow when young, hairy outside, shining and ribbed inside, 30–45 cm long; blade triangular, glabrous, covered with a brown felt of bristly hairs inside; leaves thin, linear, up to 20 cm long, glabrous above, hair beneath; leaf-sheaths hairy, small; inflorescence an enormous panicle, often occupying the entire stem; branchlets loose clusters of pale, glabrous spikes.

Germplasm

Reported from Asian Centers of Diversity, bamboos are reported to tolerate insects, laterites, low pH, slope, and weeds ($2n$ = 72, 70) (Duke, 1978).

Distribution

Wild in most parts of tropical India and Pakistan, growing up to 1000 m altitudes in the Nilgiris and hills of southern India; north into China.

Ecology

Probably ranging from Subtropical to Tropical Very Dry to Wet Forest Life Zones, spiny bamboo probably tolerates annual precipitation of ca 6 to 40 dm, annual temperature of ca 18 to 29°C, and pH of 4.3 to 7.3. Thrives in tropical to subtropical climates, growing in warm humid temperate areas as well, but thriving best under frost-free conditions, in rich to medium fertile soils with good water supply.

Cultivation

Bamboos may be produced by means of seeds, vegetative portions or by layering the stems and letting them root at the nodes. Seeds are sown in soil about 0.6 cm deep and about 2.5 cm apart in rows 7.5–10 cm apart. Germination occurs in about a week and seedlings grow rapidly. When plants are 15–20 cm tall, they are transplanted to individual containers. Transplanting to the field is done when plants are about 1 m tall. Growing plants from seed is the most economical and convenient method of propagating large numbers of plants. Clump division is the traditional and most generally prevalent method of propagating bamboos vegetatively. Active growth of young shoots from buds on the rhizome in this group of bamboos is initiated during the summer. The commonly recommended practice is to process vegetative propagules just before the initiation of growth of these buds. A clump is divided into two equal parts, retaining the root system, branches and leaves of each part as fully intact as possible. Properly set out, these propagules usually give the highest degree of success. Clump divisions taken from the edge of the clump are apt to give superior results. The rhizome should be severed at one point only, at the neck of the oldest rhizome axis in the propagule. Cut should be made at the slender neck where the minimum damage to the rhizome is done. Roots are best preserved and protected keeping them in a ball of earth when the propagule is taken from the parent plant. Some species, as *B. tulda*, has been successfully propagated by rhizomes planted *in situ*, with 95% survival not uncommon. Culm segments, with one or more nodes, bearing buds or branches, are used widely as a means of propagation in both the Old and New World. Branches are usually pruned to 30 cm or less, with no foliage retained. Such cuttings are set upright or at an angle, with at least one node well covered. *B. vulgaris* is often propagated this way.

Harvesting

Bamboos are harvested for food when the young shoots are 30–75 cm tall. Other parts of the plant are harvested whenever needed, as the leaves, branches and woody stems.

Yields and Economics

Finding no published data, I estimate the yields in excess of 10 MT DM/ha/yr. One of the most useful group of plants in the tropics, bamboos are used as food for man and fodder for livestock, for building materials, for weaving and cordage, for paper pulp and for making all types of utensils. Bamboos are very important in the economy of Oriental peoples; millions are occupied in growing and producing raw bamboo, and manufacturing of bamboo products.

Energy

New culms start growing slowly, growth soon approaching 30 cm/day with 75 cm having been recorded in one day in Sri Lanka. In Trinidad, *Bambusa vulgaris* produced more than 10 MT pure dry cellulose pulp per hectare per year on a three-year cutting cycle. The culms of *B. arundinacea* are said to be considerably more durable than those of *B. vulgaris*. With sheep, the ME of the leaves is 1.77 megacalories per kg dry weight.

Biotic Factors

Few serious diseases or pests of bamboos are reported. Bamboo borers can be problematical

References

- C.S.I.R. (Council of Scientific and Industrial Research). 1948–1976. The wealth of India. 11 vols. New Delhi.
- Gohl, B. 1981. Tropical feeds. Feed information summaries and nutritive values. FAO Animal Production and Health Series 12. FAO, Rome.

- Hartwell, J.L. 1967–1971. Plants used against cancer. A survey. Lloydia 30–34.
- Mitchell, J.C. and Rook, A. 1979. Botanical dermatology. Greenglass Ltd., Vancouver.

Complete list of references for Duke, Handbook of Energy Crops

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Last update December 30, 1997

Musa x paridasiaca L. , *Musa acuminata* Colla.

Musaceae

Apple banana, banana, Bluefield, Brazilian banana, Cavendish, dwarf banana, finger banana, Gros Michel, Jamaica, *manzano*, Martinique, *pisong jacki*, plantain, red banana, Saba, Silk Fig

---

NewCROP has Banana information at:

Banana—Julia Morton, Fruits of warm climates

Magness—J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more banana info:

BANANA "FRUIT FACTS"—(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Banana Crop Information—from University of California Davis

Banana, Plantain (*Musa* spp.)—from Mark Reiger of University of Georgia.

Publications on the International Plant Genetic Resources Institute Web Site

Cytogenetics of the genus *Musa*—by K. Sheperd

Evaluation of *Musa* Germplasm resistance to Sigatoka diseases and Fusarium wilt.—by B. Orjeda

Routine Post-harvest Screening of Banana/Plantain Hybrids: Criteria and Methods—by D.K. Dadzie, J.E. Orchard

Screening of *Musa* Germplasm for Resistance and Tolerance to Nematodes—by P.R. Speijer, D. De Waele

Musa spp. (2nd edition)—by M. Diekmann, C.A.J. Putter (eds.)

Descriptors for Banana (*Musa* spp.)

Morton, J. 1987. Banana Passionfruit. p. 332–333. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Banana Passionfruit

Passiflora mollissima Bailey

Passiflora tomentosa var. *mollissima* Tr.& Planch

Tacsonia mollissima HBK.

A distinctive and much admired passionfruit relative, *Passiflora mollissima* Bailey (syns. *P. tomentosa* var. *mollissima* Tr. & Planch.; *Tacsonia mollissima* HBK.), was given this appealing and appropriate English name in New Zealand. In Hawaii, it is called banana *poka*. In its Latin American homeland, it is known as *curuba*, *curuba de Castilla*, or *curuba sabanera blanco* (Colombia); *tacso, tagso, tauso* (Ecuador); *parcha* (Venezuela), *tumbo* or *curuba* (Bolivia); *tacso, tumbo, tumbo del norte, trompos,* or *tintin* (Peru).

Description

The vine is a vigorous climber to 20 or 23 ft (6-7 m), its nearly cylindrical stems densely coated with yellow hairs. Its deeply 3-lobed leaves, 3 to 4 in (7.5-10 cm) long and 2 3/8 to 4 3/4 in (6-12 cm) wide, are finely toothed and downy above, grayish-or yellowish-velvety beneath. The stipules are short, slender and curved. The attractive blossom has a tube 3 to 4 in (7.5-10 cm) long, gray-green, frequently blushed with red, rarely downy; corolla with 5 oblong sepals and deep-pink petals flaring to a width of 2 to 3 in (5-7.5 cm); and a rippled, tuberculated, purple corona. The fruit is oblong or oblong-ovoid, 2 to 4 3/4 in (5-12 cm) long, 1 1/4 to 1 1/2 in (3.2-4 cm) wide. The rind is thick, leathery, whitish-yellow or, in one form, dark-green, and minutely downy. Very aromatic pulp (arils), salmon-colored, subacid to acid and rich in flavor, surrounds the small, black, flat, elliptic, reticulated seeds.

Origin and Distribution

The banana passionfruit is native and commonly found in the wild in Andean valleys from Venezuela and eastern Colombia to Bolivia and Peru. It is believed to have been domesticated only shortly before the Spanish Conquest. Today it is commonly cultivated and the fruits, which are highly favored, are regularly sold in local markets. In 1920, the United States Department of Agriculture received seeds from Guayaquil, Ecuador (S.P.I. No. 51205), and from Bogotá, Colombia (S.P.I. No. 54399). The vine is grown in California as an ornamental under the name "softleaf passionflower". It has never succeeded in Florida; is grown to some extent in Hawaii and the State of Madras, India. The climate of New Zealand seems highly suitable for it and it has been grown there, more or less commercially, for several decades.

Varieties

In general, the fruit is smaller in Peru than in Colombia and Ecuador. There are said to be several varieties. A form called *curuba quiteña in* Colombia is dark-green externally even when fully ripe, the apex is abruptly pointed and furrowed; the pulp is dark-orange or orange-brown.

Climate

This species is at home at elevations between 6,000 and 7,200 ft (1,800-3,200 m) in the Andes, and has adapted well to altitudes of 4,000 to 6,000 ft (1,200-1,800 m) in Hawaii and New Zealand. It can tolerate brief drops in temperature to 28.4º F (-2º C).

Propagation

The vine can be propagated from cuttings but is usually grown from seeds which normally germinate in 10 weeks. The time can be shortened to 5 weeks by preliminary soaking in lukewarm water.

Culture

The seedlings can be transplanted when 3 months old and need to be trained onto a horizontal trellis 6 1/2 ft (2 m) high with crosswires 16 in (40 cm) apart. At a vine spacing of 6.5 ft (2 m) each way, there will be 607 plants per acre (1,500 plants/ha). Less dense planting, allowing 10 ft (3 m) each way between vines, and 20 in (50 cm) between crosswires, will result in 445 vines per acre (1,100/ha). The first crop will be produced in 2 years. At dense spacing, and with good weed control and adequate fertilization, the annual harvest in Colombia will be 200 to 300 fruits per vine, amounting to 200,000 to 303,000 fruits per acre (500,000-750,000 fruits per ha), or about 31,000 to 47,000 lbs per acre (roughly the same number of kg per ha). The individual fruits range from 2 to 5 1/2 oz each (approximately 50-150 g). Some growers have practiced pruning, which improves air-flow, reducing disease, and facilitates weeding, irrigation, spraying and harvesting. It produces larger fruits but fewer and therefore is generally viewed as not practical as size is not important to the consumer. In India, the average yield is said to be 40 to 50 fruits per vine beginning with the 6th year from planting.

Season

There is more or less continuous fruiting the year around in Colombia. In New Zealand, the crop ripens from late March or early April to September or October.

Keeping Quality

The fruit stands shipment well and will keep in good condition in a dry and not too cold atmosphere for a reasonable length of time.

Pests and Diseases

In humid and poorly drained situations, some plantations suffer from nematodes *(Meloidogyne* sp.). Leaves and shoots may be attacked by leafhoppers *(Empoasca* sp.) and by *Dione* or *Agraulis, vanillae;* leaves and fruits may be plagued by mites *(Tetranychus* sp.); larvae of *Hepialus* sp. invade the flowerbud; stems may be bored and tunneled by *Heteractes* sp. and *Nyssodrys* sp. Occasionally the fruits are attacked by fruit flies. Young shoots are prone to powdery mildew *(Asterinia* sp.) and anthracnose *(Colletotrichum* sp.) may affect the vine and fruits. Boron deficiency causes cracking of fruits. Sometimes, for physiological reasons not yet fully understood, 50 to 60% of the fruits may drop prematurely.

Food Uses

The pulp is eaten out-of-hand or is strained for its juice which is not consumed alone but employed in refreshing mixed cold beverages. In Bolivia, the juice, combined with aguardiente and sugar, is served as a pre-dinner cocktail. Colombians strain out the seeds and serve the pulp with milk and sugar, or use it in gelatin desserts. In Ecuador, the pulp is made into ice cream.

The New Zealand Department of Agriculture has developed enticing recipes to encourage the growing and utilization of the seeded pulp as pie filling, and also for making meringue pie, sauce, spiced relish, jelly, jam and other preserves. It is also advocated as an ingredient in fruit salad, especially with pineapple, and for blending with whipped cream as a pudding, and for cooking and preserving as an ice-cream topping.

Canning the juice with benzoate of soda as a preservative loses much of the quality and, therefore, there is as yet no commercial processing.

Food Value Per 100 g of Edible Portion*	
Calories	25
Moisture	92.0 g
Protein	0.6 g
Fat	0.1 g
Carbohydrates	6.3 g
Fiber	0.3 g
Ash	0.7 g

Calcium	4 mg
Phosphorus	20 mg
Iron	0.4 mg
Riboflavin	0.03 mg
Niacin	2.5 mg
Ascorbic Acid	70 mg

*Analyses made in Colombia.

Leonhardt, K.W. and Richard A. Criley. 1999. Proteaceae floral crops: Cultivar development and underexploited uses. p. 410–430. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Proteaceae Floral Crops: Cultivar Development and Underexploited Uses*

Kenneth W. Leonhardt and Richard A. Criley

The Proteaceae apparently originated on the southern supercontinent Gondwana long before it divided and began drifting apart during the Mesozoic era, accounting for the presence of the Proteaceae on all of the southern continents (Brits 1984a). The Protea family comprises about 1400 species in over 60 genera, of which over 800 species in 45 genera are from Australia. Africa claims about 400 species, including 330 species in 14 genera from the western Cape. About 90 species occur in Central and South America, 80 on islands east of New Guinea, and 45 in New Caledonia. Madagascar, New Guinea, New Zealand, and Southeast Asia host small numbers of species (Rebelo 1995).

Proteas are neither herbaceous nor annual, and they are always woody. Their structural habit is variable from groundcover forms with creeping stems, and those with underground stems, to vertical to spreading shrubs, to tree forms. The leaves are generally large, lignified, hard, and leathery. A mature leaf will generally snap rather than fold when bent. The leaf anatomy is specially adapted for water conservation and drought resistance. These characteristics and the high leaf carbon to nitrogen ratio render the leaves indigestible to most insect pests (Rebelo 1995), accounting for the relatively pest-free status of most commercial protea plantings.

The distribution of the family is linked to the occurrence of soils that are extremely deficient in plant nutrients (Brits 1984a). An accommodating characteristic of the family is the presence of proteoid roots. These are dense clusters of hairy rootlets that form a 2–5 cm thick mat at the soil surface which enhances nutrient uptake from the nutrient-sparse soils on which the Proteaceae evolved. All species examined so far, in at least ten genera, possess proteoid roots (Lamont 1986).

The capitulum, in which the flowers are borne on a flat or pointed receptacle, is the most common type of flowerhead. Involucral bracts surround the receptacle and may be prominent, as in *Protea*, or inconspicuous, as in *Leucospermum*. Involucral bracts in *Leucadendron* are also inconspicuous, but the floral bracts of female plants are large and develop into woody cones. An important taxonomic feature of the family is that its flowers do not have separate sepals and petals. The perianth is made up of a single set of four segments called tepals. As a bud opens, the perianth segments curl back to expose the style which extends from the superior ovary to the stigma. In some species, small floral nectaries at the base of the ovary secrete nectar to attract pollinators (Rebelo 1995). Another adaptation of evolution that has become important in the utilization of *Leucospermum* and *Protea* as cutflowers is bird pollination. The large, usually solitary, terminal flowers of these genera, and their predominant colors of creamy white, and blends of yellow, orange, and red, colors birds are attracted to, are probably adaptations to pollination by the Cape Sugarbird, *Promerops cafer*, and other nectar eating native birds. This is thought to be the prime reason why the South African species, and perhaps particularly *Leucospermum* and *Protea*, are the most attractive of the family and have excellent potential as cutflowers (Brits 1984a).

The floral biology of proteas is protandrous, with anthesis occurring prior to the stigma becoming receptive; a mechanism to help insure cross pollination. Most *Protea* seem incapable of self-pollination, although certain *Leucospermum* and *Serruria* species will produce seed when self pollinated. There are four types of pollinators, or pollen delivery; rodents, birds, insects, and wind. The flowerheads of certain *Leucospermum* and *Protea* species are visited by several species of gerbils, mice, rats, and shrews. Many *Leucospermum*, *Mimetes*, and *Protea* species are pollinated by birds. Since birds do not rely on smell, bird-pollinated species have little if any scent. The small species of *Leucospermum* and *Protea* are pollinated by bees and wasps and a few other insects; *Leucadendron* are pollinated by several beetle species, and most small-flowered genera are visited by a number of beetle, fly, and wasp species. Ten *Leucadendron* species are the only wind-pollinated proteas in southern Africa (Rebelo 1995).

The hermaphrodite species of protea are extremely low seed producers, with only one to 30% of flowers resulting in seed. It is surmised that a large percentage of hermaphrodite flowers function only as males. Another reason for low seed production may be the plant's need to produce nutrient rich seeds to reduce seedling mortality in a nutrient-poor environment. However, dioecious species generally have a high seed set, possibly because all flowers on a female plant are reproductively functional (Rebelo 1995).

HISTORICAL

In 1771, the great Swedish botanist Carl Linnaeus wrote a colleague in Amsterdam, "*Inexhaustum credo Cap. B. spei esse plantarum speciebus; certe nulla Flora ditior erit*." Freely translated this reads, "I believe the Cape of Good Hope is by no means exhausted of plant species; surely no other flora could be richer..." The Australian Proteaceae contain more genera, but it is the South African ones that have attracted the interest of the world, commencing with the attempts by Joseph Knight to cultivate them under artificial conditions in the late 1700s. They proved to be difficult subjects, but the first flowers produced outside of South Africa were shown at the Royal Botanical Gardens at Kew in 1774 and 21 species had bloomed there by 1810. In the 18th and 19th centuries they became a "patrician indulgence" as collections were found in the royal conservatories from St. Petersburg to Paris (Parvin 1984).

Although there has been much exploration of the Cape Floral Kingdom over the past 400 years, new species are still being found, many of them in the Proteaceae. The interest in this family began with the 1605 description by botanist Carolus Clusius of the flowerhead of *Protea neriifolia* as thistle-like, graceful, and unique. The Proteaceae are often the most prominent elements of the Cape fynbos with large, stiffly erect flowerheads. A cut flower industry developed around flowers harvested from the fynbos (Brits 1984b). A far-sighted Stellenbosch farmer, Mr. Frank Batchelor pioneered the development of the commercial protea industry in South Africa as he retired from deciduous fruit production. From wild-collected materials, he moved into selection, hybridization, and vegetative propagation, recognizing that superior quality was required for the marketplace (Soutter 1984).

Contemporaneously, Marie Vogts took up the challenge to learn more about the habits and production of proteas. Wild plants in their natural habitat were her reference books as she established cultivated plantings which could be studied and compared. By the late 1950s, she had acquired enough knowledge to conclude that proteas could be cultivated, and her book "Proteas: Know them and grow them" (1958) was published. The book focused attention on the economic possibilities of proteas. Continuing her work, she sought out the natural variants that occurred in the mountains and brought them into cultivation. Seeing horticultural potential as well as marketability in these variants, she recognized the variations in flowering times at different sites as important to extending the marketing season (Vogts 1984). She was instrumental in founding the Protea Research Unit of the South African Department of Agriculture and focusing its attention on the genetic variability of wild populations and interspecific hybrids, and initiating a research program to improve their adaptability to cultivation (Brits 1984b). Her four decades of research and investigation laid a foundation for an industry that benefits not only South Africa's landed establishment, but also their rural peoples, and that has reached beyond the Cape Floral Kingdom to Australia, New Zealand, Israel, California and Hawaii, Zimbabwe, El Salvador, Chile, the Canary Islands, France, and other distant lands. Thus, this "alternative crop/new crop" has a long and honorable history predating the 1990s interest.

The University of Hawaii became involved in 1964 when a visiting professor of Horticulture, Dr. Sam McFadden, imported seed of various Proteaceae for trial in Honolulu. The next year additional seed were planted at the Maui Agricultural Research Center, 1000 m up the slope of

Haleakala crater, where they flourished. Evaluations were made in 1969 separating 34 species into those suitable for cutflowers, for landscaping, and those unsuitable for either purpose. In 1970, 63 species of nine genera were imported, and a research program with emphasis on propagation and nutrition began to take form (Parvin et al. 1973). It was soon recognized that *Leucospermum* flowered on Maui as much as two months earlier than in California, suggesting the potential for a competitive advantage for a Hawaii export industry (Parvin 1984) if early flowering cultivars of horticultural merit could be obtained or created. The first pollinations in a new breeding program were made in 1972. The current research program emphasizes breeding for improved cultivars for cutflower production, the physiology of flowering, disease management, and postharvest handling and storage for *Leucospermum* and *Protea*.

The results from protea research programs in South Africa and Hawaii, and to an extent, Israel, have helped to stimulate protea cultivation in those and several other countries around the world, primarily for the international cutflower trade. Europe has been the traditional market for protea, but the United States and Japan have significantly expanded floral consumption and increased purchases of protea in recent years. Israeli market research recently reported that the world-wide cutflower markets can still absorb large quantities of proteas without lowering prices, but that the market is in need of new cultivars to refresh existing selections (Danziger 1997).

The emphasis on cultivar development is put into perspective by Soutter (1984); "It is generally said that a horticultural industry is only as good as its cultivars, and certainly in the case of floriculture, one can add the rate at which new cultivars are placed on the market." Numerous cultivars have been introduced by scientists and commercial breeders, hobbyists, and plant and flower collectors gathering from the native fynbos. *The International Protea Register*, Stellenbosch, South Africa, now in its fourth edition, keeps track of named cultivars along with their origin and brief descriptions to the extent it can obtain the information. This valuable resource allows researchers and producers to exchange plant materials and communications about known cultivars and their adaptability and performance in cultivated situations around the world. Table 1 summarizes the registered cultivars, and cultivars recognized but not yet registered, of four protea genera.

Table 1. Summary of cultivars in The International Protea Register (the number of interspecific hybrids is in parentheses).

Genus	Named cultivars					
	Registered		Recognized but not registered		Total	
Leucadendron	12	(5)	101	(18)	113	(23)
Leucospermum	30	(19)	58	(15)	88	(34)
Protea	42	(24)	139	(29)	181	(53)
Serruria	2	(2)	4	(1)	6	(3)
Total (4 genera)	86	(50)	302	(63)	388	(113)

The register also lists cultivars of unknown origin, including 14 *Leucadendron*, 14 *Leucospermum*, and 24 *Protea*. It lists only one intergeneric hybrid, (*Mimetes* × *Leucospermum*) 'Splendidus'. The

86 registered cultivars are authored by 20 registrants from five countries; Australia, New Zealand, South Africa, United States, and Zimbabwe (Sadie 1997).

The International Protea Association (IPA) supports the promotion and commercial production of protea as well as scientific research and conservation of native germplasm (Mathews 1984). The IPA held its 9th biennial conference in Cape Town, South Africa, in August 1998 with representatives from 12 nations participating. Regional production and marketing reports were made by industry leaders, while academics and graduate students gave oral and poster presentations on research progress in areas of conservation, pest and disease management, cultivar development, propagation, pruning, irrigation, nutrition, and postharvest physiology.

Economically, the most important protea species is *Macadamia integrifolia*, the only native food plant in Australia to achieve international status as a commercial nut crop. Macadamia breeding and selection work was initiated in 1934 by the University of Hawaii, and over the next 50 years 13 cultivars were introduced from 120,000 seedlings evaluated. Commercial development of this crop began in Hawaii in the 1940s (Hamilton and Ito 1984). Hawaii was the world's leading producer until Australia recently claimed that spot. Today, this gourmet dessert nut is cultivated commercially in Australia, Brazil, Costa Rica, Guatemala, Hawaii, Kenya, Malawi, South Africa, and Zimbabwe. Recently, China established commercial plantings on Hainan island.

Selected Proteaceae floral crops were analyzed for their potential profitability, on a hypothetical 4 ha farm, and determined to be profitable, given adequate farm management and marketing. A computerized spreadsheet model of protea production in Hawaii enables one to estimate profitability over a wide range of conditions (Fleming et al. 1991, 1994). The computerized program is available free by contacting fleming@hawaii.edu.

A variety of protea species have uses within or near their habitat. The seeds of *Brabeium stellatifolium* of South Africa are roasted and eaten or used as a coffee substitute. The seeds of *Finschia chloraxantha* from New Guinea and *Gevuina avellana* from South America are eaten by natives. The timbers of the Australian silky oaks *Cardwellia sublimis*, *Orites excelsa*, and *Grevillea robusta* are used in furniture and panelling. The Australian *Oreocallis wickhami* and *Banksia serrata* are used for yokes and boat knees, and the wood of *B. verticillata* for railway carriages and furniture. *Hakea leucopteris* and *H. vittata* wood is used for smoking pipes. The barks of *Faurea saligna* and *Leucospermum conocarpum* are used for tanning leather in South Africa. Species reported to have medicinal uses are *Faurea speciosa* for ear drops (root and leaf extract), and *F. saligna* to treat dysentery and diarrhea (root extract). Most protea flowers are of value to apiarists for their abundant nectar production (Rao 1971).

PROTEA

Protea is a large genus with 136 species of which 70 are distributed in the southern hemisphere temperate zones and the balance distributed in southern hemisphere sub-tropical to tropical zones, with 3 extending above the equator into the northern tropics (Rao 1971). Of the 117 species native to the African continent, 82 are from South Africa (Vogts 1982). A recent account of *Protea* species in Southern Africa lists 90 species and numerous subspecies (Robelo 1995). Linnaeus named the genus *Protea* in 1735 after the Greek god Proteus, who, according to legend, was able to transform his shape and appearance into numerous animate and inanimate forms at will (Robelo 1995). It was from the name *Protea* that the family name Proteaceae was assigned by the French botanist Jussieu (Rousseau 1970).

The natural habitat of *Protea* ranges in elevation from sea level to over 2000 m. In South Africa a rich diversity of species inhabit the well-drained, moderately-acid, low fertility, granite soils from Cape Town to the Table Mountain areas up to 1300 m (Parvin et al. 1973).

The genus is characterized by large bracts, often brightly colored, surrounding a composite type flower. The bracts are smooth or pubescent, with many species having bracts fringed with a dark "fur" lending a tactile as well as visual appeal. The range of colors includes red, pink, yellow, white, and occasionally green (Watson and Parvin 1973). The most widely recognized species in the genus is *Protea cynaroides*, the King Protea, the national flower of South Africa. It has flower heads up to 30 cm across, with widely spaced bracts arranged around a peak of flowers that vary in color from near white to soft silvery-pink to deep rose pink to crimson, in a few selected cultivars.

Many natural variants of *P. cynaroides* can be placed into three South African ecotypes. Those from the eastern cape and southern coastal plain have long leaves on long stems that terminate with relatively small but wide-open flower heads. They are very attractive but difficult to pack. The plants are vigorous and bear 10 to 20 heads per plant. Variants from the Outeniqua mountains region bear large bowl-shaped rose colored flower heads on thick stems. The heads are more easily packed because the bracts do not flare out. Average flower head yield is five to eight per plant. The variants from the Western Cape region are slow growing and average only about four heads per plant, but are described by Vogts (1980) as beautifully goblet-shaped. A miniature form of *P. cynaroides*, with flower heads the size of a typical pincushion protea, offers much promise for expanded florist use of this species. *Protea cynaroides* generally show good resistance to *Phytophthora* root rot (von Broembsen and Brits 1986).

Several clonal selections of *P. neriifolia* are grown commercially for their prolific production of fall and winter blooms. The plant becomes a large shrub with foliage resembling that of oleander. Flower heads range in color from light pink to rose to dark red, with some white selections known. Some selections have silvery hairs subtending tufts of black hairs at the bract tips. Plants of 20 years age have been reported to bear commercial quality flowers (Vogts 1980). This species also shows good resistance to *Phytophthora* root rot (von Broembsen and Brits 1986).

The grey-leaf sugarbush, *P. laurifolia* (formerly *P. marginata*), is similar to *P. neriifolia* for many characteristics, although their natural distributions do not overlap and natural hybrids between the two do not occur. To the non-taxonomist, foliage characteristics may be the most distinguishing feature between the two species. The leaves of *P. laurifolia* are grey-green to blue-green, elliptic and broader than the bright green leaves of *P. neriifolia* (Vogts 1982). If left unmanaged, *P. neriifolia* will grow to become an erect shrub 3 m tall while *P. laurifolia* will become an 8 m tall tree (Robelo 1995).

Protea magnifica, the Queen protea, is somewhat susceptible to *Phytophthora* (von Broembsen and Brits 1986) but is still grown for its large 15 to 20 cm flower heads of white to rose pink to salmon colors. Many cultivars have black-and-blond tufts of hair on the bract margins (Vogts 1980) and are sometimes referred to as woolly-beard protea.

The rose-spoon protea, *P. eximia*, gets its common name from the long spathulate inner bracts that are widely splayed and easily distinguish this large flowered species from others (Vogts 1982). These bracts range in color from pink to orange-brown. Awns extending from the perianth have purple-black velvety hairs. Plants generally range in height from 2 to 5 m, are sparsely branched, and flower from early winter through late spring (Robelo 1995). A tall tree-like variant reaches peak flowering in summer (Vogts 1982).

Long, narrow leaves, and flower heads with pointed bracts characterize *P. longifolia*. Bract color is variable from white to pink and green. Plant stature and growth habit are also variable in its native stands, where many natural hybrids with other *Protea* species overlapping its range have been found.

Protea grandiceps, also somewhat susceptible to *Phytophthora* (von Broembsen and Brits 1986) comes from high elevation mountainous regions that are snow-covered in winter. It is a slow growing long-lived plant that bears up to 40 salmon-colored flower heads of 10 to 15 cm. Plants can be cultivated for more than 20 years (Vogts 1980).

The sugar bush, *P. repens*, is widely grown commercially for its white to pink to deep red colors and long flowering season (Vogts 1980). It is another species with good resistance to *Phytophthora* root rot and can be used to replant *Phytophthora* infested fields (von Broembsen and Brits 1986).

Protea compacta has lanky flower stems on a stiffly upright, sparsely branched shrub that grows to 3.5 m tall. The rich pink bracts, with their light-reflecting fine-hair-fringed margins are longer than the cup-shaped flower heads. The prominent flower heads, unobscured by foliage, make fine winter cutflowers (Vogts 1982).

Numerous selections of these and other species, and of naturally occurring hybrids that have been identified from the South African fynbos, are cultivated by commercial growers. Cuttings of 22 named selections of *Protea* of South African origin were imported by the University of Hawaii in 1988, propagated, field planted, and evaluated for adaptability and plant growth characteristics at its Kula Agricultural Research Center on Maui. Yield, seasonality of bloom, and keeping quality were recorded from 1989 to 1993. The yield and seasonality over a 12 month period (August 1992 through July 1993) of the seven cultivars that produced 30 flowers or more are reported in Table 2. By careful evaluation of seasonality in localized climates, it is possible to select cultivars to cover a large portion of the year, although some months may not be well represented (Criley et al. 1996).

Table 2. Yields and seasonality on Maui for selected South African *Protea* accessions.

Cultivar	Yield (12 mo)	Months of flowering											
		Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Annette	37					ü	ü	ü	ü	ü	ü	ü	
Brenda	210			ü	ü	ü	ü						
Cardinal	31	ü					ü	ü	ü	ü	ü	ü	ü
Guerna	86	ü	ü	ü	ü	ü	ü	ü	ü	ü	ü	ü	ü
Heibrech	45	ü	ü	ü	ü	ü	ü	ü	ü		ü	ü	

Red Baron	86	ü	ü	ü	ü	ü	ü	ü	ü		ü		
Sylvia	66	ü	ü	ü	ü	ü	ü	ü	ü	ü	ü	ü	ü

Protea can be propagated from seed, with the resulting variation expected of cross-pollinated heterozygous materials. Given the availability of clonal selections, the method of choice among progressive commercial growers is to propagate from cuttings. Terminal and sub-terminal cuttings are made from the current season's mature growth. Robust cuttings of 20 to 25 cm in length root readily, for most cultivars. Longer cuttings may be taken if the grower desires to have lower branches well above ground level. Removing half of each leaf of long leaf cultivars is a common practice. An IBA auxin treatment of 4000 to 8000 ppm is beneficial. The rooting medium should be very well aerated but not allowed to dry. Mixtures of 25% to 50% peat with the balance being polystyrene or perlite has given good results. Rooting is generally done under standard mistbed conditions. An approved fungicide sprayed over the cuttings following planting can prevent infections. Rooting time is variable among species, with *P. cynaroides* rooting quickly and *P. neriifolia* often taking many weeks (Mathews 1981).

When selecting a production site, good soil drainage is the most important requirement for protea production. Deep soils that allow expanded root development and can store a good supply of water and nutrients are preferred, but shallow soils can be suitable if drainage is rapid and frequent irrigation can be provided (Claassens 1981).

Relatively low concentrations of nutrients are required for normal growth of proteas. Most species react favorably to nitrogen, particularly in the ammonium form, while most are intolerant of amounts of phosphorus that would be considered moderate for non-proteaceous plants. Protea plants seem to have a very effective mechanism to scavenge phosphorous from soils with low phosphorus status (Claassens 1981, 1986).

Cresswell (1991) produced a tissue analysis standard for assessing the appropriate phosphorus status for two *Protea* cultivars. Only the desirable ranges are reported in Table 3. Values lower or higher than those reported here were considered low to deficient or high to toxic, respectively.

Table 3. Desirable ranges of phosphorus in tissues of two *Protea* cultivars.

Cultivar	Desirable phosphorus (ppm)		
	Stems	Recently matured leaves	Old leaves
Satin Pink	0.19–0.35	0.19–0.29	0.21–0.44
Pink Ice	0.06–0.29	0.06–0.27	0.16–0.46

The recommended developmental stage for harvesting most *Protea*, to insure market quality and acceptable postharvest life, is the so-called soft-tip stage when bracts have lost their firmness and begin to loosen but still cohere (Meynhardt 1976). At this stage, few insects are present because anthesis has not yet occurred, so there is little to attract them. However, flowers picked too early will not open (Coetzee and Wright 1991). A serious problem with marketing several species of *Protea* is the undesirable discoloration of leaves soon after harvesting. The problem is most pronounced in *P. eximia* and *P. neriifolia*, and their hybrids, and to a lesser extent with *P.*

compacta and its hybrids (Ferreira 1986; Paull 1988).

Leaf blackening, or browning as it is sometimes called, in *Protea* is caused by carbohydrate depletion due primarily to the sugar demand by the inflorescence for nectar production (Dai and Paull 1995). Low availability of mobile carbohydrates in the leaves, combined with the high respiratory demand of the inflorescence, resulted in a 70% decline in mobile leaf carbohydrate levels in *P. neriifolia* within 24 hours of harvest (Jones et al. 1995). Warm temperatures and low light in postharvest storage have been correlated with increased rates of leaf blackening (Ferreira 1986). Refrigeration, especially during postharvest storage, packaging, and shipping periods, has a most significant effect on delaying the onset of leaf blackening (Paull 1988). Refrigeration will slow respiration, reduce water stress, and slow nectar production by the inflorescence, thereby conserving carbohydrate reserves in the stem and foliage. A storage and transport temperature of 2° to 5°C will help ensure bloom quality and postharvest life (Coetzee and Wright 1991). Pulsing cut *Protea* stems in a 1% sucrose solution, or a floral preservative solution, before packing and especially post-unpacking is an effective treatment to delay the onset of leaf blackening (Brink and de Swardt 1986; Paull 1988). Another form of leaf browning results from fumigation with methyl bromide (Coetzee and Wright 1991), which imported shipments are often subjected to if insects are present. Growers should practice good field sanitation and appropriate postharvest disinfestation practices prior to packing, so that agriculture inspectors at the receiving end will not fumigate the shipment.

Natural hybrids within the genus *Protea* are not an uncommon occurrence where the geographic ranges of two or more species overlap. Scientists at the Fynbos Research Unit, Elsenburg, South Africa, have made a collection of such natural hybrids and in most cases have been able to determine their parentage (Table 4). Some of these meet standards of commercial horticulturists and have been released to South Africa's protea industry. Dr. Littlejohn, the protea breeder at Elsenburg, recently initiated a program to produce controlled hybrids in the genus *Protea* to further benefit the protea industry.

Table 4. Recent *Protea* hybrids of South African origin.

Sheila	(*P. magnifica* × *P. burchelli*)
Venetia	(*P. magnifica* × *P. neriifolia*)
Pink Duke	(*P. compacta* × *P. susannae*)
Candida	(*P. magnifica* × *P. obtusifolia*)
Valentine	(*P. cynaroides* × *P. compacta*)
King Grand	(*P. cynaroides* × *P. grandiceps*)
Venus	(*P. repens* × P. aristata)
Liebencherry	(*P. repens* × *P. longifoli*)
unnamed	(*P. cynaroides* × *P. nitida*)
unnamed	(*P. cynaroides* × *P. repens*)

LEUCOSPERMUM

Leucospermum species are evergreen woody perennials with growth habits that range from small trees to spreading shrubs to prostrate ground covers. The most widely grown species are floriferous, spreading shrubs on which relatively short-stemmed inflorescences are borne in the spring. Horticulturists have had to develop management practices to improve stem length and straightness for their use as cut flowers.

Rourke (1972) and Jacobs (1985) describe the inflorescence as a capitulum that develops from an axillary rather than a terminal bud, but that appears to arise distally. Inflorescences may be solitary, as in *L. cordifolium*, *L. lineare*, and *L. vestitum*, or in clusters (conflorescences), as in *L. oleifolium*, *L. tottum*, and *L. mundii*. The individual florets consist of a perianth formed by four fused perianth segments, one of which separates from the other three as the flower opens. The perianth curls back to display a prominent style; the striking appearance of the whole inflorescence of open flowers resembles a pincushion—thus one of the common names is pincushion protea. The styles, perianth, and involucral bracts may be white, yellow, pink, orange, or red and the combinations are responsible for the popularity of the pincushion proteas as cutflowers.

Although most of the *Leucospermums* are indigenous to nutrient-poor, coarse, acidic, sandstone-derived soils, they seem adaptable to a variety of soil types within a narrow range of pH and fertility levels. This is evidenced by their culture in several regions of southern Africa, southern California, Israel, Australia, and in the volcanic soils of Hawaii and the Canary Islands (Criley 1998).

Propagation of the commercial cultivars of *Leucospermum* is by cuttings, of which most root readily. While cuttings can be rooted at almost any physiological stage of development, a preferred cutting is the recently matured new growth, known as a semi-hardwood cutting (Malan 1992). This type of material is gathered in autumn after shoot growth terminates.

A tissue culture protocol for *Leucospermum* was developed using axillary bud explants induced to proliferate on a basal medium of half-strength Murashige and Skoog inorganic salts supplemented with sucrose and benzyl adenine (Kunisaki 1989, 1990). *Leucospermum* Hawaii Gold, propagated from tissue cultures, is flowering at the Kula Agriculture Research Center and appear identical to the type cultivar from which the explants were taken.

Grafting is often viewed as a solution to problems of root system adaptation to low or high pH soils, or soil-borne diseases. The selection of rootstock plays a significant role in improving adaptability and yield of *Leucospermum* (Van der Merwe 1985). Grafting onto lime-tolerant rootstocks, such as *L. patersonii*, has been recommended as an approach to problems of protea production on soils of neutral to slightly basic pH (Brits 1984b). The standard grafting technique is wedge-grafting of leafy semi-hardwood scions onto selected rootstocks (Rousseau 1966; Vogts et al. 1976). Cutting grafts, where the graft union develops while the cutting roots, is also recommended (Brits 1990b). Brits (1990c), in screening 19 species and several hybrids for their potential as rootstocks, determined that *L.* 'Spider' (a primary hybrid of *L. formosum* × *L. tottum*) has a degree of tolerance to *Phytophthora cinnamomi*. *Leucospermum* 'Spider' is presently being used as a rootstock by several commercial producers in South Africa. *Leucospermum saxosum* has also been determined to have low susceptibility to *Phytophthora* (Moffat and Turnbull 1994), and a selection of *L. patersonii*, designated 'Nemastrong', has tolerance to nematodes (Ackerman et al. 1995). Such rootstocks may have the potential to expand and increase yields of plantings where *Phytophthora* and nematodes are a problem.

The production period for *Leucospermum* is late winter to late spring. Parvin (1974) reported that 65% to 75% of the total crop of *L. cordifolium* 'Hawaiian Sunburst' was harvested from Dec. through Feb. in Hawaii. They are also high yielding. During a three-year study, beginning with 6-year-old plants, the per plant yields averaged 600 to 650 flowers.

Research on postharvest handling practices has shown that the pincushion protea will tolerate cool, dry, long-term storage and still provide a useful vaselife. *L. cordifolium* flowers that were cooled and hydrated at 1°C in water, wrapped in newsprint and bagged in plastic film withstood periods of three and four weeks at 1°C storage, and after rehydration, possessed an average vaselife of 8 days (Jones and Faragher 1990). Downs and Reihana (1986) found significant varietal differences in vaselife following a period of simulated transport, with the New Zealand cultivar 'Harry Chittick' at 35.5 days, a Hawaii hybrid of *L. lineare* × *L. cordifolium* at 29.7 days, and 'Veldfire', a South African hybrid at 16.9 days.

Parvin (1978) improved vaselife with 2% to 4% sucrose plus 200 to 600 ppm hydroxyquinoline citrate solutions. Silver nitrate at 1000 ppm did not benefit cultivars of *L. cordifolium* but improved vaselife for the hybrid *L.* 'Hawaii Gold' (Parvin and Leonhardt 1982). Criley investigated revival of wilted flowers with extruded styles, in order to increase packing densities for export shipments. Flowers pulsed with a preservative prior to partial dehydration (20% loss of FW) and storage (24 h at 13°C) could be revived, although vaselife was not as long as with fresh cut flowers (Criley et al. 1978a,b). Flowers cut in bud (7 cm diam.) offered better promise, with full development and less loss of vaselife than flowers cut at a younger stage (Criley et al. 1978a; Parvin and Leonhardt 1982).

While a number of Proteaceae may be grown as potted plants, the *Leucospermums*, with their relative ease of rooting and attractive floral display, have the greatest potential (Sacks and Resendiz 1996). Criley (1998) reported that budded cuttings flowered soon after rooting, adding confirmation to their potential as potted plants, and proposed that stock plants be manipulated to achieve stronger branches for this use.

Research on photoperiod responsiveness of *Leucospermum* (Wallerstein 1989; Malan and Jacobs 1990) indicates that daylength manipulation may have implications for potted flowering plant production. High light intensity was shown to be necessary for flowering (Jacobs and Minnaar 1980; Napier and Jacobs 1989; Ackerman et al. 1995) and to promote rapid rooting of cuttings.

Leucospermum species suitable for potted plants are of two types: those having a single large inflorescence, such as *L. cordifolium*, *L. lineare*, and *L. tottum*; and those with small multiple inflorescences (conflorescences) such as *L. oleifolium*, *L. muirii*, and *L. mundii* (Brits et al. 1992; Ackerman et al. 1995; Brits 1995a). It is important to select material that will root rapidly and support flower initiation and development on a young root system (Ackermen and Brits 1991; Brits et al. 1992).

Although the genus *Leucospermum* consists of 48 species (Rourke 1972), little genetic improvement through hybridization has taken place until relatively recently. Jacobs (1985) reported that only a few species were utilized as cut flowers (*L. cordifolium*, *L. patersonii*, *L. lineare*, *L. conocarpodendron*, *L. vestitum*), but that natural and man-made interspecific hybrids exist as clonal selections. Collection and introduction of natural interspecific hybrids has occurred (Brits and van den Berg 1991), and controlled crosses were made between species in efforts to produce later flowering, improve color and shape, and to introduce tolerance to *Phytophthora cinniamomi* (Brits 1992a). Today, active breeding programs are being conducted at the Fynbos Research Station, Elsenburg, South Africa (Brits 1992a,b; Littlejohn et al. 1995) and at the Maui Agricultural Research Station of the University of Hawaii (Ito et al. 1978, 1979, 1990; Leonhardt et al. 1995), and in Israel (Shchori et al. 1995).

As of the fourth edition of the *International Protea Register* (*International Registration Authority: Proteas 1997*), 30 cultivar names have been registered and another 58 have been noted but not registered for selections and interspecific hybrids (Criley 1998). Among the hybrids registered, only three are advanced hybrids (having more than two species in their genealogy). These hybrids, developed and registered by the University of Hawaii, are:

L. 'Rachel', with parentage (*L. lineare* × *L. vestitum*) × *L. glabrum*

L. 'Hawaii Moon', with parentage (*L. lineare* × *L. cordifolium*) × *L. conocarpodendron*

L. 'Kathryn', with parentage (*L. lineare* × *L. cordifolium*) × *L. conocarpodendron*

The criteria for developing new *Leucospermum* cultivars must consider the needs of growers, handlers, retailers, and consumers. The criteria developed for the Hawaii breeding program includes disease resistance, earliness to flower, an extended flowering season, long slender and straight stems, slender leaves, reduced leaf pubescence, ease of propagation, high yields, good postharvest characteristics, new and improved colors, and market acceptance (Leonhardt et al. 1995). Leaf and stem characteristics, and disease resistance are given emphasis.

Many commercial *Leucospermum* cultivars are bulky, heavy, and cumbersome to pack due to large stem diameters and large heavy-textured leaves. These are undesirable characteristics, particularly to exporters, because freight charges are based on a formula that considers cubic dimensions and weight of the box. A densely packed, light-weight box reduces the per-bloom freight charge and allows exporters to compete more favorably in overseas markets. The species *L. lineare*, and particularly the selection *L. lineare* 'Starlight', has slender, light-weight yet strong stems with narrow, nearly needle-like foliage. Breeding has demonstrated that these characteristics are heritable and that *L. lineare* hybrids have improved leaf and stem characteristics. *Leucospermum lineare* is also free of foliar pubescence. Foliar pubescence attracts and retains moisture, which provides an environment for fungal spore germination and infection (Leonhardt et al. 1995).

The most important diseases occurring on protea in Hawaii are root and collar rots caused by *Phytophthora cinnamomi*, *P. nicotianae*, and *Cylindrocladium* sp., stem and leaf scab caused by *Sphaceloma* (Elsinoe) sp., leaf spots and blights caused by *Drechslera biseptata* and *D. dematioidea*, leaf spec caused by *Alternaria alternata*, and root knot galls caused by *Meloidogyne incognita*, the root-knot nematode (Nagata and Ferreira 1993). Root-knot nematodes can severely limit growth and productivity of *Leucospermum*. Heavily infected plants show stunting and chlorosis, followed by death of the plant (Cho et al. 1976; Cho and Apt 1977). Wu reported that this nematode can reduce cut flower yields by at least 25% in infected fields compared to fumigated fields (Wu et al. 1978).

The Hawaii breeding program has utilized ten species and numerous F_1, F_2, and F_3 hybrids to produce seedling populations that are evaluated for disease resistance and other horticultural characteristics (Leonhardt et al. 1995). Some of the parental materials are used for very specific purposes. A selection of *L. saxosum* for example, was determined to be immune to *Sphaceloma* (Elsinoe scab disease) (Nagata et al. 1995) and has been used to impart resistance into commercial hybrids. Among hybrids, *L.* 'Rachel' has demonstrated a good level of resistance to *Sphaceloma*, and has also shown a good level of resistance to two isolates causing *Botrytis* blight and moderate resistance to two isolates causing *Drechslera* blight. The hybrid *L.* 'Ka Hoku Hawaii' (Hawaii Star), *L. cordifolium* × (*L. lineare* × *L. vestitum*), and the unnamed hybrids No. 36, *L. lineare* × [*L. conocarpodendron* × (*L. lineare* × *L. cordifolium*)], and No. 49, [*L. conocarpodendron* × (*L. lineare* × *L. cordifolium*)] × *L. cordifolium* 'Sweet Lemon', have shown a good level of resistance to both *Drechslera* isolates. The hybrids *L.* 'Pohaka La Hawaii' (Hawaii Sunbeam), (*L. lineare* × *L. glabrum*), and No. 36 have shown a good level of resistance to *Botrytis* isolates (Nagata et al. 1995; Leonhardt et al. 1995).

Commercial producers in Hawaii compete in North American markets with California producers. The flowering season for *Leucospermum* begins several weeks earlier in Hawaii than in California. Producers in Hawaii could enjoy this advantage for a longer period if earlier flowering cultivars could be developed. The species *L. patersonii* and *L. pluridens* are among the earliest-flowering, and are being used in breeding for that quality. Two accessions of *L. pluridens* × (*L. lineare* × *L. cordifolium*) flower earlier at the Maui Agriculture Research Station than the hybrid parent (Leonhardt et al. 1995).

LEUCADENDRON

The South African genus *Leucadendron* contains about 60 species, collectively referred to as the conebushes. They are easily identified since they are dioecious, having plants of separate male and female sexes. Both sexes have terminal flowerheads. Female plants produce woody cones containing fruits and seeds while male plants do not produce cones. The cones on female plants consist of spirally arranged floral bracts which partially cover the cone. Male plants are often larger and more heavily branched and may have smaller leaves than female plants (Robelo 1995).

As with most Proteaceae, the *Leucadendrons* grow best in areas with light, well-drained soils with low concentrations of dissolved salts, an adequate supply of fresh water, temperatures in the range of 7°C to 27°C, and frequent if not regular light winds. *Leucadendrons* require an acid soil with a pH not exceeding 5.0. Sandy soils with some humus provide the best growing medium (Vogts 1980).

Several species are cultivated commercially for their decorative foliage, including *L. argenteum, L. discolor, L. galpinii, L. laureolum, L. salicifolium, L. salignum, L. tinctum*, and *L. uliginosum*. *Leucadendron argenteum*, the 'Silver Tree', can grow to a 8 m tall tree if left unmanaged. Its leaves are grey-green with abundant fine satiny silver hairs that glisten in sunlight. It is grown for its long-lasting cut foliage, and also makes an attractive landscape plant. Its natural habitat is arid, and in cultivation it will succumb to overwatering, soil fungi, and nematodes. *Leucadendron discolor*, harvested in winter and spring, ranges in color from light to dark green to yellow to red, and is a spreading bush up to 1.5 m high. *Leucadendron laureolum* is chartreuse to bright yellow when flowering in winter and spring while *L. salignum* (formerly *L. adscendens*) is bright red, becoming more intensely colored as temperatures decrease. A particularly outstanding cultivar is the female selection *L. salignum* 'Safari Sunset'. *Leucadendron uliginosum* has elegant, slender shoots covered with numerous shiny, silvery leaves (Vogts 1980, Kepler 1988).

The genetic variation in *Leucadendron* is vast and largely untapped for breeding purposes (Littlejohn et al. 1995), although a few hybrids have been introduced to the commercial trade, mostly from South Africa. Hybrids cultivated by commercial growers include *L.* 'Silvan Red' and *L.* 'Inca Gold', both (*L. laureolum* × *L. salignum*), *L.* 'Kam-ee-lion' (*L. salignum* × *L. eucalyptifolium*), and the recent South African introduction *L.* 'Rosette' (*L. laureolum* × *L. elimense* ssp. *salterii*), which can be harvested as a green, yellow, or red-brown product, depending on the season (Littlejohn et al. 1998).

In addition to their highly colorful, easily packaged, long and long-lasting cut stems, a characteristic of many *Leucadendrons* that makes them commercially important is their potential for very high yields. Pruned and managed *L.* 'Silvan Red', in a 3 year study at 3 locations averaged 265 marketable stems per plant per year (Barth et al. 1996). This cultivar can be harvested in the fall as a red-foliaged stem, and in the winter as a tricolor stem with yellow, red, and green foliar bracts. *Leucadendron* 'Safari Sunset', a selection of New Zealand origin, is probably the most widely grown commercial cultivar, with extensive plantings in Australia, New Zealand, South Africa, and Israel. The erect bushy plant is vigorous and fast growing. Its deep wine-colored bracts have excellent keeping quality, lasting up to 60 days (Tija 1986). Dr. Ben-Jaacov, in his presentation at the International Protea Association Conference in Cape Town in 1998 reported that 'Safari Sunset', under intensive management in Israel, has given yields in excess of 600,000 marketable stems per hectare per year. Recent research in South Africa compared *L.* 'Rosette' with *L.* 'Safari Sunset' for yield and stem length. In the third harvest year *L.* 'Rosette' yielded 44.5 stems per plant with 20 stems 80 cm or longer while *L.* 'Safari Sunset' yielded 37.0 stems per plant with 10 stems 80 cm or longer (Littlejohn et al. 1998). Both cultivars are exceptional commercial materials.

Although more widely known as commercial cut foliages and landscape plants, *Leucadendrons* can be grown as colorful potted "flowering" plants. The male *L. discolor* 'Sunset' naturally flowers profusely in early spring with colorful flower-heads. Israeli research has demonstrated that flowering potted plants of 'Sunset' can be produced in 3–5 months by rooting large branched cuttings with initiated flowers. The basal stems of branched 15 cm long cuttings were dipped in a 4,000 ppm IBA solution prior to sticking in a styrofoam/peat medium under intermittent mist and 25% reduced natural light. Rooting began in 4 weeks. The stage of development of the flower-head at rooting was critical for the cutting's further development into a flowering potted plant. If not fully initiated as floral buds, the meristem aborted or reverted to the vegetative state. However, when cuttings were taken at the right stage of floral initiation, colorful flowering potted plants were produced in 3–5 months. Conventional technology for producing potted flowering plants of *L. discolor* by rooting small unbranched vegetative cuttings, growing them to the appropriate size, retarding them chemically, and bringing them to flower, would take 2 years or longer (Ben-Jaacov et al., 1986). The potential for using this technology to produce attractive *Leucadendron* flowering potted plants for the commercial nursery trade is significant.

BANKSIA

The fourth largest export wildflower crop of Australia (Sedgley 1996), the genus *Banksia* is named for the famous botanist, Sir Joseph Banks. Seventy-six taxa have been described under 2 sub-genera, 3 sections, and 13 series (Sedgley 1998). *Banksia* are evergreen, woody perennials with growth habits that range from prostrate ground-huggers to trees. Most of the species are found in the south-west with the remainder along the southern and eastern coasts and tablelands. Nearly all have ornamental features that confer horticultural potential, whether as fresh or dried cut flowers, cut foliages, or in the landscape (Elliott and Jones 1982; Joyce 1998; Parvin et al. 1973; Sedgley 1998; Wrigley and Fagg 1996).

Species widely grown for cut flowers and foliages are shown in Table 5. The most popular cut flower types bear their cylindrical flower spikes terminally, but a few terminal-flowering selections have been made of axillary bearers (Sedgely 1998). Some species produce attractive flowerheads upright on horizontal branches and would need considerable management to be suitable for the commercial markets. Although many commercial plantings are produced from seed and show considerable variability, progress has been made in cultivar development (Fuss and Sedgley 1991; Sedgley et al. 1991; Sedgley 1991, 1995a,b,c,d).

Table 5. Some Banksia species suitable for cut flower or cut foliage production. Sources: Parvin et al. 1973; Elliot and Jones 1982; Salinger 1985; Sedgley 1998.

Banksia species	Cut flower	Cut foliage
ashbyi	ü	
baxteri	ü	ü
burdettii	ü	
coccinea	ü	
ericifolia		ü
grandis	ü	ü
hookeriana	ü	
integrifolia		ü
menziesii	ü	
occidentalis		ü
prionotes	ü	
speciosa	ü	ü
victoriae	ü	

Concurrent with these developments is a need to improve the vegetative propagation systems, as cutting propagation often results in development of a large knob of callus (Hocking 1976). Cutting propagation yields variable results, but the use of intermittent mist (allowing some drying between cycles) and auxin stimulates better root development on semi-hardwood terminal cuttings (Bennell and Barth 1986; Sedgley 1995c). Grafting onto various disease resistant species such as *B. robur* and *B. spinulosa* offers some promise, but additional research is needed to establish successful techniques and timing and to determine compatibility relationships and tolerance to stresses. It is necessary to avoid rootstocks that form lignotubers as these may sucker and compete with the scion (Elliott and Jones 1982). Cutting grafts have been successful with a few species (Elliot and Jones 1982).

Seed germination is reliable, but not for the hybrids, and seed supplies are limited. *Banksia* seed is produced in a hard follicle that often requires heat or heat followed by immersion in water to cause it to open. Seedlings are susceptible to damping off and should be germinated in a sterile well-drained medium. Germination requires 21 to 90 days at 20°–25°C (Elliot and Jones 1982). The optimum medium temperature can range from a constant 10° to 25°C or fluctuate by 10° to 15°C (Bennell and Barth 1986). Transplanting is done as soon as the seedling is large enough to handle.

All species grow best in light, sandy soils of acid pH. They are adapted to soils of low fertility, but benefit from a supply of calcium and application of nitrogen, potassium and iron (Sedgley 1996, 1998). Like other Proteaceae banksias tend to be intolerant to high levels of phosphorus which interfere with iron uptake (Handreck 1991). In cultivation, pruning is necessary to remove shoots that will not flower and to encourage development of shoots with sufficient diameter to initiate the inflorescence (Fuss et al. 1992; Sedgley and Fuss 1992; Rohl et al. 1994; Sedgely 1996).

Sedgley (1996, 1998) notes that there has been little published research on postharvest care of cut *Banksia*. Sucrose pulses did not improve the 15 days vase life of *B. coccinea* (Delaporte et al. 1997), and anti-bacterials such as 0.01% chlorine, acidifiers such as 0.01% citric acid, and 0.02% aluminum sulfate have been recommended as a matter of course, but without verified results (Sedgely 1996).

GREVILLEA

A large genus (more than 340 species) of shrubs and trees from dry sclerophyll forests and heaths in Australia (5 species are found in New Caledonia, Sulewesi, and Papua New Guinea), grevilleas have many ornamental uses, especially in landscapes. Growth habits of the most popular species range from prostrate ground covers to mounded shrubs. Some have unusual, asymmetric, or layered habits. A tree form, *Grevillea robusta*, flourishes in sub-tropic climates and has potential as an invasive species because of its abundant seed production.

Grevillea have been in cultivation outside of Australia for over 200 years, with the earliest record of introduction of 3 species to England in 1791 and another 15 species in the 1820s (Elliot and Jones 1990). Nurseries in New Zealand and California also grow a wide range of species for landscape uses. As these locations and their native habitats suggest, many grevillea are frost and cold tolerant to –4°C (Elliot and Jones 1990). Drought tolerance is another quality to recommend many species in areas with dry summers.

Grevillea inflorescences are mostly toothbrush-like clusters, about 5 to 12 cm in length, and running the color gamut from white and greenish through yellow, orange, purplish, and red, and include some multi-colored forms. Other inflorescence categories include upright spider-like, pendant, or terminal cylindrical clusters. Some have very strong aromas while others are pleasant and sweet. Flowering tends to be seasonal, depending upon moisture, temperature, and daylength. Flowering is strongest in sunny locations and diminished in shade (Wrigley and Fagg 1996). There are also reports of skin irritation and rash from handling some prickly as well as non-prickly species.

While a number of hybrid grevilleas and more tropical species have been selected for large colorful inflorescences (Tully 1977), they are not widely marketed as cut flowers because of short vaselife and a tendency for floret abscission. Although the best can achieve a vase life of 7 to 10 days following cutting, production is said to be low (Olde and Marriott 1995). They are also alleged to be difficult to pack. The potential for their use is good if the problems can be overcome through the use of postharvest treatments, improved packaging, and breeding and selection (Joyce et al. 1996). A sugar, 2% citric acid, and bleach mixture has been recommended for home use, together with maintaining turgor by placing the cut stems in water.

Grevillea foliage displays a wide range of textures, colors, and shapes. The textures and shapes range from deeply divided, fern-like and fishbone-like leaves to entire or broadly-lobed shapes and pinnately-divided and regularly toothed and holly-like foliage. Colors range from silver-grey to dark glossy green. Many species have attractive undersurface of silver or bronze indumentum. These elements contribute to their value as landscape plantings, but also to their use as cut foliages. Cut as a growth flush matures, the foliage may last 30 days in water or commercial floral preservatives (Parvin 1991; Criley and Parvin 1993). It is this use that has potential in the floriculture trade. Management practices for cut foliage production need to be developed.

Potted grevillea plants have wide acceptance for patio and garden use both because of their foliage and flowers. They are easily rooted and managed, both by pruning and with growth regulators (Ben-Jaacov et al. 1989). The development of tissue culture techniques enables greater availability of attractive, but difficult-to-root cultivars such as 'Robyn Gordon' (Gorst et al. 1978, Watad et al. 1992). Several potted grevilleas have been introduced into the trade by Israel producers (Ben-Jaacov et al. 1989).

Grevillea may be propagated by seed, cuttings, layers, grafting, and tissue culture. Propagation by cuttings is said to be easy with mid to late summer matured growth (Wrigley and Fagg 1996). A Hawaii study indicated that quick dips in liquid auxin formulations (2000 to 4000 ppm) applied to terminal or immediately sub-terminal growth gave satisfactory results in 5 to 6 weeks (Groesbeck and Rauch 1985). Commercial liquid and powder auxin formulations provided good rooting for a number of species. Bottom heat of 29°C with no auxin stimulated 90% take on older wood of *G.* 'Robyn Gordon' (Dupee and Clemens 1981). Interesting landscape forms have been produced by approach-grafting weeping or prostrate forms onto rootstocks of *G. robusta* (Crossen 1990) or *G. banksii* or *G.* 'Poorinda Royal Mantle'(Wrigley and Fagg 1996). The cleft graft was reported successful as well (Dupee and Clemens 1981). However, it is recommended that a healthy top bud be left near the cut to prevent dieback below the graft (Elliot and Jones 1990). Air layering is reported as regularly successful (Tully 1977). Seed germination is enhanced by a presoak in 0.2% potassium nitrate for 12–24 hours, sowing in a sandy medium, and subjecting the seed to alternating warm (25°–33°C) temperatures (Heslehurst 1977). Germination required 4 to 5 weeks. Scarification or seedcoat removal also improves germination (Dupee and Clemens 1981).

More than one-half of the species have been tried in horticulture because of their wide adaptability to a range of soil conditions (Molyneux 1978). Many of the Western Australia species are found on infertile, non-calcareous soils, sands, and leached lateritic soils. Many of the eastern species can be found in clay or clay-loam soils. A few inhabit deserts or rainforests, and some tolerate slightly saline or alkaline soils (Elliot and Jones 1990; Olde and Marriott 1995). Many of the Western Australian species are not demanding of substrate as long as it is well-drained, although there are a few that will even tolerate poor drainage (Olde and Marriott 1995). While they respond to good fertility, high nutrient levels, especially phosphorus, are not required. Controlled release fertilization with careful attention to the form provided is recommended (Bowden 1987).

Longevity under well-fertilized conditions appears to be a problem, especially where the plants are also well-watered (Specht 1978). However healthy 10 to 15 year old plants can be found. These have generally benefited from regular pruning (Elliot and Jones 1990). *Phytophthora cinnamomi* is very devastating to grevilleas (Molyneux 1978).

ISOPOGON

Isopogon is native to temperate Australian regions, with the main distribution in southwestern Australia. Many are coastal or near-coastal in habitat and grow in well-drained, highly-leached sandy or lateritic soils and gravels or clay loams. They range from sea level to moderate altitudes and cope with a wide temperature range down to –7°C, where damage occurs. Full sun is the preferred light environment, but some tolerate semi-shade (Elliot and Jones 1990).

They offer some interesting, hardy plant materials for the landscape, and possibly for the cutflower trade. Most of the 35 described species are temperate zone shrubs of 1 to 2.5 m tall, but a few can grow into small trees (Foreman 1997). Most species are small to medium-sized shrubs while others are dwarf, spreading undershrubs. A number of species are adapted to container culture.

Cone- or drumstick-shaped flower clusters, of white to yellow to pink to mauve, are borne terminally or in the upper leaf axils. Flowering is chiefly in the spring months. A few species have good vase life and are grown commercially in Australia. Among species with cutflower potential are the winter-flowering *I. cuneatus*, and spring-flowering *I. latifolius* and *I. formosus* (Salinger 1985; Elliot and Jones 1990; Foreman 1997). While their cones are decorative, the scales are often shed with the seed.

Seed is not plentiful because it is often lost when the scales dehisce from the cone. Fresh seed, sown shallowly in a moist medium, germinates in 20 to 90 days. One pregermination recommendation is to lightly singe the seed with a flame (Elliot and Jones 1990). Cutting propagation is usually successful when aided by hormone rooting powders.

In culture, controlled release fertilizers with a low phosphorus content are recommended. Established plants are fairly drought tolerant, and over-watering contributes to loss of plants because the wet conditions favor *Phytophthora cinnamomi* infection. Tip pruning following flowering stimulates bushy growth. Species with lignotubers tolerate severe pruning.

DRYANDRA

These Australian natives (120 species) have a variable growth habit, ranging from prostrate shrubs to small trees. Foliage characteristics range from soft and needlelike to tough and prickly. The flowerhead resembles a shaving brush surrounded by basal bracts. Flower colors are mainly in the yellow to orange to bronze shades. Their potential as cutflowers needs further evaluation, but some species, such as *D. formosa*, dry nicely and could be added to this niche market (Joyce 1998). Among the recommended cut flower species are *D. formosa*, *D. praemorsa*, and *D. quercifolia* (Elliot and Jones 1984). Many species have foliage so spiny that they are not suitable for floral purposes (Salinger 1985).

Propagation is generally by sowing fresh or stored seed into a well-drained, loose medium; however, seed-feeding insects often render viable seed scarce (Elliot and Jones 1984). Pregermination treatments do not seem necessary (Cavanaugh 1994). Germination times range from 3 weeks to 3 months with an average of 5 to 8 weeks. Transplanting can be done fairly early, when seedlings have attained 50–75 mm in height. Cutting and grafting propagation successes have been reported for some species (Cavanaugh 1994), but neither practice is widely used. Softwood cuttings taken during winter and treated with rooting hormones have yielded some success (Elliot and Jones 1984).

Their native habitats include lateritic gravel, sandy, or granitic soils, always well-drained (Elliot and Jones 1984). Once established, they are said to be more drought tolerant than *Banksia* species (Elliot and Jones, 1984). Many species are fairly cold tolerant, tolerating light frosts or short-lived snowfalls. Cultural conditions for success include full sun, good drainage, and good air circulation. As with other Proteaceae, low fertility is adequate and high phosphorus levels are to be avoided. Chlorosis is a problem on some soils and may be countered with weak iron chelate drenches. A few species are recommended as container plants: *D. ferruginea*, *D. polycephala*, and *D. speciosa* (Elliot and Jones 1984).

TELOPEA

Five species of *Telopea* have been described, and a number of hybrids have been released (Dennis 1991; Nixon and Payne 1996; Wrigley and Fagg 1996). They are native to acid, infertile, well-drained soils in New South Wales, Victoria, and Tasmania. As small trees or managed shrubs, they have both landscape value and commercial cutflower use. All species produce terminal, brilliant to rose red (occasional pink, white or yellow) inflorescences up to 15 cm in diameter on stems of up to 1 m length. The florets are arranged spirally on elongated cones subtended by an involucre of similarly colored bracts. *Telopea speciosissima* and *T. oreades* are the principal species for commercial flower production. Unlike other proteas, there is little by-pass by lower shoots. Plants tend to be upright and vigorous.

The most important species, *T. speciosissima* is known as the waratah and is the floral emblem of New South Wales, Australia. Although blooms were originally wild-collected, commercial production has increased in Australia as well as in New Zealand, US (Hawaii), Israel, and South Africa (Offord 1996). Australian production has been reported at 20,000 to 50,000 stems/ha five years after establishment in high density plantings (Worrall 1994), with annual production estimated at 0.6 to 1.7 million stems (Worrall, cited in Offord 1996). The plants are long-lived and capable of production for many years with good management.

While telopeas occur in woodland situations, they flower best in full sun or light shade. Flowering occurs in spring to early summer, but the bloom period is only 4 to 5 weeks duration. Choice of location can influence flowering time as can selection of hybrids (Matthews 1993; Offord 1996). Floral display life is about 7 to 13 days (Dennis 1991) and browning of the bracts can be a problem. The inflorescence is usually harvested before all florets have matured, and is discarded when one-third have turned blue-red (Faragher 1986). Vase life could be extended 3 to 5 days by harvesting when only the first cycle of flowers has matured, by the use of 5% sucrose and a germicidal compound in the water, and by refrigerating the cut flowers at 2°C after hydration (Lill and Dennis 1986). Ethylene does not appear to be a critical factor in senescence (Faragher 1986). Selection for lack of bract browning and low nectar production is a consideration in developing commercial types (Salinger 1981).

Telopea are readily propagated from fresh seed with germination occurring in 2.5–4 weeks at 25°C (Worrall 1994; Wrigley and Fagg 1996). Seed can be stored at room temperature for 6 months and for at least 2 years at 5°C (Worrall 1994; Offord 1996).

Semi-hardwood terminal cuttings (20 cm length with 5–6 leaves) of *T. speciosissima*, treated with 2000 to 4000 ppm IBA as a quick basal dip rooted with success rates of 50 to 75% after 8 weeks (Worrall 1976). A talc dust of 0.3% IBA is also satisfactory. Bottom heat of 24°C enhances rooting as does intermittent mist (Worrall 1994). Response varied with season, and cuttings from actively growing mother plants responded better to the low levels of IBA than to cuttings taken in winter from dormant plants. Leaf bud cuttings have been used to increase selected plants when propagative material is limited (Ellyard and Butler 1985). Tissue culture has been successful as well (Seelye et al. 1986; Offord and Campbell 1992; Offord et al. 1992).

Telopea culture requires well-drained soils, full sun, and freedom from frost. While their native soils are deep sands, they also thrive on well-drained basaltic clays (Offord 1996). Water requirements are high during summer flower bud initiation. Established plants tolerate a temperature range from 3° to 24°C. Plants are spaced at 1.5 to 3 m in rows with 3 m between rows (Dennis 1991). Pruning at or soon after harvest is practiced to encourage new stems of suitable length for cutflowers in the next season. Rejuvenation pruning is practiced periodically to reduce plant height and encourage production of longer stems (Worral 1994). Pot culture is also possible, but the lignotuber produced by the plants requires a fairly large container (Offord 1996). Potting media need to be well-drained with a pH of 5.5 and low phosphorus content.

SERRURIA

Like many other South African proteas, the genus *Serruria* (50 species) occur in well-drained nutrient-poor soils of the winter-rainfall area (1000 mm) of the Cape Floral Kingdom of South Africa. Their distribution is limited to small, specific localities within this region (Rebelo 1995), and many are endangered because of loss of habitat (Worth and van Wilgen 1988).

The serrurias are small shrubs (prostrate habit to 2 m tall) with fine, feathery foliage and prominent, white to pink bracts subtending the individual flowers borne multiply on one to 11 capitula. Commonly called spiderheads in their native South Africa, serruria inflorescences may be solitary or consist of clusters of small flowerheads. The principal species in commercial culture are *S. florida* (Blushing Bride) and *S. rosea* and their hybrids.

The cutflower serrurias tend to be upright growers. The globose flowerheads range from 3 to 5.5 cm in diameter but appear larger because of the bracts. Flowering occurs in the late winter to early spring, and is known to be stimulated by the long days of the preceding summer and fall (Malan and Brits 1990). Initiation and early development required about 6 weeks and another 10 weeks was required to reach anthesis. Little work has been reported on improving vase life, which is about 7 to 10 days following cutting. The flowers also dry well (Matthews and Carter 1993).

Serruria potted plants have good floral display qualities and can be produced in less than one year (Malan and Brits 1990). Cuttings should be taken during the high light, long days of early spring and summer as induced cuttings taken in the fall had low rooting percentages (Ackerman et al. 1995). The flowering period ranges from 30 to 55 days under outdoor conditions. Short durations of darkness as in shipping are not damaging to the post-harvest life of potted plants. Growth retardants such as paclobutrazol inhibit shoot elongation, while ethephon increases branching and branch angle (Brits 1995).

Propagation of serrurias to establish desirable clones is by mainly by cuttings. Ten weeks is required for acceptable rooting, but up to 20 weeks may be required if cuttings are taken during late fall or winter. Cutting bases are dipped for 10 seconds into a potassium salt formulation of IBA at the rate of 4000 mg/L (Ackerman et al. 1995). Techniques to establish and proliferate *Serruria* in vitro have been reported, but the rooting of plantlets from such cultures was not described (Ben-Jaacov and Jacobs 1995). Seed is reportedly long-lived and germinates in response to soil temperature fluctuations following clearing of the understory by fire (Brits 1986a; Worth and Wilgen 1988), but soaking in 1% hydrogen peroxide has been shown to stimulate germination in the laboratory (Brits 1986b).

MIMETES

Known as the Pagoda flowers in their native South Africa, *Mimetes* species bear large terminal flowerheads containing smaller headlets (capitula) bearing few to many flowers. Leaves and bracts subtending these headlets are often brightly colored and may curl around to clasp the flowers. Some species in the Silver Pagoda group bear silvery hairs, making them attractive for this character rather than for colored bracts.

Most of the 13 species of *Mimetes* are rare and found in isolated habitats of the south and southwestern Cape (Rourke 1984), frequently at high elevations in low to moderate rainfall areas. Most are found on sandstone-derived soils, but a few are found in moist peaty soils along marshes and swamps (Rebelo 1995). Coastal species such as *M. cucullatus* also withstand salt winds. Repeated burning maintains the shrub in a rounded form with numerous upright unbranched stems arising from a woody, persistent lignotuber (Rourke 1984). Flowering is most profuse on the vigorous young growth, suggesting that commercial flower production will be dependent upon efficient pruning.

Mimetes cucullatus is one of the more widely distributed species. It flowers year around but most heavily during the fall and winter months and offers potential as a cutflower as it produces 30 cm stems tipped with scarlet red and yellow bracts. It is said to have good vase life as a cutflower (Matthews and Carter 1993). It is a long-lived shrub once established and tolerates heavy pruning. Other *Mimetes* species with attractive flowerheads are reportedly short-lived although the seed remains viable for many years, ready to germinate when the natural habitat is cleared by fire (Rebelo 1995).

Cultivation of *Mimetes* requires well-drained, acid soils with some organic matter. Studies of plant management are still needed. Propagation is by seed or semi-hardwood cuttings taken in the fall (Matthews and Carter 1993).

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Yellow Wild-Indigo

Baptisia tinctoria (L.) R. Br.

Other common names.—Baptisia, indigo weed, yellow indigo, American indigo, yellow broom, indigo broom, clover broom, horsefly weed, shoofly, rattlebush.

Habitat and range.—This native herb grows on dry, poor land and is found from Maine to Minnesota and south to Florida and Louisiana.

Description.—Yellow wild-indigo is an erect, much-branched, very leafy plant about 2 to 3 feet in height with cloverlike leaves. The flowers are bright yellow, one-half inch in length, and are produced in numerous clusters from June to September. The root, which is round and fleshy, sending out branches and rootless almost 2 feet in length, has a white interior and a thick, dark-brown bark. The bark root has a bitter, nauseous taste.

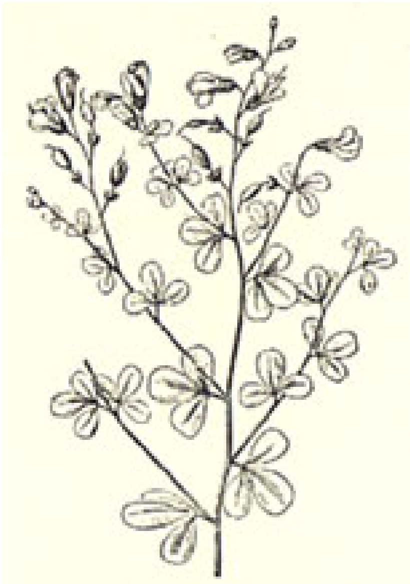

Figure 127.—Yellow wild-indigo (*Baptisia tinctoria*)

Other species.—A related species, said to possess similar properties, is *Baptisia alba* R. Br., called the white wild-indigo. This plant has white flowers and is found in the Southern States and on the western Plains.

Part used.—The herb and the root, the latter collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Bar or Bargad *Ficus benghalensis* L.

Pankaj Oudhia
Society for Parthenium Management (SOPAM)
28-A, Geeta Nagar, Raipur - 492001 India
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Scientific name: *Ficus benghalensis* L.
Synonyms: *Ficus indica* L
Family: Moraceae.
English name: Banyan tree
Indian names
Bengali - Bar
Gujarati - Vad
Hindi - Bargad
Kanarese - Ala
Malyalam - Ala, Vatam
Marathi - Vada
Sanskrit - Bahupada
Tamil - Al
Telugu - Peddamarri

Habitat: Monsoon and rain forests. Often planted throughout the forest tract of India. Hardy, drought resistance and withstands mild frost.

Botanical Description: Very large, fast growing, evergreen tree up to 3.0 meters, with spreading branches and many aerial roots. Leaves stalked, ovate-cordate, 3-nerved, entire, when young downy on both sides; petiole with a broad smooth greasy gland at the apex, compressed, downy; Fruit in axillary pairs, the size of a cherry, round and downy.

Propagation: Through seed, transplanting and stem-cutting.

Useful Parts: Bark, root-fibers, leaves, seeds, milky juice (i.e. latex).

Medicinal Uses and Properties: According to Ayurveda, it is astringent to bowels; useful in treatment of biliousness, ulcers, erysipelas, vomiting, vaginal complains, fever, inflammations, leprosy. According to Unani system of medicine, its latex is aphrodisiac, tonic, vulernary, maturant, lessens inflammations; useful in piles, nose-diseases, gonorrhea etc. The aerial root is styptic, useful in syphilis, biliousness, dysentery, inflammation of liver etc.

Other Uses
It is planted for soil conservation
Timber is used for well-curbs, furniture etc.
Suitable for paper pulp.
Leaf (Crude protein 9.63%) lopped for fodder
Fruits are used to prepare Shurbut traditionally.

Other Links
Doomar or Gular (Ficus glomerata) as medicinal herb in Chhattisgarh, India
http://botanical.com/site/column_poudhia/127_doomar.html

Interactions with the traditional healers of Chhattisgarh Plains, India specialized in use of Bar (*Ficus benghalensis*, family: Moraceae) as medicinal herb
http://botanical.com/site/column_poudhia/141_bar.html

Interactions with the traditional healers of Chhattisgarh Plains, India, specialized in use of Pipal (*Ficus religiosa*) as medicine
http://botanical.com/site/column_poudhia/142_pipal.html

Resource Person:
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Table 1. Major species of *Ficus* in India.

Species	Synonyms	Common names
Ficus auriculata	*F. roxburghii; F. macrophylla*	English - Eve's Apron Hindi - Timla, Tirmal
Ficus benghalensis	*F. indica*	English - Banyan Hindi - Barh, Bargad
Ficus benjamina var. comosa	*F. comosa*	
Ficus carica		English - Fig Hindi - Anjeer
Ficus glomerata	*F. goolereea; Covellia glomerata*	English - Cluster fig Hindi ö Gular Chhattisgarh - Doomar
Ficus hispida		Hindi - Kathumbar, Konea - dumbar.
Ficus krishnae		English - Krishna's Fig, Krishna's butter cup Hindi - Makhan Katori
Ficus lucescens	*F. lacor; F. infectoria*	Hindi-Pilkhan, Plaksha.

Ficus microcarpa	*F. retusa; F. benjamina*	Hindi - Chilkan
Ficus palmata	*F. virgata; F. caricoides*	Hindi - Anjiri, Khat Guleri
Ficus religiosa	*Urostigma religiosum*	English-Bo-tree Hindi - Pipal, Asvattha
Ficus rumphii	*F. cordifolia; Urostigma cordifolium*	Hindi - Gagjaira, Pakar
Ficus semicordata	*F. cunia*	Hindi - Khewanua
Ficus tsjakela	*F. venosa*	Hindi - Pilkhan
Ficus virens var. *sublannceolata*	*F. Saxophila* var. *sublanceolata*	
Ficus virens	*F. infectoria* var. *lambertiana*	Hindi - Pilkhan
Ficus altissima		

Table 2. Major differences in three major species of *Ficus*

	Ficus benghalensis	*Ficus religiosa*	*Ficus carica*
Common Indian names			
Gujrati	Vad, Vadlo	Jari, Pipers, Pipal	Anjir
Hindi	Bar, Bargad, Bargat	Pipal, Pipali	Anjir
Kanarese	Ala, Alada, Goli, Vata, Nyagrodha	Arani, Ashwatha mara, Pippala, Ragi	Anjura, Simeyam
Marathi	Vad	Pimpal	Anjir
Sanskrit	Avaroha, Bahupada, Bhringi, Jatalo, Vat	Ashvatha, Bodhidruma, Pippala, Shuchidruma, Vrikshraj, yajnika	Kakodomar, Anjir
Botanical Differences			
General Plant	Large evergreen tree with spreading branches, sending down to the ground many aerial roots, which afterwords develop into separate trunks.	A medium sized, glabrous tree	A small tree or large bush. Branches round, green or resset, covered with a coarse shortdown
Leaves	Coriaceous, 10-20x5-12.5 cm, ovate to elliptic, cordate or rounded base, shining above.	10-15x10-12 cm, ovate-round, entire, coriaceous, shining, apex long tailed.	Rough on the upper side coarsely downy beneath, cordate, 3-5 lobed or almost entire, coarsely sirrated

Fruit	Globose, with male, female and gall flowers.	Receptacles sessile, paired, smooth, depressed, globose, dark purple when ripe.	Solitary, axillary, more or less pear shaped or almost round, sweet, succulent and pleasant to the taste.
Medicinal Uses and Properties			
Ayurveda	Astringent to bowels; useful in treatment of biliousness, ulcers, erysipelas, vomiting, vaginal complaints, fever, inflammations, leprosy etc.	All parts cooling and useful in diseases of blood, vagina, uterus, leucorrhoea, burning sensation, biliousness, ulcers Ripe fruits are alexipharmic, good for foul taste, thirst, heart disease, Root good for sout whereas rooot bark good in stomatitis.	Fruit cooling, useful in diseases of head and blood, leprosy, nose bleed etc.
Unani	Its milky juice is aphrodisiac, tonic, vulnerary, maturant, lessens inflammations, useful in piles, nose-diseases, gonorrhoea.	Root bark aphrodisiac, good for lumbago; bark useful in inflammations and glandular swellings of neck; Fruits purgative, aphrodisiac, checks vomiting.	Roos tonic and useful in leucoderma, ringworm; Fruit antipyretic, purgative, alexiteric, aphrodisiac, lithotriptic, useful in inflammation, weakness, paralysis, thirst, liver and spleen diseases, pain in chest etc. Milky juice expectorant, iuretic, etc.

Cynodon dactylon (L.) Pers.

Poaceae

Bermudagrass, Common stargrass, Baramagrass, Dhubgrass, Devilgrass

We have information from several sources:

African Grasses—Glenn W. Burton

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Doob (*Cynodon dactylon*): Traditional Medicinal Uses in India—Pankaj Oudhia

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Morton, J. 1987. Barbados Gooseberry. p. 349–351. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Barbados Gooseberry

Pereskia aculeata Mill.

Pereskia pereskia Karst.

Cactus pereskia L.

A climbing, leafy cactus, the Barbados gooseberry, *Pereskia aculeata* Mill., (syn. *P. pereskia* Karst.; *Cactus pereskia* L.), has various English names: West Indian gooseberry, Spanish gooseberry, lemon vine, sweet Mary, leaf cactus, blade apple, and gooseberry shrub–the latter in Barbados. It is known as *grosellero* or *ramo de novia* in Cuba; *buganvilla blanca* in Chiapas, Mexico; *guamacho* in Venezuela; *ora-pro-nobis* (pray for us) in Brazil; *bladappel* in Surinam. The generic name is sometimes spelled *Peireskia*, especially in Europe, for it was adopted in honor of Nicholas Peiresk, a senator of Aix in Provence, France, and a patron of botany.

Description

The plant is an erect woody shrub when young, becoming, with age, scrambling or climbing and vinelike, with branches up to 33 ft (10 m) long that may shroud a large tree. Spines on the trunk are long, slender, in groups; those on the branches are short, recurved, usually in pairs, rarely solitary or in 3's, in the leaf axils. The deciduous, alternate, short-petioled, waxy leaves are elliptic, oblong or ovate, with a short point at the apex; 1 1/4 to 4 in (3.2-10 cm) long, sometimes fleshy. To some people, the flowers are lemon-scented; others say sweet and pungent in odor; still others, of unpleasant or repulsive odor. They are borne profusely in panicles or corymbs; are white, yellowish or pink-tinted; 1 to 1 3/4 in (2.5-4.5 cm) across and the calyx tube is prickly. The fruit is round, oval or pyriform, lemon- or orange-yellow or reddish; 3/8 to 3/4 in (1-2 cm) wide, with thin, smooth, somewhat leathery skin. It is beset with the curling, leafy sepals of the calyx and often a few spines, until fully ripe, when it is juicy and subacid to tart. There are only a few flat, thin, brown or black, soft seeds about 1/6 in (4 mm) long.

Fig. 97: A leafy, spiny, climbing shrub, the Barbados gooseberry *(Pereskia aculeata)* is an atypical cactus.

Origin and Distribution

The Barbados gooseberry is believed to be indigenous to the West Indies, coastal northern South America and Panama. It is seldom found truly wild but is frequently grown as an ornamental or occasionally for its fruits in the American tropics, Bermuda, California, Hawaii, Israel, the Philippines, India and Australia. In many areas it has escaped from cultivation and become thoroughly naturalized. It was growing at the Agricultural Research and Education Center in Homestead in the early 1940's and running wild to some extent in the Redlands, but has since disappeared, possibly destroyed by winter cold or excessive rainfall. At least one nursery in Winter Haven, Florida, is now growing the plant in quantity. Gardeners had to give up the plant in South Africa in 1979 when it was banned as an illegal weed because it had been invading and overwhelming natural vegetation. It is frequently grown in greenhouses and as a house plant in temperate regions of both hemispheres. Horticulturists often use this species as a rootstock on which to graft other less vigorous cacti.

Fig. 98: The pecular yellow or reddish fruits of the Barbados gooseberry bear recurved, leafy sepals until fully ripe.

Varieties

There are 2 cultivars in the ornamental-plant trade:

'Godseffiana'–bushy, with broad leaves basically yellow-green variegated with scarlet and copper on the upper surface, purplish or rosy-red on the underside.

'Rubescens'–the leaves variegated with red.

Climate

The Barbados gooseberry is tropical and suited only to low elevations. In greenhouses, the favorable temperature range is from 68º F (20º C) at night to 99º F (37.22º C) in daytime. Chilling causes the leaves to fall.

Propagation

The plant is easily grown from seeds or cuttings of half-ripe wood.

Culture

Flourishing with little or no care, the plant is drought-tolerant and suffers from over-watering. In greenhouse experiments, it has been found highly responsive to light. Under high light intensity, it can be kept erect and compact; under low light, it grows higher, with ascending stems and the leaves are larger and thinner.

Season

In Jamaica, the plant blooms in June and again in October and November; fruits mature in March and October.

Food Uses

The fruits are generally stewed or preserved with sugar, or made into jam. Young shoots and leaves are cooked and eaten as greens. In rural Brazil, they are important as food for humans and livestock.

Food Value Per 100 g of Edible Portion

	Fruit	*Leaves*
Moisture	91.4 g	
Protein	1.0 g	
Fat	0.7 g	6.8-11.7 g
Carbohydrates	6.3 g	
Fiber	0.7 g	9.1-9.6 g
Ash	0.6 g	20.1-21.7 g
Calcium	174 mg	2.8-3.4 mg
Phosphorus	26 mg	1.8-2.0 mg
Iron	Trace	
Vitamin A	3,215 I.U.	
Thiamine	0.03 mg	
Riboflavin	0.03 mg	
Niacin	0.9 mg	
Ascorbic Acid	2 mg	
Magnesium		1.2-1.5 mg
Amino acid per 100 g Protein:		

Arginine	5.00-5.36 g
Histidine	2.49-2.54 g
Isoleucine	3.78-4.23 g
Leucine	6.99-8.03 g
Lysine	5.32-5.43 g
Methionine	1.72-2.03 g
Phenylanine	5.06-5.08 g
Threonine	3.09-3.60 g
Valine	4.78-5.52 g

Studies of the leaves in Brazil show a protein content of 17.4-25.5% and a mean digestibility of 85.0%.

Protein, lysine, calcium, phosphorus and magnesium levels are higher than in cabbage, lettuce and spinach.

Other Uses

In Israel, the flowers are said to be of great value in apiculture.

Medicinal Uses: In Brazil, the leaves are valued for their emollient nature and are applied on inflammations and tumors.

Cress, Upland

Winter cress, Scurvy grass, Belle Isle cress, Spring cress, Yellow rocket, Toi

Cruciferae *Barbarea vulgaris* R. Br., *B. verna* (Mill.) Aschers.

Source: Magness et al. 1971

These cresses, related to water cress and horse-radish, are cultivated sparingly for winter salads and pot herbs. Plants are naturalized in many parts of the U.S. Plants are hardy biennials. Leaves are generally entire but notched, and smooth. As grown under cultivation, leaf exposure and general culture are similar to those of spinach and turnips for greens. Portion of the plant consumed is the leaves.

Last update February 18, 1999 by ch

Hordeum vulgare L.

Poaceae

Barley, barleycorn, barley flakes, barley grits, malt, naked barley, pearl barley, pot barley, Scotch barley, six-row barley, two-row barley

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States. Interregional Research Project IR-4, IR Bul. 1 (Bul. 828 New Jersey Agr. Expt. Sta.)

New Crops: Solutions for Global Problems—Noel Vietmeyer

Barley and malting barley in New Crops for Canadian Agriculture—Ernest Small

Outside links

Barley from Lost Crops of Africa: Volume I: Grains

Echinochloa crusgalli (L.) Beauv.

Poaceae

Barnyardgrass

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update August 23, 1996 by aw

Basella rubra L.

Basellaceae

Ceylon spinach, Indian spinach, Malabar Spinach, Red vine spinach, Vine spinach

We have information from several sources: Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Food and feed crops of the United States Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Ocimum basilicum L.

Lamiaceae

Basil, basilic common, *basilico*, bush basil, sweet basil, wild basil

We have information from several sources:

FactSheet contributed by James Simon

Herbs: An Indexed Bibliography. 1971-1980—J.E. Simon, A.F. Chadwick and L.E. Craker

Midwest Vegetable Production Guide for Commercial Growers 1998

Antioxidant Activity of Basil—H.R. Juliani and J.E. Simon

Basil Seed Oils—Paul Angers, Mario R. Morales, and James E. Simon

Basil: A Source of Essential Oils—James E. Simon, James Quinn, and Renee G. Murray

Essential Oils and Culinary Herbs—James E. Simon

New Aromatic Lemon Basil Germplasm—Mario R. Morales, Denys J. Charles, and James E. Simon

New Basil Selections with Compact Inflorescences for the Ornamental Market—Mario R. Morales and James E. Simon

Basil: A Source of Aroma Compounds and a Popular Culinary and Ornamental Herb—James E. Simon, Mario R. Morales, Winthrop B. Phippen, Roberto Fontes Vieira, and Zhigang Hao

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Basil: Promising New Essential Oil Crop—James E. Simon

New Ornamental Basils

New Basils

Savory Herbs: Culture and Use. Lowman, M.S. and M. Birdseye. 1946.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Sweet Basil: A Production Guide—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

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Outside links to other *Ocimum* information:

Images of glandular trichomes of basil - essential oil glands

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Basin wild-rye

Gramineae *Elymus cinereus* Scribn. and Merr.

Source: Magness et al. 1971

This is a cool season, slightly spreading grass found throughout the Western States--particularly on alkaline soils. It is a tall, coarse grower, sometimes reaching to 10 feet. It is relatively low in palatability and is not planted commercially but affords emergency summer or winter pasturage where present.

Last update February 18, 1999 by ch

Bayberry

Myrica cerifera L.; *M. carolinensis* Mill.

Other common names.—(1) Southern waxmyrtle, waxberry, tallow berry, candleberry, tallow shrub, candleberry myrtle; (2) northern bayberry, small waxberry.

Figure 13.—Northern bayberry (*Myrica carolinensis*)

Habitat and range.—The bayberry is native in sandy swamps or wet woods from New Brunswick south to Florida. *Myrica cerifera* is found as far west as Texas and Arkansas while M. carolinensis is common in bogs in northern New Jersey and Pennsylvania.

Description.—The southern waxmyrtle is a shrub or slender tree up to 40 feet high. The leaves are from 1 to 4 inches long, narrow, wedge-shaped, entire or with a few teeth, and have a fragrant odor when crushed. The flowers appear from March to May, according to locality, generally before the leaves are fully expanded. Male and female flowers are borne on separate trees, the male flowers in cylindrical yellow clusters and the female flowers in green somewhat shorter clusters. The fruit, which remains on the tree for several years, consists of clusters of round, 1-seeded, somewhat berrylike nuts covered with a whitish wax. Northern bayberry is a shrub 8 feet high or less, with broader and blunter leaves.

Part used.—The bark of the root, collected in late autumn. After thorough cleansing and while still fresh the bark is loosened and removed by heating the root. The wax obtained from the berries, used for making bayberry candles, is also an article of commerce.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 16, 1998 by aw

Monarda sp.

Lamiaceae (Labiatae)

Bergamot, American horsemint, bee balm, bergamot herb, gergamot orange, horsemint, mellarosa, wild bergamot

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Monarda: A Source of Geraniol, Thymol, Linalool, and Carvacrol-rich Essential Oils—G. Mazza, F.A. Kiehn, and H.H. Marshall

Bean

Leguminosae *Phaseolus* sp., *Vigna* sp., *Vicia* sp., *Dolichos* sp., *Glycine* sp.

Source: Magness et al. 1971

Beans of several genera and species, and numerous varieties, are important food crops and are of some importance as feed crops in many countries. All are annuals, grown from seeds. The fruits are pods in which the seeds are contained. In green or snap beans, also termed 'string', pods are harvested before ripening, and both pods and the immature seeds are consumed, mainly as pot vegetables. In some kinds, the seeds when near full grown, but while still immature, are threshed from the pods and frozen or canned. In dry or field beans pods and seeds are allowed to ripen, then threshed and seeds only are consumed. Plants may be "bush," non-climbing and reaching a height of 15 to 30 inches; or "vine" or "pole," vining types reaching 10 or more feet in length.

Last update February 18, 1999 by ch

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Bean, Broad, Favabean or Fava

Fava bean,Faba bean, Horse bean, English bean, Windsor bean, Haba, Tick bean, Cold bean, Silkworm bean

Leguminosae *Vicia faba* L.

Source: Magness et al. 1971

This type of bean is very important as a cool-season crop in Mediterranean areas and in cool regions of Europe, but is grown to only a limited extent in the U.S. Plants are erect annuals reaching 2 to 4 feet and very leafy. Pods are large and thick, 2 inches up to a foot or more in length. Seeds are large and flat. They are used as green-shell, the seeds removed from the pod before maturity, or as dry beans. They are also used as feed for livestock.

Season, planting to harvest: 4 to 5 months. Pod set to harvest, 30 to 60 days.

Production in U.S.: No data; very limited.

Use: Cooked vegetables and stock feed.

Part of plant consumed: Seeds for food; immature pods as snap-beans and whole plant for feed.

Last update February 18, 1999 by ch

Phaseolus vulgaris L.

Fabaceae

Bean, Common bean, Caraota, Feijao, French bean, Kidney bean, Haricot bean, Field bean, Poroto, Snap bean, String bean, Frijol, Wax bean

We have information from several sources:

Dry Edible Beans: A New Crops Opportunity for the East North Central Region—Glenn H. Sullivan and Lonni R. Davenport

New Crops for Canadian Agriculture—Ernest Small

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Midwest Vegetable Production Guide for Commercial Growers 2000

Fieldbean—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Dry Edible Beans—Alternative Crop Guide

Growing Beans In The Home Vegetable Garden—HO-175 Purdue University Cooperative Extension Service

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)
Phaseolus spp.
Field Bean

Food and feed crops of the United States. Magness, J.R., G.M. Markle, C.C. Compton. 1971.
Common dry bean
Common bean

Outside links

Phaseolus Beans—production links

Nuñas (Popping beans) can be found in Lost Crops of the Incas from National Academy Press

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Psophocarpus tetragonolobus (L.) D.C.

Leguminosae

Winged bean, asparagus bean, asparagus pea, four-angled bean, Goa bean, long bean, long-podded cowpea, Manila bean, princess pea, snake bean, vegetable cowpea, winged pea

We have information from several sources:

The Winged Bean: A Potential Protein Crop (Abstract)—S. Venketeswaran, M.A.D.L. Dias, and Ursula V Weyers

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

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Dolichos lablab L.

Leguminoseae

Hyacinth bean, Lablab

We have information from several sources:

Hyacinth Bean: Stems for the Cut Flower Market—Robert G. Anderson, Sharon Bale, and Wenwei Jia

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update October 17, 1997 by aw

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Bean, Jack

Chickasaw lima bean, Brazilian broad bean, Coffee bean, Ensiform bean, Horse bean, Mole bean, Go-Ta-Ki, Overlook bean, Pearson bean, Watanka

Leguminosae *Canavalia ensiformis* (L.) DC.

Source: Magness et al. 1971

This bean is grown in Southern U.S. mainly for stock feed, but young pods can be used as snap beans. The plant is vining. Pods reach 10 to 14 inches in length, but are harvested at half that size for eating. Seeds are large, 1/2 to 3/4 inch long, and nearly as broad, and are sometimes used as coffee substitute. jack beans are not grown as a commercial food crop in this country.

Last update February 18, 1999 by ch

Phaseolus lunatus L.

Fabaceae

Lima bean, Butter, Haba, Burma bean, Guffin bean, Hibbert bean, Java bean, Sieva bean, Rangood bean, Madagascar bean, Paiga, Paigya, Prolificbean, Civet bean, Sugar bean

We have information from several sources:

Dry Edible Beans: A New Crops Opportunity for the East North Central Region—Glenn H. Sullivan and Lonni R. Davenport

Midwest Vegetable Production Guide for Commercial Growers 2000

Phaseolus Beans—production links

Growing Beans In The Home Vegetable Garden—HO-175 Purdue University Cooperative Extension Service

Food and feed crops of the United States.—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Neglected Crops—1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 47-62.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Bean, Moth

Mat, Dew gram

Leguminosae *Phaseolus aconitifolius* Jacq.

Source: Magness et al. 1971

This bean is, a trailing plant, with stems up to 2 feet, covered with stiff hairs. Pods are small, about 2 inches long, nearly round and glabrous. Seeds are small. Moth bean is cultivated for food in South Asia and for forage, but is rarely grown in the U.S. Seeds are used as dry beans.

Last update February 18, 1999 by ch

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Vigna radiata (L.) R. Wilcz.

syn: *Phaseolus aureus* Roxb.

Leguminosae

Mung bean, Black dhal, Black gram, Black mung, Golden gram, Gram bean, Green gram, Red mung bean, Urd

We have information from several sources:

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Mungbean—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Chickpea, Faba Bean, Lupin, Mungbean, and Pigeonpea: Potential New Crops for the Mid-Atlantic Region of the United States—Harbans L. Bhardwaj, Muddappa Rangappa, and Anwar A. Hamama

New Opportunities in Vigna—Richard L. Fery

Food and feed crops of the United States.—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Bean

Common, Kidney, Pea, Navy, Habichuela as dry or field beans.

Leguminosae *Phaseolus vulgaris* L. Tepary bean. P. *acutifolius* A. Gray.

Source: Magness et al. 1971

These are beans that ripen prior to harvest and are threshed dry from the pods. Only the ripe seeds are marketed. Four main types are grown as follows: (1) Medium type includes Pinto, Great Northern, Sutter, Pink Bayo, and Small Red or Mexican Red; (2) Pea or Navy; (3) Kidney; and (4) Marrow. Seeds vary in size from about 1/3 inch long in the pea or navy bean to 3/4 inch in the Kidney. All plants are of bush type. They are usually cut or pulled when most pods are ripe, then vines and pods are allowed to dry before threshing.

The Tepary bean *P. acutifolius*, is native to southwestern U.S. and Mexico and long grown by the Indians there. It is highly heat and drought resistant, but eating quality is less desirable than *P. vulgaris*. Culture is similar to that of other dry or field beans.

Season, bloom to harvest: 3 to 3.5 months.

Production in the U. S.: 900,000 tons.

Use: Commercially canned, soup, cooked in homes.

Part of plant consumed: Seed only.

Last update February 18, 1999 by ch

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Phaseolus coccineus L.

Fabaceae

Scarlet runner bean

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Neglected Crops : 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 47-62.

Last update Wednesday, April 29, 1998 by aw

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Bean, Urd

Urud bean, Black gram

Leguminosae *Phaseolus mungo* L.

Source: Magness et al. 1971

This bean is similar to Mung bean except plants are more prostrate, pods are long and hairy, and seeds are oblong and black. Use is similar to that of Mung bean.

Last update February 18, 1999 by ch

Mucuna deeringiana (Bort.) Merr.

Leguminosae

Velvet bean

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

New Crops: Solutions for Global Problems—Noel Vietmeyer

last update October 23, 1997

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Beech nuts

Fagaceae: *Fagus* sp.

American beech: *F. grandifolia* Ehrh

European beech: *F. sylvatica* L.

Source: Magness et al. 1971

The seeds of these beech species are sometimes gathered from native trees, or from trees planted for other purposes, and used as food. The seeds are formed in prickly burrs, about 0.75 to 1 inch in diameter, which remain closed until ripe, then partially open. The angular seeds or nuts are up to 0.75 inch long. The seed coat must be removed from the kernel before eating. In general, beech nuts are similar to small chestnuts. The trees are not cultivated for the purpose of nut production.

Last update February 18, 1999 by ch

Perilla frutescens (L.) Britton

Lamiaceae or Labiatae

Perilla, Shiso, Beefsteak plant

NewCROP has perilla information from:

Perilla FactSHEET contributed by David Brenner

Perilla: Botany, Uses and Genetic Resources. Brenner, D.M. 1993. p. 322-328. In: J. Janick and J.E. Simon (eds.), New Crops. Wiley, New York.

And outside links to Perilla information:

Perilla - an Asian Culinary Herb . By John Burgmans and John Scheffer at the Ruakura Agricultural Research Centre, New Zealand

Last update September 26, 1997

Beta vulgaris L.

Chenopodiaceae

Beetroot, chad, chard, European sugar beet, garden beet, Harvard beet, mangel, mangelwurzel, red beet, red-beet leaf, red garden beet, spinach beet, sugar beet, Swiss chard, white-rooted beet, wild beet, yellow beet

We have information from several sources:

Potential of Sugar Beet Nematode-Resistant Radishes and Mustard for Use in Sugar Beet Rotations—James M. Krall, David W. Koch, Fred A. Gray, and Li Mei Yun

Midwest Vegetable Production Guide for Commercial Growers 2000

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Sugarbeets: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Beet and Swiss Chard (with Spinach) production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Chard
- Garden beet

Ewart, L.C. 1993. New bedding plants. p. 604-608. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

New Bedding Plants

Lowell C. Ewart

New floricultural crops have been defined by Roh and Lawson (1990) as "a newly discovered genera or species; newly introduced cultivars of plants grown in earlier years, but forgotten or without complete cultural information; plants that are cultivated in foreign countries but have not been introduced in the United States; or crops that can be produced with new production technologies that can enhance crop quality and shorten the total production time." If this classification is followed, new bedding plants fit the definition of new crops very well.

There has been a renewed interest to bring new bedding crops to market in the last five years. The trend is to introduce new perennial, bulb, and wildflower plants in addition to annuals for the bedding plant and landscape industries. This trend will likely continue well into the next century, especially with bedding plants and garden plants leading all other floriculture crops with a wholesale value of $971 million in 1990 (Agr. Stat. Board 1991). This represents an 8% gain over 1989, and reflects a yearly increase that has remained unbroken for over 10 years.

NEW CROPS FOR CONSIDERATION

The following taxa selections are either under evaluation or have recently been released for bedding plant sales. Additional new bedding plants are listed in Table 1.

Begonia

Begonia MSB-1 is a hybrid derived from inbreds developed from crossing *Begonia* x *semperflorens-cultorum* Hort. with *Begonia schmidtiana* Regel. The purpose was to develop material suitable for hanging basket production from seed rather than from cuttings. The plants grow fast, have a nice spreading, branched habit, and the flower color is a bright red. Evaluations have been excellent.

Canna

Canna x 'Tropical Rose' is an All-America Selections Flower Award Winner for 1992, the first canna ever to receive this award. 'Tropical Rose' is an improved dwarf canna that can be sold as young potted plants from seed sown 6 to 8 weeks prior to selling and which reaches heights of 76 cm (Sutherland 1991). Usually, cannas are grown from rhizomes rather than from seed. The soft rose-colored blooms appear the first of July and continue the rest of the summer in the Midwest.

Catharanthus

Catharanthus roseus (L.) G. Don still commonly known as vinca, has had several new additions due, in great part, to the work of R.D. Parker of the University of Connecticut. The cultivars 'Parasol' and 'Pretty In Rose' are both 1991 All-America Selections Bedding Plant Award Winners, and 'Pretty in White' is a 1992 All-American Selections Award Winner in this category.

'Parasol' improves on the cultivar 'Little Bright Eye' for flower size and flower quality. The large 4 to 5 cm blooms are pure white with a red center. The blooms have overlapping petals creating a full round flower. 'Parasol' exhibits heat and drought tolerance, and is an excellent landscape subject.

'Pretty in Rose' is a new deep rose, almost purple, color now available for the first time in vinca; whereas, 'Pretty in White' is a beautiful white with a small cream-colored eye. Both of these cultivars bloom all summer long and perform best in full sun. In combination with other annuals, they are perfectly suited to hanging baskets, planters, or patio urns.

These cultivars were derived from species and escaped 'wild' accessions (R.D. Parker pers. commun.). The collection, which began in 1978, contains material principally from Madagascar and Mauritius, but also contains material collected in Brazil, India, Mexico, Portugal, and South Africa.

Craspedia

Craspedia x 'Drumstick' is new to horticultural cultivation. This native from Australia is easily grown from seed. It is a green pack item and blooms approximately 170 days from seeding. The 3 cm globular flowering heads of golden yellow are held atop long, wiry stems about 60 cm tall. The excellent cutting stems rise from compact rosettes of ground level foliage. The flowers have very good durability either fresh or dried.

Gomphrena

Gomphrena x 'Strawberry Field' is the first true strawberry-red red gomphrena and is a beautiful, continuous blooming annual. The 3.5 cm blooms are borne in profusion on 60 cm stems, and they are delightful in bouquets either fresh or dried. It is a green pack item and starts to bloom approximately 90 days from seeding and will bloom all summer.

Hosta

Hosta selection MSH-1 (Fig. 1) was found growing among what appeared to be a variable group of seedlings in an old abandoned garden. The plants are very dwarf, early flowering with 26 cm flower stalks with light purple flowers. The plant silhouette is on the order of *Hosta lancifolia* Engl., but much smaller. The plants, in regular perennial fashion, bloom the second year from seed in early June in the Midwest and are excellent as a rock garden subject.

Iris

Dwarf bearded iris (*Iris pumila* L.) (Fig. 2) are beautiful in the spring and are usually purchased as rhizomes in late summer. They can now be produced as a spring sales, pot plant item (E.J. Holcomb pers. commun.) by storing potted rhizomes at 7°C for 8 weeks. There are many cultivars with various colors that bloom in about 25 days after storage and produce more flowering stalks per pot if the plants are grown under high pressure sodium lighting. These dwarf iris are excellent for rock garden or edging use, blooming in late April to early May. They are best grown in full sun in a well drained location.

Kalanchoe

Kalanchoe MSK-20, a selection developed for hanging basket production, was derived from crossing *Kalanchoe* x 'Jingle Bells' with *Kalanchoe manginii* Hamet. & Perr. B, and can be produced from cuttings or from seed. The plants need 5 weeks of short days to induce flowering. The critical photoperiod is 12 h, but the optimum is 9 h. The habit of the plant is more like *K. Manginii*, only larger. The 2.5 cm long, trumpet shaped, red flowers are borne in profusion on the ends of the branches. The natural flowering time is December through March in the United States.

Kalanchoe MSK-1 (Fig. 3), 2, and 4, selections from crosses within *Kalanchoe blossfeldiana* Poelln., are produced from seed and are intended for mass market sales. The plants require short days for flower induction. The colors of MSK-1, 2, and 4 are orange scarlet, hot pink, and apricot-yellow, respectively. The individual flowers have a spread of 17 mm, and the natural flowering time is December through April in the United States.

Rhodohypoxis

Rhodohypoxis bourii (Bak.) Nel., known as the Starlet Flower, is native to South Africa and hardy only into zone 8. Grown from rhizomes, it has been used as a rock garden plant. It is suitable as an attractive spring pot plant, ready for sale 5 to 6 weeks from potting. The flower colors range from white, pale pink to red, and the flowers, each comprising 6 petals, meet at the center with no eye. The slender stems produce a succession of 2 cm flowers. The plants can be enjoyed as a patio subject or planted out in the garden, but should be removed before freezing temperatures are experienced. The rhizomes can reflower after 8 to 10 weeks of storage at 4°C (Bay City Flower Co. pers. commun.). Production of this crop is still somewhat hampered by the limited number of rhizomes available each year.

Salvia

'Lady in Red' salvia, an All-America Selections Flower Award Winner for 1992, is derived from *Salvia coccinea* Juss. ex J. Murr., sometimes called Texas sage. The bright red flowers, which attract humming birds and butterflies, are borne in loose whorls along a spike above the foliage. Mature plant height is 60 cm. 'Lady in Red' can be produced as a flowering bedding plant, using the same culture as for *Salvia splendens* F. Sellow ex Roem. & Schult (Sutherland 1991). Crop time from sowing to initial bloom is about 10 to 12 weeks, and the plants will flower all summer long.

Steirodiscus

Steirodiscus x 'Gold Rush' has a beautiful yellow, daisy-like flower about 2.5 cm in diameter. In full bloom, the flowers cover the entire plant which grows to 12 to 18 cm in height (Hamrick 1989). It is produced from seed and will grow well at 15° to 21°C. The plants, however, require a cool night temperature of 2° to 5°C and 15°C days to flower. Temperatures over 26°C will result in poor growth and shorten the bloom period. In general, the crop time is 12 weeks (American Takii Inc. pers. commun.).

Trillium

A double flowered form of *Trillium grandiflorum* (Michx.) Salisb. ('Flore Pleno') (Fig. 4) is quite rare as a commercial item. The single flowered type at one time was forced as a pot plant, but went out of style. Now, with the renewed interest in wildflowers in the landscape, such items have become popular again. The plants, however, are now protected in some states and cannot be dug from the wild. The double flowering form can be propagated vegetatively, but at a premium price. Potted up during the summer previous to spring sales and stored overwinter, this plant sells itself when in bloom at a garden center outlet. The double flowers have a good 2 to 3 weeks duration time which adds to their value for spring sales. The plants can be enjoyed best, however, if planted as soon as possible into the landscape.

Viola

Violet MSV-1 (Fig. 5) is of hybrid derivation from within the wild *Viola* stemless, blue, cut-leaved group. In the spring, the plants are covered with blue flowers that are held above the foliage forming a beautiful blue carpet. Propagation is by seed or division. Violets are photoperiodic (Mastalerz 1977), producing conspicuous clasmogamous flowers under short day, and inconspicuous clestogamous flowers under long day conditions. It should be possible to keep the plants flowering year-round by manipulating photoperiod and temperature. This should allow sales of flowering plants for landscape use from spring through most of the summer.

Zinnia

The most economic important garden zinnia (*Zinnia elegans* Jacq.) is very susceptible to several leaf diseases. *Zinnia angustifolia* HBK, however, is virtually disease free. Until now only the orange flowered cultivar 'Classic' was available. A new white flowered cultivar 'Star White' (Fig. 6) has been introduced. The single, daisy-like flowers measure about 2.5 cm and appear in mass on plants reaching 35 cm. The plants thrive in hot, dry conditions and carry the same disease resistance found in *Z. angustifolia* (Burpee pers. commun.). The plants bloom all summer and are propagated from seed.

CONCLUSION

The plants highlighted represent an interesting and colorful group of new plants that should find a home in the garden for years to come. They are an example of what new crops can do for increasing the interest of color and diversity in the landscape.

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- Hamrick, D. 1989. 1989 International pack trials report. Grower Talks 53(3):32-67.

- Mastalerz, J.W. 1977. The greenhouse environment. Wiley, New York.
- Roh, M.S. and R.H. Lawson. 1990. New floriculture crops, p. 448-453. In: J. Janick and J.E. Simon (eds.). Advances in new crops. Timber Press, Portland, OR.
- Sutherland, L. 1991. AAS winners span the spectrum in fresh, bright colors. Grower Talks 55(2):73-79.

Table 1. Examples of other new cultivars and species that show potential for bedding plant sales.

Taxa	Comments
Annuals	
Calandrinia x 'Bogota'	Very dwarf, heat tolerant, violet rose color
Centaurea x 'Blue Midget'	Dwarf, free flowering
Gaillardia x 'Red Plume'	Dwarf, heat tolerant, excellent flower production
Gaillardia x 'Yellow Sun'	Dwarf, heat tolerant
Impatiens x 'Spectra'	Dwarf New Guinea-type from seed
Lisianthus x 'Blue Lisa'	Dwarf, deep blue
Nasturtium x 'Tip Top'	Dwarf, in single colors or as a mix
Sanvitalia x 'Double Sprite Yellow'	Double flowers, heat tolerant
Perennials	
Claytonia verginica L.	Wildflower
Dicentra Cucullaria (L.) Bernh.	Wildflower
Lychnis x 'Molten Lava'	Dwarf, deep red
Platycodon x 'Sentimental Blue'	Dwarf, large flowered

Fig. 1. Three-year-old plant of hosta selection MSH-1 in bloom.

Fig. 2. May flowering selection of *Iris pumila*.

Fig. 3. Kalanchoe selection MSK-1 in bloom from seed

Fig. 4. Double flowering form of *Trillium grandiflorum*.

Fig. 5. Violet selection MSV-1 in bloom in early May.

Fig. 6. *Zinnia angustifolia* cultivar 'White Star' in full bloom.

Last update September 17, 1997 aw

Moringa oleifera Lam.

Moringaceae

Horseradish-tree, Ben-oil tree, Drumstick-tree

We have information from several sources:

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

New Crops: Solutions for Global Problems—Noel Vietmeyer

Last update October 23, 1997

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Benincasa hispida (Thunb.) Cogn.

Cucurbitaceae

Fuzzy melon, Hairy melon, Chinese Preserving Melon, Chinese squash, Chinese vegetable marrow, Chinese winter melon, *Moqua*, Wax gourd, White gourd, Zit-Kwa

We have information from several sources:

Asian Vegetables: Selected Fruit and Leafy Types—Marita Cantwell, Xunli Nie, Ru Jing Zong, and Mas Yamaguchi

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Growing Cucumbers, Melons, Squash, Pumpkins, and Gourds—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

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Sesamum indicum L.

Pedaliaceae

Sesame

Other common names are: benne seed, benniseed, gingelly, sim sim, and til.

NewCROP has Sesame information at:

Food, Industrial, Nutraceutical, and Pharmaceutical Uses of Sesame Genetic Resources—J. Bradley Morris

Progress in Mechanizing Sesame in the US Through Breeding—D. Ray Langham and Terry Wiemers

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sesame: New Approaches for Crop Improvement—Raghav Ram, David Cathn, Juan Romero, and Craig Cowley

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Magness J.R. et al. 1971. Food and Feed Crops of the United States.
Sesame
Sesame Oil

Sesame: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

And outside links to more Sesame info:

SESACO.net

Sesame Seeds Consumer Information from McCormick, Inc.

Oregon Hollygrape

Berberis aquifolium Prursh.

Other common names.—Oregon grape, Rocky Mountain grape, hollyleaved barberry, California barberry, trailing mahonia.

Figure 81.—Oregon hollygrape (*Berberis aquifolium*)

Habitat and range.—This shrub is native in woods in rich soil among rocks from Nebraska to the Pacific Ocean, but it is especially abundant in Oregon and northern California.

Description.—Oregon hollygrape is a low-growing shrub from 2 to 5 feet in height, resembling the holly of the Eastern States. The leaves are divided like those of an ash; the five to nine leaflets from 2 to 3 inches long and about 1 inch wide are evergreen, thick, leathery, smooth, and shining on the upper surface with marginal spines. The numerous small yellow flowers appear in April and May and are borne in erect clusters. The fruit consists of a cluster of blue berries. The rootstock and roots are more or less knotty, about an inch or less in diameter, with tough yellow wood and brownish bark.

Other species.—The roots of *Berberis nervosa* Pursh, which is found in the same region, are sometimes collected with that of Oregon hollygrape.

Part used.—The bark, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

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Brazil nut

Butter nut, Cream nut, Para nut

Myrtaceac *Bertholletia excelsa* Humb. & Bonpl.

Source: Magness et al. 1971

The tree is very large, up to over 100 feet. It is a tropical evergreen, native to northern Brazil, with large leathery leaves, 2 feet long and 6 inches wide. The tree forms forests along the Amazon and Rio Nigro Rivers. Large quantities of nuts are gathered from such trees, but they are little cultivated. The fruits are round, about 6 inches in diameter, with a hard shell near 0.5 inch thick, which contains 18 to 24 of the 3-sided angular nuts. The shell of the individual nut is woody, rather thin, and completely filled with the white, creamy kernel. Brazil nuts are not produced commercially in the U.S., but large quantities are imported.

Last update February 18, 1999 by ch

Index|Search|Home | Aromatic, Spice and Medicinal Plants

Betula lenta L.

Betulaceae

Sweet birch, black birch, cherry birch, spice birch

We have information from several sources:

The Herb Hunters Guide—.Sievers, A.F. 1930.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Phyllanthus niuri L. Ann

Phyllanthus fraternus Webster

Euphorbiaceae

bhuiaonla (Hindi) kiranelligida (Canarese), bhuiavli (Marathi), ajata, amala, bbumyamalaki, sukshmadala, vituntika (Sanskrit)

We have information from several sources:

Bhuiaonla (*Phyllanthus niruri*): A Useful Medicinal Weed P. Oudhia

Conservation of medicinal and aromatic plants in BrazilR.F. Vieira

Big bluegrass

Gramineae *Poa ampla* Merr.

Source: Magness et al. 1971

This is a strong-growing perennial bunchgrass native in Western United States. Plants are up to 4 feet tall, with numerous basal leaves 8 to 16 inches long by 0.375 inch wide and a deep, fibrous root system. Stands are generally not dense, but the high production of palatable forage make this a very valuable range grass. It starts growth early in the spring and continues into fall. It is very useful for regrassing farm and depleted range lands. Mixed plantings of big bluegrass and legumes as alfalfa have produced high yields of excellent forage. It is easily injured by overgrazing. Seed is large in size and produced readily. Propagation is by seeding.

Last update February 18, 1999 by ch

Big trefoil

Leguminosae *Lotus pedunculatus* Cav.

Source: Magness et al. 1971

In general appearance big trefoil resembles birdsfoot trefoil, but its range of adaptation is quite different. It is much less winter hardy so is adapted only to humid areas with mild winters. It is grown mostly in western Oregon but also is promising for the Southeastern States. It tolerates submergence and grows well on wet, poorly drained soil. It spreads by underground stems. The root system is shallow. It can be grown in combination with sod-forming grasses, competing well with them. It is high in palatability, both as pasturage and as hay. Seed inoculation is important in establishing plantings. While less important nationally than birdsfoot trefoil, it is a valuable crop for special areas.

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Hibiscus cannabinus L.

Malvaceae

Kenaf, Bimli, Bimlipatum, Jute, Deccan hemp

We have information from several sources:

FactSHEET contributed by: Charles S. Taylor

Non-wood Fiber Crops: Commercialization of Kenaf for Newsprint—Daniel E. Kugler

Kenaf Commercialization: 1986-1995—Daniel E. Kugler

Kenaf: An Emerging New Crop Industry—Charles S. Taylor

Kenaf: Production, Harvesting, Processing, and Products—Charles L. Webber III and Robert E. Bledsoe

Economics of Kenaf Production in the Lower Rio Grande Valley of Texas—Andrew W. Scott, Jr, and Charles S. Taylor

The Rise and Fall of Kenaf as a Fiber Crop in North Carolina—Wilham T. Fike

Kenaf: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

New Industrial Crops: Northwestern Argentina Regional Project—Ricardo Ayerza (h) and Wayne Coates

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Salt Tolerance of Kenaf—L.E. Francois, T.J. Donovan, and E.V. Mass

Response of Kenaf to Multiple Cutting—Frank E. Robinson

Kenaf in Irrigated Central Washington—David W. Evans and An N. Hang

Utilization of Methanol Stress for Evaluating Kenaf Quality—Charles G. Cook and Andrew W. Scott, Jr.

The Effects of Metolachlor and Trifluralin on Kenaf Yield Components—Charles L. Webber III

Adaptation of Kenaf to Temperate Climatic Zones—Brian S. Baldwin

Response of Kenaf to Nitrogen Fertilization—Charles L. Webber III

Potential for Kenaf Improvement via Somaclonal Variation—Nancy A. Reichert and Brian S. Baldwin

Growth of Bedding Plants in a Kenaf-Based Potting Medium—Nancy A. Reichert and Brian S. Baldwin

Kenaf: An Alternative Crop for Delaware (Abstract)—Hames Don Tilmon, Richard Taylor, and George Malone

Cultivar Evaluations and Fertility Requirements of Kenaf in Southeast Texas (Abstract)—John W. Sij

Feasibility of Adopting Kenaf on the Eastern Shore of Virginia—Altin Kalo, Susan B. Sterrett, Paul H. Hoepner, Fred Diem, and Daniel B. Taylor

Kenaf Production: Fiber, Feed, and Seed—Charles L. Webber III, Harbans L. Bhardwaj, and Venita K. Bledsoe

Kenaf Harvesting and Processing—Charles L. Webber III, Venita K. Bledsoe, and Robert E. Bledsoe

Kenaf Yield Components and Plant Composition—Charles L. Webber III and Venita K. Bledsoe

Effect of Kenaf and Soybean Rotations on Yield Components—Charles L. Webber III

New Crops Research and Development: A Federal Perspective—L.H. Princen

Commercializing Promising Technologies—Paul F. O'Connell

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside links:

American kenaf Society

ReThink Paper

Commercial products:

Kenaf paper The Evanescent Press

Kenaf seed photograph by University of Minnesota Center for Alternative Plant & Animal Products.

Betula lenta L.

Betulaceae
Cherry birch, Sweet birch, Black birch

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

A beer is made from birch bark. Fernald et al., (1958) quote an old English recipe for the beer:

"To every Gallon of Birch-water put a quart of Honey, well stirr'd together; then boil it almost an hour with a few Cloves, and a little Limon-peel, keeping it well scumm'd. When it is sufficiently boil'd, and become cold, add to it three or four Spoonfuls of good Ale to make it work...and when the Test begins to settle, bottle it up . . . it is gentle, and very harmless in operation within the body, and exceedingly sharpens the Appetite, being drunk ante pastum."

According to Grieve (1931), Kamschatka natives drink the sap without previous fermentation. In Spring, the inner bark can be cut up into noodle-sized strips and cooked as birch "noodles." Like maple sap, the sap can be used for honey, syrup, or sugar after boiling down. Wood used by cabinet makers. The oil distilled from the wood is insectifugal and can be used to preserve furs.

Sweet Birch oil is used as a counter irritant for arthralgia and neuralgia, usually in balms, liniments, and ointments. It is used to impart a wintergreen flavor in such things as baked goods, candies, chewing gums, dairy desserts, gelatins, puddings, and root beer, rarely constituting as much as 0.1% of candy (Leung, 1980). Used in cosmetic shampoos (List and Horhammer, 1969–1979), and in the sugar industry for flavoring and in perfumery. Birch tar oil, distilled from the wood and bark of Betula pendula Roth is used for eczema, psoriasis, and other skin diseases.

Folk Medicine

According to Hartwell (1967–1971), the birch species are used in folk remedies for abdominal and mammary cancers and carcinomas and warts. Reported to be alterative, anodyne, antiseptic, counterirritant, deobstruent, depurative, diaphoretic, diuretic, parasiticide, pectoral, stomachic, and vulnerary, sweet birch is a folk remedy for burns, chafing, cold, cough, dandruff, dysentery, dysmenorrhea, gout, gravel, lumbago, rheumatism, scalds, sciatica, and sores (Duke and Wain,1981; List and Horhammer, 1969–1979; Erichsen-Brown, 1979). The bark has been used as an astringent, antiseptic, antipyretic, and antirheumatic. Cherokee chewed the leaves for dysentery and used the bark tea for colds, dysentery, milky urine, and stomach ailments. Delaware used the bark decoction as cathartic or emetic. Iroquois used it for colds, fever, soreness, and venereal diseases. Ojibwa used bark as diuretic. In the days of Milspaugh, much of the so-called oil in wintergreen was made instead from young birch, there being little variance between oil of wintergreen and oil of birch (Duke,1983c).

Chemistry

Per 100 g, the leaves are reported to contain, on a zero-moisture basis, 28.1 g protein, 8.6 g fat, 55.6 g total carbohydrate, 16.9 g fiber, and 7.7 g ash (Miller, 1958). Hager's Handbuch lists 3% monotropitoside (Salicylic-acid primvercoside, gaultherin, $C_{19}H_{26}O_{12}$) and 0.23–0.6% essential oil, 99.8% of which is methysaliclate. Buds contain 4–6% essential oil containing betulol. According to Morton (1977), the distilled oil contains 97–99% methyl salicylate (List and Horhammer, 1969–1979).

Toxicity

Very toxic orally, methyl salicylate can be absorbed through the skin, resulting in human fatalities. As little as 4, 700 mg can be fatal in children (Leung, 1980).

Description

Aromatic tree with brown, exfoliating bark on young stems, twigs glabrous. Leaves ovate or elliptic, 2.7–10 cm long, 1.5–6 cm wide, pubescent on the veins beneath, apically acute or acuminate; sharply serrate, base cordate, rounded or cuneate; petioles usually pubescent, 0.8–1.9 cm long. Pistillate catkins cylindric or oblong, 1.2–3.4 cm long, 0.6–1.2 cm broad; bracts glabrous; samaras obovoid, 2.5–3.5 mm broad, apically winged, glabrous (Radford et al, 1968).

Germplasm

Reported from the North American Center of Diversity, cherry birch, or cvs thereof, is reported to tolerate heath balds, frost, shade, and slope. ($2n = 28$).

Distribution

Southern Maine to southern Ontario, southern to eastern Ohio and Delaware, along the mountains to Alabama and Georgia.

Ecology

Estimated to range from Cool Temperate Moist to Wet through Boreal Moist to Wet Forest Life Zones, and to tolerate annual precipitation of ca 6 to 15 dm, annual temperature of 5 to 12°C, and pH of 4.5 to 7.5. Farther south in rich woods and heath balds.

Cultivation

For the oil, birch is usually harvested from the wild. Birch seeds do best if stratified, or can be sown after collection in late summer or fall. Seed is broadcast and covered very lightly (2–5 mm) keeping the seedbed moist if possible. Epigeal germination is usually complete 4–6 weeks after spring sowing. Seedlings require light shade during their first summer.

Harvesting

Midrange this flowers from April to May, fruits ripening from August to September, the seeds dispersing from September to November (Agriculture Handbook 450). Birch seed is collected by picking or stripping the cones while they are still green (to prevent shattering). Ripe cones, on the other hand, are placed in, bags to prevent loss of seed. Seedling densities of 250–475 m^2 are suggested.

Yields and Economics

Most sources indicate that birch oil, which replaced wintergreen oil, has been largely replaced by synthetic methyl salicylate. Salicylic acid is now synthesized and selling at ca $2.50 to $3.00 per kilo. Salicylic acid in technical form is used as a coupling agent dye intermediates, in the foundry industry as a curing agent in the production of shell moulding compounds, as an agent for retarding the vulcanization process in rubber, as a preservative for glues and leather goods, and in alkyl/alkyd resins and latex paints (CMR, Dec. 13, 1982).

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges from 3 to 12 MT/ha in various species of birch, standing biomass 2–220 MT/ha. Rather lower productivity and standing biomass are reported by Cannell (1982). If there were a decent market for the oil of the bark and wood, then most of the aerial biomass could be an energetic byproduct.

Biotic Factors

Browne (1968) lists the fungi *Melampsoridium betulinum* and *Nectria galligena* and hymenoptera *Heterarthrus nemoratus* affecting cherry birch. Agriculture Handbook No. 165 lists the following as affecting this species: *Comandra umbellata* (seed plant parasitic on roots), *Cryptospora betulae* (on dead branches), *Cryptospora humeralis, Dermea molliuscula* (on dead twigs), *Diatrypella betulina* (on dead branches), *Fomes applanatus* (white-mottled heart rot), *F. connatus* (white spongy heart rot), *F. pinicola* (brown crumbly heart rot), *F. robustus* (white sapwood and heart rot),.*Gloeosporium betularum* (leaf spot), *Hymenochaete agglutinans* (trunk canker), *Melanconis acrocystis, M. stilbostoma, Microsphaera alni* (powdery mildew), *Nectria coccinea* (on branches), *Phyllactinia corylea* (powdery mildew), *Poria laevigata* (white spongy rot, trunk canker), *Poria obliqua* (white spongy rot, trunk canker), Septoria betulicola (leaf spot), *S. microsperms, Steganosporium piriforme* (on twigs), *Taphrina* sp. (leaf blister), and *Torula ligniperda* (red stain of heartwood).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update December 30, 1997

Birdsfoot trefoil

Leguminosae *Lotus corniculatus* L.

Source: Magness et al. 1971

Birdsfoot trefoil is a perennial, fine-stemmed, leafy legume that has become of increased importance in American agriculture in recent years. Introduced by chance from Europe, strains selected in this country are now of major importance as pasture and hay crops. It is hardy and adapted to areas of ample moisture supply from the Ohio and Potomac Rivers north into Canada and west to the edge of the Great Plains, also in humid parts of the Pacific States. The leaves are sessile along the stems, each with 5 linear to oval leaflets. Stems are decumbent unless in fairly dense stands, reaching 20 to 40 or more inches in length. The plant has a deep, branched root system and tolerates both wet and moderately dry conditions. It is unusual among legumes in that it does not cause bloat in cattle. Both as pasture and as hay it is highly palatable and nutritious. Harvested seed increased 6-fold from 1949 to 1959, and in the latter year was sufflcient to plant about 300,000 acres, according to census data.

Photographs from University of Minnesota Center for Alternative Plant & Animal Products.

Last update December 9, 1997

Rollinia mucosa Baill.

Annonaceae

Biriba

We have information from several sources:

Biriba—Julia Morton, Fruits of warm climates

South American fruits deserving further attention.—Campbell, R.J. 1996. p. 431-439. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Last update Thursday, January 28, 1999 by ch

Citrullus colocynthis (L.) Schrad.

Cucurbitaceae

Colocynth, Egusi, Bitter apple

We have information from several sources:

Colocynth: Potential Arid Land Oilseed from an Ancient Cucurbit—Zohara Yaniv, Ella Shabelsky, and Dan Schafferman

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Bitter Nightshade

Solanum dulcamara L.

Figure 15.—Bitter nightshade (*Solanum dulcamara*)

Other common names.—Bittersweet, dulcamara, nightshade, climbing nightshade, woody nightshade, amara dulcis, fevertwig, violet-bloom, blue bindweed, felonwort, poisonberry, poisonflower, pushion-berry, morel, snakeberry, wolfgrape, scarlet berry, tether-devil, dwale, skawcoo.

Habitat and range.—This plant occurs in low damp grounds and moist banks of rivers from New Brunswick to Minnesota and south to New Jersey and Kansas.

Description.—Bitter nightshade has a climbing, somewhat woody, branched stem about 2 to 8 feet long. The leaves are from 2 to 4 inches long, some entire and others having one to three lobes at the base. The purplish flowers, which resemble those of the potato, are produced from about May to September in compound clusters. The berries, which ripen in autumn, are oval, red, juicy, and contain numerous seeds. The plant has a handsome appearance in autumn with its colored berries, and is often planted as an ornamental.

Part used.—The young branches from plants only 1 or 2 years old, collected after the leaves have fallen.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 149–163.

Andean tubers

The authors of this chapter are C. Arbizu and M. Tapia (CIP. Lima, Peru).

Oca (*Oxalis tuberosa*)

Botanical name: *Oxalis tuberosa* Molina

Family: Oxalidaceae

Common names. English: oca, oxalis; Quechua: oqa, ok'a; Aymara: apilla; Spanish: oca (Peru, Ecuador), oca, ibia (Colombia), ruba, timbo, quiba (Venezuela), papa roja, papa colorada, papa extranjera (Mexico)

Oxalis tuberosa is a crop native to the Andes. Together with the potato. the domestication of this and other Andean tubers in the central region of Peru (lat. 10°S) and northern Bolivia (lat. 20°S), where the greatest diversity both of cultivated and wild forms is found, is thought to have given rise to agricultural activity in the higher agro-ecological areas of the Andes. The migrations of pre-Columbian communities extended its cultivation to lat. 8°N in Venezuela and lat. 25°S in northern Argentina and Chile. Its cultivation was introduced into Mexico about 200 or 300 years ago and, nowadays, it is grown relatively extensively in the region of the Transverse Neovolcanic Axis. Oca was introduced into Europe in the last century and, even though it was produced as a new vegetable, it did not become established as a permanent crop. It is known to have existed in New Zealand since 1860 and its cultivation seems to have gained popularity in the last 20 years.

The oca is sown together with the ullucu, mashwa and native potatoes on plots from 30 to approximately 1000 m^2. It is therefore difficult to tell what its cultivated area and production is. However, it is estimated that 20000 ha are sown annually in Peru, with an average production of 3 to 12 tonnes per hectare, although some experimental selections and treatments have produced as much as 97 tonnes per hectare.

Uses and nutritional value

Oca is first sun-dried to make it sweeter and then parboiled, roasted or prepared as *pachamanca* (meat roasted in a hole in the ground).

The dried, frozen tuber is called *khaya*. If it is washed after freezing, a whiter product called *okhaya is* obtained which is considered to be of superior quality. The flour of the latter is used to make porridges and desserts. Oca is first and foremost a good source of energy; its protein and fat content is low.

Botanical description

O. tuberosa is an annual, herbaceous plant that is erect in the first stages of its development, and decumbent or prostrate towards maturity. The tubers are claviform-ellipsoid and cylindrical, with buds on the whole surface, and variegated in colour: white, yellow, red and purple.

The leaves are trifoliate, with petioles of varying length (2 to 9 cm). The inflorescences consist of four or five flowers. The calyx is formed by five pointed, green sepals. The corolla has five purple-striped, yellow petals; ten stamens in two groups of five; and a pistil that is shorter or longer than the stamens. Propagation is almost exclusively by the tubers. The flower structure has an efficient mechanism which facilitates cross-pollination.

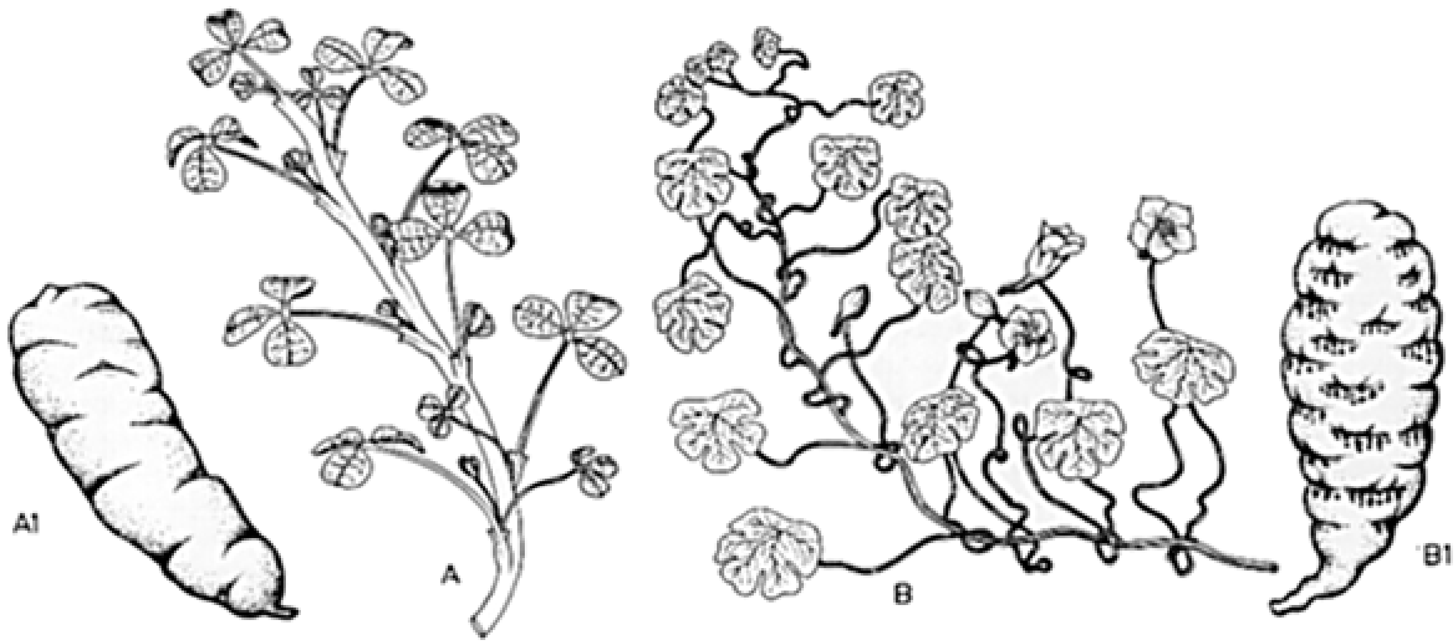

Figure 15. Andean tubers: A) oca (*Oxalis tuberosa*); A1) tuber; B) mashwa (*Tropaeolum tuberosum*); B1) tuber

Ecology and phytogeography

Oca is grown from 3000 to 4000 m, from Colombia to Chile. However, the greatest concentration is found between 3500 and 3800 m, in the suni agro-ecological zone (mountain slopes).

Wild species of the genus *Oxalis* are found on the low ridges of the Peruvian coast, or growing sympatrically with cultivated oca in the Andes and on the edges of forests.

Genetic diversity

The basic number of chromosomes has been established as x = 11. There are reports of ocas that are close to pentaploid (2n = 2x = 58) and hexaploid (2n = 2x = 66) and also of hexaploid cultivated ocas. The frequency of diploids, triploids, tetraploids, pentaploids and hexaploids as well as those that are not exactly euploid should be clarified. The role of the 2n gametes in the formation of the polyploid complex and the nature of the F_1 and F_2 material needs to be studied.

The pattern of variability in the oca seems to be fairly complex. In fact, cultivated forms have hitherto been grouped together into a single species which includes several shapes and colours of tuber.

The self-incompatibility system present in the oca and consequent cross-pollination, together with the aesthetic selection made by Andean farmers, must have had an influence on the existence of the wide variety of tuber colours and shapes. as well as the number and depth of "eyes" or "buds".

The wide variability found in the colour of the tubers suggests a continual variation, since colours range from white to black, with various hues of yellow. pink and red in between. Flesh colour also seems to undergo continual variation, although less than skin colour does. Ocas have been seen with ivory-yellow and violet-purple flesh in several hues. There are a great many shapes in the vascular ring pigmented with the same colouring as the skin, followed in colour intensity by the medulla.

Oca collections in South America

Over the past ten years, expeditions have been made to Peru, Ecuador and Bolivia to collect cultivated oca. Field collections in Peru are being maintained and evaluated at the Universities of Cuzco, Huancayo, Ayacucho, Cajamarca and Puno, and at INIAA, where there are over 1000 accessions with sufficient duplications. Most of this material is kept in vitro at the Biotechnological Laboratory of the Universidad Nacional Mayor San Marcos in Lima. The collection of Ecuadorian oca is kept as a field collection at the Santa Catalina station in Quito.

Cultivation practices

The three Andean tubers (oca, mashwa and ullucu) are grown in the same agro-ecological zone and their soil requirements and cultivation practices are very similar to those of the potato: for this reason they are dealt with together.

In the northern area of the Peruvian sierra. the traditional form of cultivation is on *melgas:* after cultivation of the potato, the land is divided into three to five plots, each of which is sown with one of the Andean tubers.

On the high plateau of Puno and in the agro-ecological zone of the semi-humid puna, a mixture of tubers is sown. By contrast, in the quechua agro-ecological zone, the oca and ullucu are planted together with maize. These crops show a high response to agricultural work such as fertilization, earthing up, hoeing and, above all, the control of pests and diseases; their production increases to levels of 40 to 50 tonnes per hectare, which are comparable to the highest potato yields.

Prospects for improvement

The prospects for this crop lie in the possibility of increasing its yield and in its use as an alternative source of flour to wheat.

The following aspects should be taken into account:

- The oca has to compete for ground (cultivation areas) with potatoes; as a result, its expansion could be limited; research carried out in southern Peru seems to confirm this.
- Attacks by pests, such as weevils, may cause the loss of an entire crop; studies on the integrated control of these pests, through cultivation practices, biological control using the fungus *Beauveriabrogniartii*, postharvest management and the use of resistant varieties would need to be carried out; bitter ocas show a degree of resistance to the various weevils.
- **Presence of viral diseases:** Although just one virus has been identified in the oca, it seems that others exist which damage the crop: the purity of commercial varieties and genetic materials must be established as standard practice, as virus-free varieties would give higher yields.

- The extensive growing period of seven to eight months exposes the crop for a longer time to attack from biotic and abiotic factors. and oca cultivation is consequently being gradually replaced by early varieties of potato (with a growing period of four to five months), the short duration of the tuber also affects its propagation.

The high yields in dry matter obtained from this crop and the possibilities of attaining up to 6 or 7 tonnes of flour per hectare are factors that ought to be dealt with in an agro-industrial research programme.

Mashwa (*Tropaeolum tuberosum*)

Botanical name: *Tropaeolum tuberosum* Ruíz & Pavón

Family: Tropeolaceae

Common names. English: mashwa; Spanish: mashwa, mashua (Peru, Ecuador), isaño, añu (Peru, Bolivia), maswallo, mazuko, mascho (Peru) and cubio (Colombia)

Tropaeolum tuberosum apparently originates from the central Andes (lat. 10° to 20°S). Its cultivation is thought to have been spread by pre-Columbian migrations to Colombia (lat. 8°N) and northern Argentina and Chile (lat. 25°S). In spite of its hardiness, there are no references to its introduction into other countries, possibly because the tuber's flavour is not very pleasant when eaten for the first time.

Grown together with ullucu, oca and native potatoes on plots from approximately 30 to 1000 m^2, it is difficult to ascertain its cultivated area and production. However, it is estimated that around 6000 ha are sown annually in Peru, with an average yield of 4 to 12 tonnes per hectare. Under experimental conditions, up to 70 tonnes per hectare have been obtained.

From an agronomic point of view, mashwa is very hardy because it grows on poor soil, without the use of fertilizers and pesticides. Even under these conditions, its yield can be double that of the potato. Its cultivation together with ullucu, oca and native potatoes could be accounted for by the nematicide and insecticide control properties that the plant has.

Since the time of the Incas, who included them in their soldiers' rations, the tubers have had anaphrodisiac properties attributed to them. Today, it is known that testosterone levels are significantly reduced in male rats that are fed mashwa.

Uses and nutritional value

Mashwa is important for meeting the food requirements of resource-poor people in marginal rural areas of the high Andes. It is prepared in the form of a stew, as a roast or in the form of *thayacha*. For the latter preparation, the tubers are exposed overnight to frost and are eaten the following day accompanied by sugar-cane syrup.

Botanical description

T. tuberosum is an annual herbaceous plant of erect growth when it is young and it has prostrate stems with compact foliage when mature. This enables it to compete advantageously with weeds. At first sight, the tubers may be confused with oca tubers, but they can be distinguished by their conical shape, dark markings and a greater concentration of buds on the distal part, as well as by their sour taste.

The growing cycle of this species varies between 220 and 245 days. Unlike oca and ullucu, mashwa produces a great quantity of viable seeds.

Ecology and phytogeography

Mashwa is cultivated from Colombia to Bolivia, from 3000 to 4000 m, with a greater concentration between 3500 and 3800 m. In spite of the poor-quality soils, extreme temperatures, radiation. variation in precipitation and the winds of the Andes, the plant grows quickly, managing to repel insects and nematodes, suppress weeds and maximize photosynthesis. The proportion of dry matter transferred to the tubers can be as high as 75 percent.

Genetic diversity

The genus *Tropaeolum* has a wide geographical distribution and seems to be very variable. There are an estimated 50 species in Mexico and Central and South America. Wild species of mashwa in Peru can be found on the low ridges of the Peruvian coast, on the edges of forests or growing sympatrically with cultivated mashwa in the Andes.

Ornamental *Tropaeolum* can be found in gardens on the coast and in the Andes. Weed forms of mashwa, called kite añu, are sporadic in the maize or tuber fields of the sierra. *T. edule, T. polyphyllum* and *T. patagonicum* have also been described as producers of tubers in the Andes of Chile and Argentina, but they apparently have no economic use.

As in the case of the oca, the crossability groups are not known, in other words the situation of the mashwa's gene stock is unknown.

Chromosome calculations have established the basic number as $x = 13$. Cultivated forms are clearly tetraploids ($2n = 4x = 52$). The frequency of diploids, triploids and tetraploids is not known and nor is the possible gene flow.

Cross-pollination and the tendency towards self-fertilization, together with aesthetic selection, must have influenced the appearance of various morphotypes. It can be said that the diversity of the mashwa is less than that of the oca, and slightly less than that of the ullucu. However, variation has been found in tuber colour, shapes, bud characteristics and flesh colour. The tuber's skin colour varies from ivory to very dark-purplish violet, with several hues of yellow, orange and purplish violet in between. Pink or purple speckles or stripes may occur on the skin at the apex and under the buds. Tuberization in the buds is more frequent in clones of shortened conical tubers than elongated and ellipsoid conical tubers. The greatest variation in tuber colours and shapes is found in the region between central Peru and northern Bolivia.

Mashwa collections in South America

Cultivated mashwa, just like ullucu and oca, has been collected extensively in Peru, Ecuador and Bolivia during the last ten years. The field collections of Peru. stored and evaluated in the gene banks of Ayacucho, Cajamarca, Huancayo, Cuzco and Puno, exceed 300 accessions. Many of the accessions are kept *in vitro* in the biotechnological laboratory of the Universidad Nacional Mayor San Marcos in Lima. The field collection of Ecuadorian mashwa is stored and evaluated at the Santa Catalina experimental station in Quito.

Cultivation practices

Mashwa cultivation practices are the same as those described for the oca.

Prospects for improvement

Because of its flavour, the mashwa could have a better chance of more extensive use in animal feeding. In this connection. certain clones with a protein content of up to 11 percent show good prospects.

An investigation into the factors limiting mashwa production. carried out by the CIP in the Peruvian Department of Cuzco (1989). elicited the following answers from the peasants: scarcity of suitable land (28 percent): low crop yields (17 percent): and scarcity of seed (17 percent).

The rise in population and consequent pressure on the land would seem to be a limiting factor not only in Cuzco but also in other parts of the Andes. Low crop yields would not be a serious limiting factor. since the mashwa responds well to good soil management. Seed scarcity is a problem that can be solved.

The main lines of research are as follows:

- the function of undesirable substances:
- the long cultivation period:
- tuber storage:
- the selection of varieties for the various agro-ecological conditions:
- consumption patterns in rural and urban populations.

Bitter Potatoes (*Solanum* x *juzepczukii*), (*Solanum* x *curtilobum*)

Botanical names: *Solanum* x *juzepczukii*, *Solanum* x *curtilobum*

Family: Solanaceae

Common names. English: bitter potato; Aymara: luki; Quechua: ruku; Spanish: choquepito, ococuri

It seems that the domestication of bitter potatoes began some 8000 years ago and that, as cultivated domesticated species, they have been used extensively for at least 3000 years.

Acosta, one of the first Spanish chroniclers to describe the agricultural resources of the Andes, mentions that bitter potatoes that had been exposed to the cold overnight and then pressed and dried were transformed into what was known as *chuño* and were used as bread is in Europe. A century later, the priest Bernabé Cobo reported that. on the high plateau, there were wild potatoes and bitter potatoes which the Aymaras called aphus and which could only be eaten when processed as *chuño*: this food constituted the main staple in the high plateau region between Peru and Bolivia.

In spite of their importance for the agro-ecological zones of the puna. where frosts during the growth period limit food production, these crops were not studied during the time of the settlement, nor at the start of the Republic. During the 1920s, the Russian expedition organized by Vavilov and undertaken with his students Juzepczuki and Bukasov made a detailed description of these species on the basis of collections gathered on the high plateau around Lake Titicaca.

Several studies have been carried out on bitter potatoes during the past 50 years, including their origin, description and an evaluation of their nutritional capacity.

The area cultivated at present varies greatly from one year to the next, depending on whether an adequate amount of seed is available. However, there are an estimated 15000 ha in Peru and around 10000 ha on the high plateau of Bolivia, on peasants' plots ranging from 300 to 500 m^2 and over more extensive areas on land under sectoral rotation. There are further potential areas for cultivation, the inclusion of which could easily double the current production.

Uses and nutritional value

If bitter potatoes are to be eaten, they must first undergo processing to remove the glycoalkaloids. Traditional processes in the upper Andean area. described in various works, consist of exposing the tubers to several night frosts and drying them in strong sunlight at altitudes of 4 000 m to obtain black *chuño*. Larger bitter potatoes are preferably used to prepare white *chuño*, also called *tunta* (Aymara) or *moraya* (Quechua). Freezing is followed by the peeling, hydrating for up to 30 days and drying.

Black *chuño* is produced up to the edge of the forest where it keeps very well because of its characteristics as a dehydrated product. White *chuño* is preferably eaten on feast days. It fetches a high price at town markets where it is an ingredient of various regional dishes. Both white *chuño* and black *chuño* are very rich in energy.

The potential of bitter potatoes lies precisely in their ability to withstand low temperatures and yield a surplus. thus constituting an important food reserve. It has been calculated that, between August and March, black *chuño* can account for 70 percent of the food of rural populations of the Peruvian and Bolivian high plateau.

Botanical description

Solanum x *juzepczukii* measures 30 to 50 cm and has a semi-rosette growth habit, long, straight leaves. short petioles and a small, blue corolla.

S. x *curtilobum* is distinguished by its more coriaceous leaves and its corolla, which is bigger and purple with very short lobules and a pointed end.

The tubers vary in size and shape, ranging from rounded (Piñaza) to elliptical, oblong or elongated-oblong (Luki), and in colour. Clones of Ococuri have purple and white tubers.

The growing cycle varies greatly between five and eight months. The clone Piñaza is one of the earliest, taking 150 days; Ruki clones are the latest, taking up to 195 days.

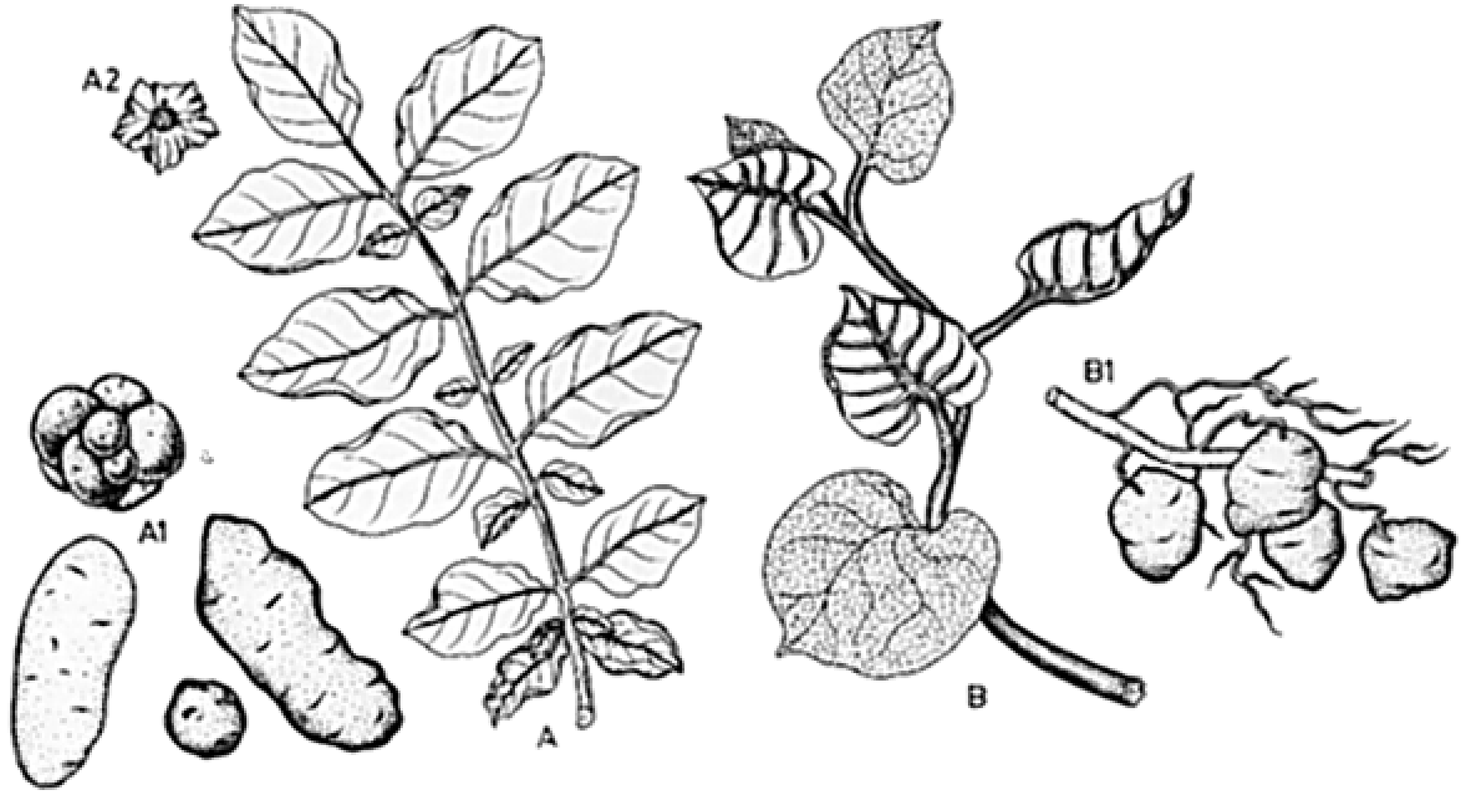

Figure 16. Andean tubers: A) bitter potatoes; A1) tubers; A2) flower; B) ullucu (*Ullucus tuberosus*); B1) tubers

Ecology and phytogeography

Bitter potatoes are cultivated at altitudes between 3000 and 4300 m, in the agro-ecological zones of the humid puna and suni, which are characterized by mean growth period temperatures of between 6 and 14°C, with precipitations which vary according to the region and year between 400 and 1400 mm, are spread over five to six months and which coincide with the summer period in the Southern Hemisphere (October-May).

Frosts may occur during the growth stage, with the temperature dropping to -5°C in some years. A greater incidence of low temperatures is observed in the dry period and these affect production heavily, with damage varying according to the species. Recently, in an area of Peru with frosts and temperatures of -5°C, the reduction in the harvest was 5 percent in the case of *S.* x *juzepczukii*, 30 percent in the case of *S.* x *curtilobum* and 40 percent in the case of the common potato.

The cultivation of bitter potatoes requires soils which have sufficient organic matter (3 to 5 percent) and which have had a period of fallow or adequate rotation. The best yields are obtained on soils which have lain tallow for three to four years and have had 2 to 3 tonnes of manure applied.

Bitter potatoes predominate on land where the main production is livestock and where there is natural pasture and thus little pressure on the land. Because of this, land can be put under a rotational system of crops with canihua (*Chenopodium pallidicaule*) or fodder plants such as barley or oats. including a prolonged period (up to six years) of fallow during which the natural vegetation covers the soil again. In areas which have a very broken topography and where the puna zone is very close to the suni or quechua (valley) zones, rotation includes other crops suited to these conditions, with tubers such as oca (*Oxalis tuberosa*) and ullucu (*Ullucus tuberosus*) or mixtures of these species.

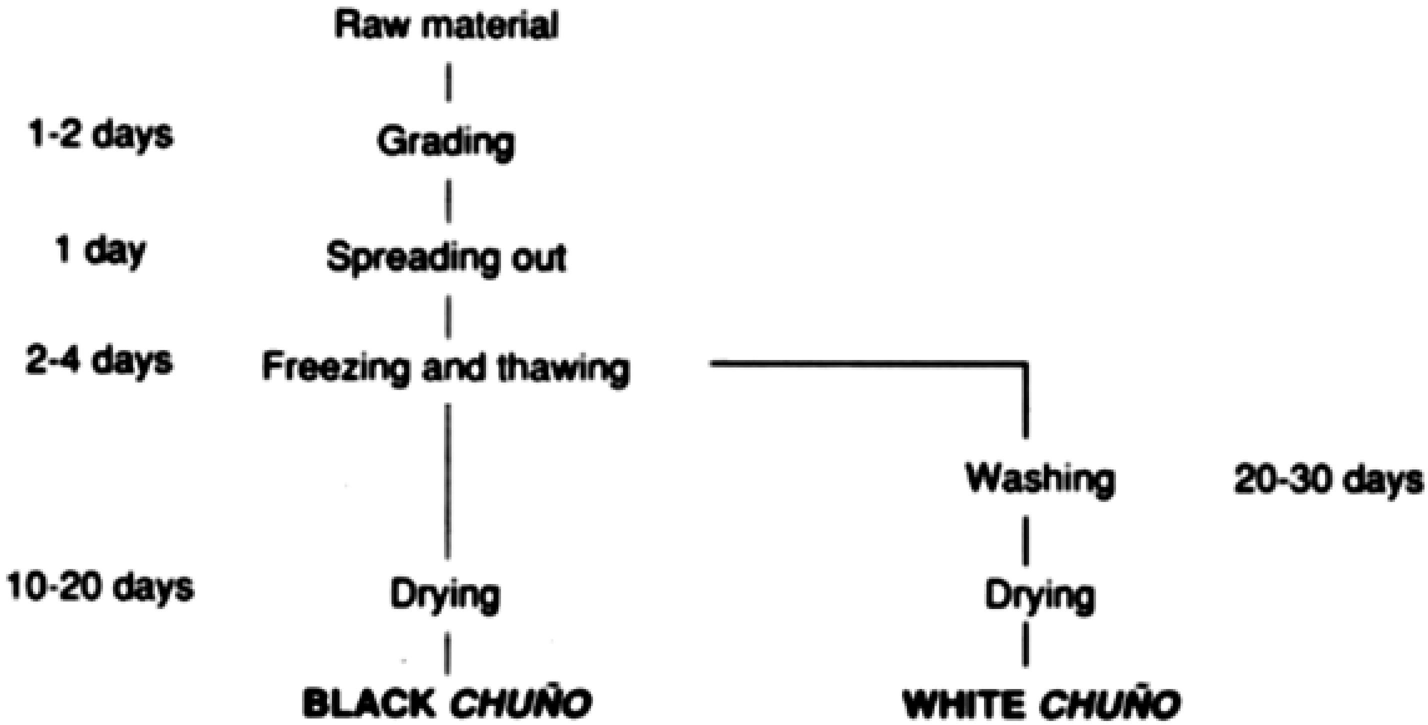

Figure 17. Diagram of *chuño* processing

Genetic diversity

In the southern region of Peru and on the Bolivian high plateau, there are a great number of varieties which have been bred by the peasants over centuries and which are suited to various ecological conditions in the highest region of the Andes.

Bitter potatoes belong to two species: *S.* x *juzepczukii* triploids and *S.* x *curtilobum* pentaploids. Because of their ploidy. which is caused by a high degree of sterility. it is difficult to use the characteristics of bitter potatoes in improvement programmes. The origin of bitter potatoes would seem to be due to various crossings derived from wild species such as *S. acaule.*

There is greater variability in the species S. x *juzepczukii*, the main cultivated varieties being Ruki, Luki, Piñaza, Parina, Locka, Parko, Keta and Kaisallu, with white or purple tubers.

In the species *S.* x *curtilobum*, we may distinguish those of the Choquepito group and the so-called Ococuri, which are characterized by a lower glycoalkaloid content than *S.* x *juzepczukii*.

There is an extensive collection of bitter potatoes in Cuzco and Puno in southern Peru, while a collection from the Bolivian high plateau is maintained at the experimental station of Patacamaya.

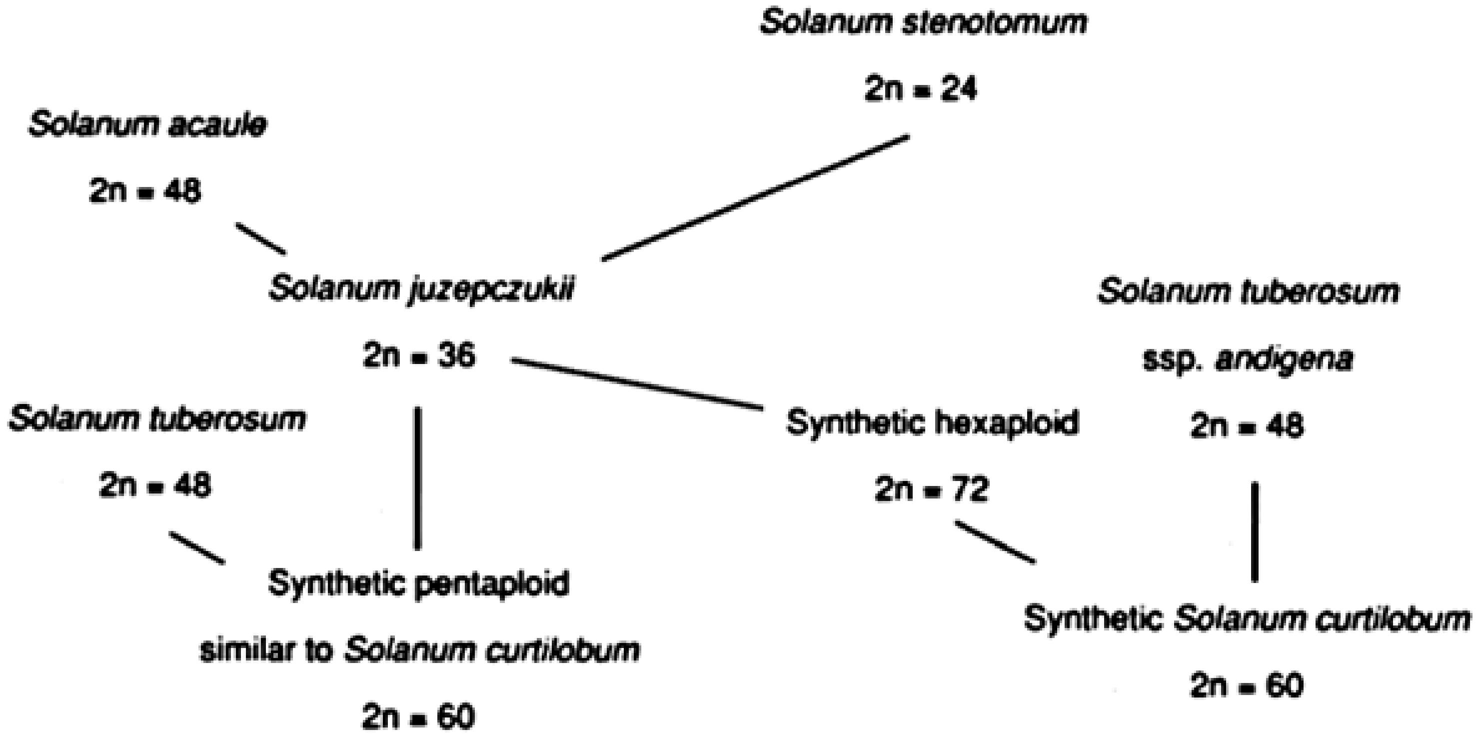

Figure 18. The origin of bitter potatoes

Cultivation practices

The soil is generally prepared with local implements, such as the *chakitakllla* or foot-plough, with the entire peasant family taking part in the operation. since it involves plots located in isolated places.

The sowing period of bitter potatoes is very much conditioned by the presence of rain, since the cap is grown under rain-fed conditions. The period extends from September to November, depending on whether the rains begin early or late. the tradition being to stagger sowing on two or three dates as a means of reducing the climatic risk. The crop needs to be earthed up once or twice when the plants reach a height of 30 to 30 cm. The start of tuberization coincides with the start of flowering, approximately seven to nine weeks after emergence, and lasts for about four weeks, during which time the absence of humidity and severe frosts is vitally important. In this respect there is a differentiation between early, intermediate and late ecotypes, which may mature between four to six months, hence a wide range is available for improvement programmes.

Fertilization is limited to sheep manure. However, there have been positive responses to the addition of chemical fertilizers in intermediate doses. The var. Piñaza responds better to fertilization than the var. Ruki, but the latter has a higher dry matter content.

The varieties of *S.* x *juzepczukii* are better suited to shallow soils than S. x *curtilobum*, which has deeper roots.

On account of their prostrate habit, bitter potatoes are susceptible to nematodes *(Naccobus aberrans*), to the Andean weevil (*Premnotrypes* spp.) and also to wart fungus (*Synchytrium endobioticum*).

Prospects for improvement

The tolerance of bitter potatoes to low temperatures is considered to be their main advantage and there is considerable scope for making selections from current populations. The existence of several varieties also enables cultivation to be extended to the different soil conditions in the highest area of the Andes. Bitter potato genes have been used more for the improvement of so-called sweet varieties than for their own improvement.

The main limitation is their glycoalkaloid content which gives them a bitter taste. In addition to solanine and chaconine, this includes tomatine, mysine and solamargine. However, since there is wide variability in this characteristic. varieties with a low content of this chemical substance can be selected. Although the current process to remove the bitter taste is fairly suited to local conditions and utilizes the climatic characteristics of the puna effectively, with its severe night frosts and intense daytime solar radiation, it is very labour-intensive (working conditions are very hard): it takes between 14 and 28 days to produce white *chuño*.

Ullucu (*Ullucus tuberosus*)

Botanical name: *Ullucus tuberosus* Loz.

Family: Basellaceae

Common names. English: ullucu, oca quina; Quechua: ulluku, ullus; Aymara: ulluma, illako; Spanish: michurui, michuri, miguri, micuche, ruba, rubia, timbo, tiquiño (Venezuela), chigua, chugua, rubas, hubas, camarones de tierra (Colombia), melloco (Ecuador), olluco, ulluco, lisa, papalisa (Peru), lisa, papalisa (Bolivia) and olloco, ulluca, ulluma (Argentina)

The ullucu is a plant native to the Andes. Ancient in origin, it is likely that its cultivation extended from the Andes of Venezuela (lat. 10°N) to northwestern Argentina and northeastern Chile (lat. 25°S) in pre-Hispanic times. However, the exact region of its domestication is not known. Ceremonial vessels of the Robles Moqo style of the Wari culture (the centre of which was Ayacucho between AD 400 and 700) are decorated with multicoloured representations of Andean plants, including the ullucu. It also appears on *qero* ceremonial vessels of the post-Incan era. The oldest vestige is the presence of starch among 4000-year-old plant remains from Ancon and Chilca on the Peruvian coast.

The ullucu's wide distribution in the Andes and its age are also revealed in the profusion of regional names.

Uses and nutritional value

Of the three Andean tubers, the ullucu is the most popular and has become established on the tables of both the rural and urban population in Ecuador, Peru and Bolivia. Traditional preparations include *mellocos* soup (Ecuador); *olluquito con charqui* (*ullucu* with meat—Peru); *chupe* (potato, meat, egg and cheese stew) and *ají de papalisas* (ullucu pepper—Bolivia and Peru). It is also suitable for use in contemporary dishes such as salads. Some varieties contain a greater quantity of mucilage and need to be preboiled before preparation to remove it. The Andean tubers perish easily, which explains why ancient Andean peoples attempted to store surpluses by freezing and drying, processes used also for the ullucu. The product obtained is called *lingli* in Peru; its average protein content is 1.7 percent in the edible tuber, while the carbohydrate and energy content is slightly less than that of most tubers.

Botanical description

The ullucu is an erect, compact plant which reaches a height of 20 to 50 cm. At the end of its growth it is prostrate. Tuber shapes vary from spherical to cylindrical and colours range from white, yellow, light green, pink and orange to purple. On very rare occasions, it forms fruit; the seed then has the form of an inverted pyramid, with very prominent angles and a corrugated surface.

Ecology and phytogeography

The origin and development of the ullucu in the cold climates of the Andes suggest that it is one of the crops most suited to the complex agro-ecology of areas between 3000 and 4000 m. Although the precise role of hybridization, introgression and mutation in the ullucu is not known, these must have acted—along with natural and human selection pressure—to favour the plant's distribution and adaptation to the various types of Andean climate and soils.

Genetic diversity

The wild ullucu would seem to indicate a sympatric distribution with the cultivated ullucu, since up to now it has been found from the Andes of La Libertad in Peru (lat. 8°S) to northwestern Argentina (lat. 25°S). This would appear to indicate a smaller geographical range of habitats than that of the cultivated ullucu. However, collecting expeditions have been orientated towards cultivated material, which is harvested in dry periods when there is no opportunity to collect wild material. It is probable that in the geographical distribution area of the wild ullucu—which seems to be wide—ullucus may be found with interesting characteristics that will help to extend our knowledge of its domestication.

Cultivated ullucus are diploid and triploid, with a basic number of 12. The presence of polyploids in the wild ullucu has also been demonstrated. Nevertheless, the frequency of diploids, triploids and probably tetraploids needs to be determined. In the wild, triploids are generally formed by hybridization between diploids and tetraploids, or by the fusion of a normal gamete and another that has not been reduced between diploid parents. Triploids are generally sterile and the only way of propagating them is vegetatively. Their great vigour allows them to prosper and occur in profusion over a wide distribution area.

The study of meiosis in the cultivated diploid ullucu shows a regular meiotic pairing with the formation of 12 bivalents. Meiosis of the triploids is within expectations, i.e. defective and with the presence of univalents and trivalents. Meiotic pairing of artificial diploid hybrids would need to be researched, provided the combinations are possible.

Ullucu collections in South America

Cultivated and wild ullucus did not arouse much interest among plant explorers in the past. In spite of the fact that the collections of Bukasov and Juzepczuki in South America between 1925 and 1928 were followed by several expeditions to gather cultivated and wild plants, ullucu does not seem to have been collected, even within the same South American countries. Three stages could be distinguished in the collection of ullucu and the formation of gene banks. The first occurred in the 1920s with the work of Bukasov and Juzepczuki; the second covers the work of León through the establishment of the then greater collection of ullucu germplasm at the IICA, with material from Colombia, Ecuador, Peru and Bolivia. Later, collections of wild ullucus were made in northeastern Argentina and Bolivia by Brucher. The third stage began in the 1970s with small local collections at the Universities of Cuzco, Huancayo and Ayacucho, and likewise in the 1980s. Thanks to very positive help from the IBPGR. FAO, CIID and IICA/OAS they were continued more intensively with national programmes such as those of the IBTA in Bolivia, INIAP in Ecuador and INIAA and the Universities of Puno, Cuzco and Ayacucho in Peru. Under these programmes, gene banks are produced annually. These banks suffer from the following shortages which limit the knowledge and promotion of the ullucu:

- **Scant geographical representation:** While the Andes of Ecuador and Peru were explored. few or no collections were made in the Andes of Colombia, Venezuela, the eastern area of Peru, southern Bolivia and northwestern Argentina.
- **Duplication of accessions:** In clonal propagation crops such as the ullucu, there is a high probability of repeatedly collecting one and the same clone in different localities: also. the exchange of germplasm between national programmes without identifying data has meant that one and the same clone can be recorded under different numbers in various banks.
- **Incomplete documentation:** No standardized. internationally accepted descriptors exist for the characterization of the ullucu; there is a lack of specimens from herbaria such information would be very useful in the event of living collections being lost.
- **A lack of wild plant collections:** There is an almost total absence of wild material, such material would help to understand the variation patterns of the cultivated forms and could provide valuable characteristics for improvement.

Cultivation practices

Ullucu cultivation practices are the same as those described for the oca.

Prospects for improvement

Although the ullucu is a hardy plant that is suited to the difficult conditions of the Andes, viral diseases seem to constitute one of its most serious problems. Viral infections in gene banks affect up to 80 percent of samples. This is a particularly serious problem, not only for gene banks, but also for the crop's management.

Viruses may form viral complexes of up to four different particles in a single plant, causing loss of vigour, deformation and leaf mottling. Moreover, they are far more difficult to eliminate than bacterial or fungal pathogens. Eradication in commercial varieties and selected genetic material is an urgent requirement, although the number of viruses which affect the ullucu is not known. Studies at the CIP have revealed at least four viruses, but the number may be higher.

Another limiting factor is the prolonged cultivation period. While modem commercial varieties of potato are harvested after four or five months in the Andes, the ullucu takes seven or eight months to mature. In other words, ullucu plants are exposed longer to drought, frost, pests, diseases and other adverse factors which are frequent in the Andes. Productivity in terms of time and space is consequently low. It seems to be one of the causes of marginalization, so that ullucu cultivation is gradually being replaced by varieties of early high-yielding potatoes.

The biggest advantage of the ullucu is that it is firmly established among rural and urban people in areas where its supply is almost continuous throughout the year.

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last update Wednesday, May 13, 1998 by aw

American Bittersweet

Celastrus scandens L.

Figure 2.—American Bittersweet (*Celastrus scandens*

Other common names.—False bittersweet, climbing bittersweet, shrubby bittersweet, fevertwig, fever-twitch, staff tree, climbing staff tree, staff vine, waxwork, Roxbury waxwork, yellowroot, climbing orange-root, Jacob's-ladder.

Habitat and range.—This woody vine or climbing shrub is found in woods and thickets, growing in rich damp soil from Ontario to Manitoba and south to North Carolina and New Mexico.

Description.—American bittersweet is a woody and shrubby climber, growing over trees or fences. It has smooth thin leaves 2 to 4 inches long and about half as wide. The small greenish-white or greenish-yellow flowers are produced in June in short clusters. The fruit is a roundish, orange-yellow capsule which opens in autumn, disclosing the scarlet-colored seed. The seed capsules remain on the plant well into the cold season.

Part used.—The bark of the plant and root, but especially that of the root.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Rubus spp.

Rosaceae

***R. idaeus*, Raspberry** - Synonyms: American red raspberry, Black-cap, Black raspberry, Purple raspberry, Thimbleberry

Raspberries—HO-44 Purdue University cooperative Extension Service

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

***R. occidentalis*, Black raspberry**

Temperate Berry Crops—Chad Finn

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

***R. idaeus*, Blackberry** - Synonyms: Boysenberry, Brambles, Dewberry, Loganberry, Olallieberry

Temperate Berry Crops—Chad Finn

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

***R. glaucus*, Mora de Castilla**

Temperate Berry Crops—Chad Finn

Hybrid berries

Temperate Berry Crops—Chad Finn

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside links:

Blackberries (*Rubus ursinus* and related species, hybrids) from the University of Georgia.

Lost Crops of the Incas from National Academy Press
Mora de Castilla (*Rubus glaucus*)
Giant Columbian Blackberry (*Rubus macrocarpus*)
Mora de Rocota (*Rubus roseus*)
Mora Común (*Rubus adenotrichus*)

Small Fruit—FAO/IBPGR Technical Guidelines for the Safe Movement of Small Fruit Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Black Cherry

Prunus serotina Ehrh.

Figure 16.—Black cherry (*Prunus serotina*)

Synonym.—*Prunus virginiana* Mill., not of Linnaeus.

Other common names.—Wild cherry, wild black cherry, cabinet-cherry, black choke, rum cherry, whisky-cherry, Virginian prune-bark.

Habitat and range.—The black cherry occurs in woods or open places and is most abundant in the Southeastern States, but its range extends from Nova Scotia to Florida, westward to Texas, and north through Oklahoma, the eastern portions of Kansas, Nebraska, and South Dakota.

Description.—This tree sometimes reaches a height of 90 feet and a maximum trunk diameter of 4 feet. The trunk is straight and covered with rough black bark, but the young branches are smooth and reddish. The smooth shining leaves are about 2 to 5 inches long. The long drooping clusters of small white flowers are borne at the ends of the branches, usually during May. The cherries, which ripen about August or September, are round, black, or very dark purple, about the size of a pea, and have a sweet, slightly astringent taste.

Part used.—The bark, collected in autumn. The outer layer is removed, and the bark is then carefully dried and preserved. Young thin bark is preferred and that from very young or very old branches should not be used. Black cherry bark should not be kept longer than one year, because it deteriorates with age.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Cimicifuga racemosa (L.) Nutt.

Ranunculaceae

Cohosh Bugbane, Black Cohosh

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Black grama

Gramineae *Bouteloua eriopoda* (Torr.) Torr.

Source: Magness et al. 1971

Black grama is a major native grass of the semiarid to arid areas from West Texas westward to California. The stems, when in contact with soil, form roots at the nodes to form other nearby plants. Stems are slender and wiry, up to 2 feet. Plants are leafy and highly palatable with good feeding value both summer and winter. They are highly drought resistant.

Last update February 18, 1999 by ch

Blackhaw

Viburnum prunifolium L.

Other common names.—Sloe, sloe-leaved viburnum, stagbush, shonny.

Figure 17.—Blackhaw (*Viburnum prunifolium*)

Habitat and range.—The blackhaw occurs in dry woods and thickets and on rocky hillsides from Connecticut to Florida and west to Michigan and Texas, but is found in greatest abundance in the South.

Description.—This shrub or small tree, from 10 to about 20 feet in height, has rather stout, spreading branches. The smooth bright-green, finely toothed, broadly or roundish oval leaves are 1 to 3 inches long. The numerous stemless flower clusters are from 2 to 4 inches broad, composed of numerous white flowers appearing from April to June. The fruit, which is sweet and edible, is about half an inch long, bluish black, covered with a bloom, and ripens in early autumn. It contains a somewhat flattened stone.

Another species.—The sweet viburnum (*Viburnum lentago* L.), known also as nannyberry and sheepberry, is collected with *V. prunifolium*. It grows in rich soil from Canada south to Georgia and Kansas. Its fruit matures in October, becoming sweet and edible, and sometimes remaining on the shrub until the following spring.

Part used.—The bark of both species, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Robinia pseudoacacia L.

Fagaceae

Black Locust

We have information from several sources:

Black Locust: A Multi-purpose Tree Species for Temperate Climates—Robert P. Barrett, Tesfai Mebrahtu, and James W. Hanover

Black Locust: An Excellent Fiber Crop—James W. Hanover

New Crops Research: Northeastern Regional and National Federal Efforts—George A.White

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update October 2, 1997 by aw

Morus alba White Mulberry

Morus nigra Black Mulberry

Morus rubra Red Mulberry

Moraceae

NewCROP has Mulberry information at:

Morus alba In: Handbook of Energy Crops. James A. Duke. 1983. unpublished.

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Mulberry info:

MULBERRY "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

last update June 12, 1997

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Brassica nigra L.

Brassicaceae, or Cruciferae

Black Mustard

NewCROP has Black Mustard information at:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

See: Black Mustard In: Potential of Fanweed and Other Weeds as Novel Industrial Oilseed Crops—Patrick M. Carr

Black Mustard From: Magness J.R. et al. 1971. Food and Feed Crops of the United States.

last update October 23, 1997

Solanum nigrum L.

Solanaceae

Black nightshade, garden huckleberry, morella, sunberry, wonderberry

We have information from several sources:

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links

Promoting the conservation and use of underutilized and neglected crops. 15.
Black nightshades: *Solanum nigrum* L. and related species
Jennifer M. Edmonds and James A. Chweya 1997. 112 pages. 17x24 Softcover. ISBN 92-9043-321-3

Black nightshade—Indiana Toxic Plant Indices, Purdue University

Nightshade, Black—Grieve's Herbal

Black nightshades—by Jennifer M. Edmonds, James A. Chweya from the International Plant Genetic Resources Institute

Morton, J. 1987. Black Sapote. p. 416–418. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Black Sapote

Diospyros digyna Jacq.

Diospyros obtusifolia Humb. & Bonpl. ex Willd.

The black sapote is not, as might be assumed, allied to either the sapote *(Pouteria sapota* H.E. Moore & Stearn) or the white sapote *(Casimiroa edulis* Llave & Lex.). Instead, it is closely related to the persimmon in the family Ebenaceae. For many years it has been widely misidentified as *Diospyros ebenaster* Retz., a name confusingly applied also to a strictly wild species of the West Indies now distinguished as *D. revoluta* Poir. The presently accepted binomial for the black sapote is *D. digyna* Jacq. (syn. *D. obtusifolia* Humb. & Bonpl. ex Willd.).

In Spanish, it is known variously as sapote, *sapote negro*, *zapote, zapote negro, zapote prieto, zapote de mico, matasano* (or *matazano) de mico,* or *ebano.* It has been called black persimmon in Hawaii.

Description


Plate LXI: BLACK SAPOTE, *Diospyros digyna*

The tree is handsome, broad-topped, slow-growing, to 80 ft (25 m) in height, with furrowed trunk to 30 in (75 cm) in diameter, and black bark. The evergreen, alternate leaves, elliptic-oblong to oblong-lanceolate, tapered at both ends or rounded at the base and bluntly acute at the apex, are leathery, glossy, 4 to 12 in (10-30 cm) long. The flowers, borne singly or in groups of 3 to 7 in the leaf axils, are tubular, lobed, white, 3/8 to 5/8 in (1-1.6 cm) wide, with persistent green calyx. Some have both male and female organs, large calyx lobes and are faintly fragrant; others are solely male and have a pronounced gardenia-like scent and a few black specks in the throat of the corolla. The fruit is bright-green and shiny at first; oblate or nearly round; 2 to 5 in (5-12.5 cm) wide; with a prominent, 4-lobed, undulate calyx, 1 1/2 to 2 in (4-5 cm) across, clasping the base. On ripening, the smooth, thin skin becomes olive-green and then rather muddy-green. Within is a mass of glossy, brown to very dark-brown, almost black, somewhat jelly-like pulp, soft, sweet and mild in flavor. In the center, there may be 1 to 10 flat, smooth, brown seeds, 3/4 to 1 in (2-2.5 cm) long, but the fruits are often seedless.

Origin and Distribution

The black sapote is native along both coasts of Mexico from Jalisco to Chiapas, Veracruz and Yucatan and in the forested lowlands of Central America, and it is frequently cultivated throughout this range. It was apparently carried by the Spaniards to Amboina before 1692, and to the Philippines long before 1776, and eventually reached Malacca, Mauritius, Hawaii, Brazil, Cuba, Puerto Rico and the Dominican Republic. In 1919, seeds from Guadalajara, Mexico, were sent to the Bureau of Plant Industry of the United States Department of Agriculture; cuttings and seeds were received from the Isle of Pines, Cuba, in 1915; seeds arrived from Hawaii in 1916 and 1917; others from Oaxaca, Mexico, in 1920. Numerous seedlings have been grown in southern California but all have been killed by low temperatures. The tree does very well in southern Florida, though it has been grown mainly as a curiosity. Outside of its homeland, the fruit has not achieved any great popularity. In Mexico, the fruits are regularly marketed.

Varieties

Certain trees tend to bear very large, seedless or nearly seedless fruits maturing in summer instead of winter as most do, but no varietal names have been attached to them in Florida.

Climate

The black sapote is not strictly tropical inasmuch as it is hardy as far north as Palm Beach County, Florida, if protected from frost during the first few years. Trees that have become well established have withstood occasional brief exposures to 28º or 30º F (-2.22º or-1.11º C). In Mexico, the tree is cultivated up to elevations of 5,000 or even 6,000 ft (1,500-1,800 m).

Soil

The tree has a broad adaptability as to terrain. In Mexico it grows naturally in dry forests or on alluvial clay near streams or lagoons where it is frequently subject to flooding. Nevertheless, it thrives on moist sandy loam, on well-drained sand or oolitic limestone with very little top-soil in southern Florida. It is said to flourish on all the soils of Cuba.

Propagation

The black sapote is usually grown from seeds, which remain viable for several months in dry storage and germinate in about 30 days after planting in flats. Vegetative propagation is not commonly practiced but the tree has been successfully air-layered and also shield-budded using mature scions.

Culture

Seedlings are best transplanted to pots when about 3 in (7.5 cm) high and they are set in the field when 1 to 2 years old, at which time they are 1 to 2 ft (30-60 cm) in height. They should be spaced at least 40 ft (12 m) apart. Most begin to bear in 5 to 6 years but some trees may take somewhat longer. The tree is naturally vigorous and receives little or no cultural attention in Florida though it has been noted that it benefits from fertilization.

Season

In Mexico, the fruits are common in the markets from August to January. Most black sapotes in Florida ripen in December, January or February. Certain trees, especially the large-fruited types, regularly come into season in June, others in July and August.

Harvesting

It is difficult to detect the slight color change of mature fruits amid the dense foliage of the black sapote tree. Many black sapotes ripen, fall and smash on the ground before one has the chance to pick them, and this is one reason why .the tree is not favored for landscaping in urban areas. An experienced picker can harvest the fruits at the green-mature or olive-green stage with a cutting pole equipped with a cloth sack.

Yield

No yield figures are available but the tree is noted for bearing well. In 1899, the annual crop in Mexico was valued at $27,000, a considerable sum at that time.

Keeping Quality

Fruits picked when full-grown but unripe (bright-green) have ripened in 10 days at room temperature. Therefore it is at this stage that they must be picked for marketing and shipping. Firm, olive-green fruits will ripen in 2 to 6 days. Fruits displayed on markets in Mexico are somewhat shriveled and wrinkled. The black sapote is very soft when fully ripe. Though it may remain fit for eating if held for a few days in cold storage, it is too soft to stand handling.

Food Uses

Unkind writers have employed unflattering phrases in describing the flesh of the black sapote and have probably hindered its acceptance. This seems quite unreasonable because the color and texture of the pulp closely match stewed prunes, to which there seems to be no aesthetic objection. In the Philippines, the seeded pulp is served as dessert with a little milk or orange juice poured over it. The addition of lemon or lime juice makes the pulp desirable as a filling for pies and other pastry. It is also made into ice cream. In Mexico, the pulp may be mashed, beaten or passed through a colander and mixed with orange juice or brandy, and then served with or without whipped cream. Also, they sometimes mix the pulp with wine, cinnamon and sugar and serve as dessert. Some Floridians use an eggbeater to blend the pulp with milk and ground nutmeg. A foamy, delicious beverage is made by mixing the pulp with canned pineapple juice in an electric blender. In Central America, the fermented fruits are made into a liqueur somewhat like brandy.

Food Value Per 100 g of Edible Portion*	
Moisture	79.46-83.1 g
Protein	0.62-0.69 g
Carbohydrates	12.85-15.11 g
Fat	0.01 g
Ash	0.37-0.6 g
Calcium	22.0 mg
Phosphorus	23.0 mg
Iron	0.36 mg
Carotene	0.19 mg
Thiamine	
Riboflavin	0.03 mg
Niacin	0.20 mg
Ascorbic Acid**	191.7 mg

*According to analyses in Mexico and Guatemala.

**The ascorbic acid content is said to be about twice that of the average orange.

Toxicity

Unripe black sapotes are very astringent, irritant, caustic and bitter, and have been used as fish poison in the Philippines.

Other Uses

Wood: The wood is yellowish to deep-yellow with black markings near the heart of old trunks; compact and suitable for cabinetwork but little used. Reports of dark wood utilized for furniture are probably the result of confusion with other species of *Diospyros.*

Medicinal Uses: The crushed bark and leaves are applied as a blistering poultice in the Philippines. In Yucatan, the leaf decoction is employed as an astringent and is taken internally as a febrifuge. Various preparations are used against leprosy, ringworm and itching skin conditions.

Note: The rare, wild relative *D. revoluta* Poir., mentioned at the beginning, has not only been included with the black sapote under the erroneous *D. ebanaster,* but has also been dealt with as *D. nigra* Perr. and under at least 8 other binomials. In Puerto Rico, the Dominican Republic, Montserrat, Dominica and Guadeloupe it is variously called black apple, *barbara*, *bambarat, barbequois, bois noir*, *bois negresse*, *ebene*, *guayabota*, *plaqueminier*, and *zapote negro*. It has smaller, thicker leaves and smaller fruits than the black sapote and the calyx is square. Little, Woodbury and Wadsworth say the fruits are poisonous and, with the bark, used as fish poison.

Juglans nigra L.

Juglandaceae

Eastern black walnut

We have information from several sources:

Eastern Black Walnut: Potential for Commercial Nut Producing Cultivars—William Reid

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Black Walnut Toxicity —Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Outside links:

Walnuts, *Juglans* spp.

Black walnut—list of publications from Cooperative Extension Service, Purdue University, West Lafayette, Indiana.

Intercropping Black Walnut in Oregon's Willamette Valley

Walnut on the Web!

Walnut Crop Information University of California Davis

Black Willow

Salix nigra Marsh.

Other common names.—Swamp willow.

Figure 19.—Black willow (*Salix nigra*)

Habitat and range.—This tree is found in low ground and along streams from New Brunswick to western Ontario and in North Dakota, Florida, and Texas.

Description.—This willow is a tree attaining a height of 120 feet and a trunk diameter of 3 feet, with narrow lance-shaped leaves 2 1/2 to 5 inches long and up to three-quarters of an inch wide, finely toothed and hairy when young. Male and female flowers are borne in separate catkins which expand with the leaves the male catkins l to 2 inches and the female catkins 1 1/2 to 3 inches long.

Part used.—The bark and buds.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Vigna unguiculata (L.) Walp. ssp. *unguiculata*

Syn: *Vigna sinensis* (L.) Savi ex Hassk.

Fabaceae

Cowpea, Asparagus bean, Crowder pea, Black-eyed bean, Black-eyed pea, China bean, Crowder pea, Field pea, Long bean, Red pea, Southern pea, Yard-long bean

We have information from several sources:

Midwest Vegetable Production Guide for Commercial Growers 2000

Legume Species as Leaf Vegetables—Robert P. Barrett

Utility of Cowpea Foliage in a Crop Production System for Space—David L. Bubenheim, Cary A. Mitchell and Suzanne S. Nielsen

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

Cowpea—Alternative Crop Guide

Cowpea—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Opportunities in Vigna—Richard L. Fery

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Growing Beans In The Home Vegetable Garden—HO-175 Purdue University Cooperative Extension Service

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

As hay, pasture, and soil improvement crop:
Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Lesquerella fendleri (A.Gray) S.Wats.

Brassicaceae

Bladder-pod, Yellow-top

We have information from several sources:

FactSHEET contributed by: David A. Dierig

Vernonia and *Lesquerella* Potential for Commercialization—David A. Dierig and Anson E. Thompson

Lesquerella and Vernonia: Oilseeds for Arid Lands—David A. Dierig, Terry A. Coffelt, Francis S. Nakayama, and Anson E. Thompson

Development of a Cosmetic Grade Oil from *Lesquerella fendleri* Seed—James G. Arquette and James H. Brown

An Ovule Culture Technique for Producing Interspecific *Lesquerella* Hybrids—Pernell Tomasi, David Dierig, and Gail Dahlquist

Chemistry of New Oilseed Industrial Crops—Robert Kleiman

Arid-land Industrial Crops—Anson E. Thompson

Germplasm Use in Arid Lands Industrial Crops—Dennis T. Ray and David A. Dierig

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

New Crops or New Uses for Old Crops: Where Should the Emphasis Be?—Shelby F. Thames and Thomas P. Schuman

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

New Industrial Crops: Northwestern Argentina Regional Project—Ricardo Ayerza (h) and Wayne Coates

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark

New Crops Research and Development: A Federal Perspective—L.H. Princen

Salinity Effects on Growth, Shoot-ion Relations, and Seed Production of *Lesquerella fendleri*—Catherine M. Grieve, Michael C. Shannon, and David A. Dierig

Growth Analysis of Lesquerella in Response to Moisture Stress—Naveen Puppala and James L. Fowler

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Blessed Thistle

Cnicus benedictus L.

Synonyms.—*Carduus benedictus* Steud., *Carbenia benedicta* Adans.

Figure 20.—Blessed thistle (*Cnicus benedictus*)

Other common names.—Holy thistle, St.-Benedict's-thistle, Our Lady's thistle, bitter thistle, spotted thistle, cursed thistle, blessed cardus, spotted cardus.

Habitat and range.—The blessed thistle is a weed which is found sparingly in waste places and stony, uncultivated localities from Nova Scotia to Maryland and the Southern States, also on the Pacific coast.

Description.—This plant, which scarcely exceeds 2 feet in height, has a coarse, erect, branched, and rather woolly stem. The leaves are 3 to 6 inches long, more or less hairy, with margins lobed and spiny. The yellow flower heads which appear from about May to August are borne at the ends of the branches, almost hidden by the upper leaves, and are about 1 1/2 inches long. Surrounding the flower heads are leathery scales, tipped with long, branching, yellowish-red spines. The herb has a rather disagreeable odor which is lost in drying.

Part used.—The leaves and leafy flowering tops, gathered preferably just before or during the flowering period.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Carambola or Star Fruit

Jalea

Oxalidaceae *Averrhoa carambola* L.

Blimbe

Grosella china, Cucumber tree, Bilimbe

***A. bilimbi* L.**

Source: Magness et al. 1971

The carambola tree attains a height of 35 feet. Its fruits are star-shaped when cut across, ovoid to ellipsoid, yellow, 4 to 5 inches in length and are acutely 5-angled. The fruit is crisp, juicy, and aromatic. The ripe fruits are used for preserves, jams and jellies. The half ripe fruit is used as pickles.

The blimbe tree attains a height from 20 to 60 feet. The mature fruit resembles small cucumbers and range from 2 to 3 inches in length. They are smooth, thin, green, rind sometimes faintly 5-angled. Fruits of blimbe are candied as a preserve. The pulp also is used to make a refreshing drink.

Last update February 18, 1999 by ch

Sanguinaria canadensis L.

Papaveraceae

Bloodroot

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Last update Monday, April 17, 1998 by aw

Blue Cohosh

Caulophyllum thalictroides (L.) Michx.

Other common names.—Caulophyllum, papoose root, squawroot, blueberry root, blue ginseng, yellow ginseng.

Habitat and range.—Blue cohosh is found in the deep rich loam of shady woods from New Brunswick to South Carolina and westward to Nebraska, being abundant especially throughout the Allegheny Mountain region.

Figure 22.—Blue cohosh (*Caulophyllum thalictroides*)

Description.—Blue cohosh is from 1 to 3 feet in height and hears at the top one large almost stemless leaf which is divided into three divisions, each of which is again divided into three divisions consisting of three leaflets each. The latter have from three to five lobes. During its early growth the plant is covered with a bluish-green bloom which gradually disappears. The small greenish-yellow flowers are borne in small heads during April and May. The small round seeds, which ripen in August, are borne on stout stalks and resemble dark-blue berries. The thick, crooked rootstock is covered with a mass of matted roots.

Part used.—The rootstock with roots, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Blueflag Iris

Iris versicolor L.

Figure 23.—Blueflag iris (*Iris versicolor*)

Other common names.—Iris, flag lily, liver lily, snake lily, poison flag, water flag, American fleur-de-lis or flower-de-luce.

Habitat and range.—Blueflag iris delights in wet, swampy localities, making its home in marshes, thickets, and wet meadows from Newfoundland to Manitoba and south to Florida and Arkansas.

Description.—This well-known plant is from 2 to 3 feet hl height With an erect stem, sometimes branched near the top, and sword-shaped leaves, shorter than the stem, from one-half to 1 inch in width and showing a slight grayish bloom. The flowers, which appear from May to July, are large and handsome, each stem bearing from two to six or more. They have a peculiar form, consisting of six segments, the three outer ones turned back and the three inner ones erect and much smaller. They are purplish blue, the narrow base of the segments variegated with yellow, green, or white and marked with purple veins. Blueflag has a thick, fleshy, horizontal, branched rootstock producing many long, fibrous roots. It is poisonous and has caused poisonous effects in persons who mistook the plant for sweetflag which it resembles greatly when not in flower.

Part used.—The rootstock, collected in autumn. demand.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Blue grama

Gramineae *Bouteloua gracilis* (HBK) Lag. ex Steud.

Source: Magness et al. 1971

Blue grama is a long-lived native perennial grass that grows throughout the Great Plains. It is low growing, up to 18 inches, with small leaves, not over 6 inches long and 0.125 inch or less in width. It is found on all soil types, but thrives best on upland, rather beavy soils. It is drought resistant. Growth is late starting in spring. It is relished as pasture by all classes of livestock. It is one of the more important range grass species, standing heavy grazing well. It is readily established by seeding.

Last update February 18, 1999 by ch

Introduced Panicgrasses

Gramineae *Panicum* sp.

Source: Magness et al. 1971

Three species of*Panicum*, one introduced from India and two from Africa, are of some importance in parts of the United States.

Blue panicgrass, *P. antidotale* Retz., native to India, was introduced via Australia in 1912. It has a coarse, vigorous root system and is sodforming. Forage yields are high on fertile, well drained soils. It is important in parts of southwestern United States, both for dry-land and irrigated pastures. It is not winter hardy in northern locations.

Kleingrass, *P. coloratum* L., is a complex of grasses which includes both bunch and sod-forming types. It was introduced from Africa. Adapted to moist, heavy soil, it is used for pasture, hay and silage - mainly in South Texas. Plants have slender stems up to 4 feet, with abundant dark green leaves.

Guineagrass, *P. maximum* Jacq., is a warm-season, spreading grass from Africa used to a limited extent for pastures and silage in Florida and other southern areas. It is a tall, coarse grower with high nutritive value when leafy and green. It is not cold hardy. Propagation is by sod pieces.

Last update February 18, 1999 by ch

Blue Vervain

Verbena hastata L.

Other common names.—Verbain, false verbain, wild hyssop, simpler's-joy, ironweed.

Figure 24.—Blue vervain (*Verbena hastata*)

Habitat and range.—Vervain is found in moist fields, meadows, and waste places from Nova Scotia to British Columbia and Florida, Nebraska, and Arizona.

Description.—This rather rough, finely haired herb has an erect, straight 4-sided stem, 4 to 7 feet high, usually branched above with broadly lance-shaped sharply toothed leaves. The small, usually blue, flowers are densely clustered in numerous slender panicled spikes 2 to 6 inches long.

Part used.—The herb.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

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Blue wild-rye

Gramineae *Elymus glaucus* Buckl.

Source: Magness et al. 1971

This wild-rye is a perennial bunchgrass native throughout the Western States.
It grows in small tufts, reaching up to 5 feet. Leaves are broad and flat, up to 12 inches long. It is abundant on moist soils but will tolerate drought. The coarse leaves are relished by cattle, particularly while succulent. It is shade tolerant and gives high yields of pasturage or of good hay if cut early. It is propagated by seeds but has not been widely planted.

Last update February 18, 1999 by ch

Blueberry

Huckleberry

Ericaceae *Vaccinium* sp.

Highbush blueberry *V. corymbosum* L.

Lowbush blueberry *V. angustifolium* Ait.

Rabbiteye blueberry *V. ashei* Reade

Source: Magness et al. 1971

Several species of blueberries are native in the U.S., and fruits of many are gathered from the wild. The three species listed are the ones in commercial culture. The lowbush is not commercially planted, but thousands of acres of natural stands are pruned, sprayed and harvested. The highbush varieties, produced by breeding during the past half century, are now widely grown. The rabbiteye is increasing in importance in the Southeast.

Plants of all are woody shrubs, varying from 2 to 3 feet in the lowbush to 10 or more feet in the highbush and rabbiteye, but in cultivation held to 5 to 6 feet by pruning. Fruit is smooth skinned with a waxy coating or bloom. Individual berries are borne in clusters, are round to oblate in shape. Size up to 0.75 inch diameter in cultivated varieties; 0.25 to 0.5 inch in natives.

Season, bloom to harvest: 2 to 4 months.

Production in U.S.: About 27,000 tons.

Use: Fresh, frozen, canned, jam, culinary.

Part of fruit consumed: All.

Last update February 18, 1999 by ch

Bluegrasses

Gramineae *Poa* sp.

Source: Magness et al. 1971

Some 200 species of *Poa* are distributed throughout the cool, temperate regions of the world, with 65 species recognized in the United States. They are valuable for pasturage, hay and lawns. They are considered the most palatable of range and pasture grasses. The more important agricultural species follow.

Big bluegrass

Texas bluegrass

Bulbous bluegrass

Canada bluegrass

Mutton bluegrass

Kentucky bluegrass

Sandberg bluegrass

Roughstalk bluegrass

Last update February 18, 1999 by ch

Bulbous bluegrass

Gramineae *Poa bulbosa* L.

Source: Magness et al. 1971

This is a cool-season bunchgrass believed native to Southern Asia and the Mediterranean Area. It is now found in nearly all temperate and subtropical regions. In this country it is grown mainly in the Pacific Area, especially Southern Oregon and Northern California. Its distinctive feature is that it forms small, true bulbs at the base and small bulblets in the panicle. It rarely forms true seeds but is propagated by planting the bulblets, which can be handled in harvesting and planting much as though they were seed. The stems reach to 18 inches high. Growth starts in the fall and continues through winter and spring in mild climates. It ceases when the bulblets form about mid-May.

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Canada bluegrass

Gramineae *Poa compressa* L.

Source: Magness et al. 1971

This grass, like Kentucky bluegrass, is native to Europe but is extensively naturalized in Northern States. The foliage is a distinctive bluegreen in color. It spreads by underground rhizomes. It is adapted to open, rather poor, dry soils and under these conditions may be better than Kentucky blue for pastures or lawns. Forage is highly palatable and nutritions. Seed production is good, and propagation is by seeding.

Last update February 18, 1999 by ch

Poa pratensis L.

Syn: *Phalaris japonica* Steud.

Gramineae

Kentucky bluegrass

We have information from several sources:

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Food and feed crops of the United States Magness, J.R., G.M. Markle, C.C. Compton. 1971

Mutton bluegrass

Gramineae *Poa fendleriana* (Steud.) Vasey

Source: Magness et al. 1971

This grass is native from the Great Lakes westward to the Cascade Mountains and south into Mexico. It is a perennial bunchgrass with erect stems up to 24 inches tall. It develops tillers at the base and rarely produces short rhizomes. Leaves are mainly basal, are rather firm and stiff. They are folded or inrolled, rarely flat. The species grows under a wide range of conditions including elevations to near the top of the Rocky Mountains. It is also found among sagebrush and in open timber stands. It is well adapted to dry slopes and is found on clay loam as well as sandy or gravelly soils. It is drought resistant, palatable and nutritious, and starts growth very early. Even the dry growth is grazed well. These characteristics make it a valuable range crrass. The name reflects the value sheepmen place on the grass for sheep feed.

Last update February 18, 1999 by ch

Roughstalk bluegrass

Gramineae, Poaceae *Poa trivialis* L.

Source: Magness et al. 1971

This bluegrass generally resembles Kentucky blue but differs in that it does not have rhizomes. It is native to Europe and is more important there as a pasture grass than in this country. It is used in this country for pasture on wet soils and for lawns in shaded areas. It is not adapted to droughty conditions. Although highly palatable, its restricted areas of adaptation Iimit its general agricultural importance.

Last update July 1, 1996 bha

Sandberg bluegrass

Gramineae, Poaceae *Poa secunda* Presl

Source: Magness et al. 1971

This is a native bluegrass occurring generally throughout the Northern Plains and Western States. It is a bunchgrass reaching to 24 inches under optimum conditions. Leaves are rather sparse. The grass starts growth early in spring and matures and dries in midsummer. While green, and even after drying, the foliage is quite palatable, so it is a valuable range grass. Seed germination is usually low. Sandberg is usually seeded in combination with later growing grasses to obtain maximum pasturage over a long season.

Last update June 28, 1996 bha

Texas bluegrass

Gramineae, Poaceae *Poa arachnifera* Torr.

Source: Magness et al. 1971

This is a vigorous sod-forming perennial native in the Southeastern and Southern Plains States. Plants grow up to 3 feet on strong soil, with numerous leaves 6 to 12 inches long and 0.25 inch wide. The grass grows throughout the winter producing abundant, nutritious pasture which is highly palatable. This is a valuable species where native, but seeding is difficult. The species is dioecious, with male and female plants. It produces only limited quantities of seed which is covered with woolly hairs that are difficult to remove. Consequently, establishment of stands for agricultural use is limited.

Last update June 27, 1996 bha

Caucasian bluestem

Gramineae *Bothriochloa caucasica* (Trin.) C.E. Hubb.

Source: Magness et al. 1971

This bunchgrass bluestem from Russia shows promise as a pasture and hay grass for the Central and Southern Great Plains. The plant is leafy with fine stems and reseeds readily. It is palatable while succulent but ripens early so is less useful for late pasture than the native bluestems. It is especially useful for erosion control and is also used for pasture and hay. It thrives best on medium- to fine-textured soils but will also grow on sandy soil.

Last update February 18, 1999 by ch

Diaz bluestem

Gramineae *Dichanthium annulatum* (Forsk.) Stapf in Prain

Source: Magness et al. 1971

This is a warm season bunchgrass from South Africa, useful for pasture in South Texas. Stems are slender, erect to semi-decumbent, up to 5 feet in height. In one variety stems are leafy and have stiff leaves at the nodes. Plants reseed aggressively. The grass is palatable both as pasture and hay. Plants are drought tolerant, somewhat alkali tolerant, and well adapted to range seeding on heavy soils.

Last update February 18, 1999 by ch

Little bluestem

Gramineae *Schizachyrium scoparium* (Michx.) Nash

Source: Magness et al. 1971

This is a vigorous, long-lived native bunchgrass, widely distributed over the United States; but most prevalent in the Central and Southern Great Plains. It is usually found associated with big bluestem grass. It is more drought resistant that big bluestem, and a smaller plant - reaching not over 3 feet. Leaves are up to 8 inches long, and not over 0.25 inch wide. It furnishes dependable grazing and cured hay, but is not highly palatable. It is especially valuable for erosion control.

Last update February 18, 1999 by ch

Yellow bluestem

Gramineae *Bothriochloa ischaemum* (L.) Keng.

***Dichanthium aristatum* (Poir) C.E. Hubb.**

Source: Magness et al. 1971

These bluestems are both native to Central or Southern Asia. Yellow bluestem is used for pasture through the Southern Great Plains. *D. aristatum* appears not to have a common name, but varieties are known as Angleton and Gordo. They are used as pasture and hay in the humid Gulf Coastal Plain in Texas. Both of these species are warm season, semiprostrate bunchgrasses, leafy or medium leafy. In palatability *D. aristatum* appears superior to yellow bluestem but both furnish good pasturage and good hay if cut early.

Last update June 26, 1996 bha

Blumea lacera: Useful Plant

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www.celestine-india.com/pankajoudhia

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Blumea lacera L., Compositae, is one of the common rabi weeds of India (Oudhia and Tripathi 1999a). It is an annual herb, with a strong odor of turpentine. Stem is erect, ash colored, densely glandular, pubescent. Leaves are often incised or lyrate. There are many flower heads in single plant, arranged in axillary cymes or terminal panicle. Pappus is white. Fruits is an achene, oblong and not ribbed. Flowering time January to April (Agharkar 1991).

The plant occurs throughout the plains of India from the north-west ascending to 2,000 ft in the Himalayas. It is a common roadside weed in Ceylon and Malaya. It is distributed to the Malay Islands, Australia, China and Tropical Africa. *Blumea* consists of about 80 species (Caius 1986). *Blumea lacera* competes with rabi crops such as linseed, chickpea, and wheat for light, food and moisture (Oudhia, 1997) and harbors diseases and insects such as *Euplexia dolorosa*, *Eublemma trifasiciata* (Lefroy, 1909). *Blumea lacera* is described as a valuable medicinal plant in many popular systems of medicine including *Ayurveda*, homoeopathy, and unani. Stimulatory allelopathy of different parts of *B. lacera* on many agricultural crops has also been reported (Oudhia 1996). Not much work has been done on various utility aspects of *B. lacera*. In many parts of India, *Blumea* is cultivated for its green leaves and roots. *Blumea* is late kharif crop in these parts (Oudhia and Tripathi 1999b)

Reported Uses

Blumea is described in *Ayurveda* as bitter, astringent, acrid, thermogenic, errhine, anti-inflammatory, styptic, opthalmic, digestive, anthelmintic, liver tonic, expectorant, febrifuge, antipyretic, diuretic, deobstruant, and stimulant (Warner et al. 1996). The root kept in the mouth is said to cure disease of the mouth. In the Konkan region of India, the plant is used to drive away fleas and other insects. It is prescribed as an antiscorbutic in West Africa (Caius 1986). Essential oil from *Blumea* has been shown analgesic, hypothermic, and tranquilizing activities (Anonymous 1972). Campestrol has been isolated from aerial parts and 5-hydroxy-3, 6, 7, 3',4'- pentamethoxy flavone, 5,3',4' trihydroxy flavone and an unidentified flavone have been isolated from leaves (Rastogi and Mehrotra 1991). *Blumea lacera* is considered a valuable homoeopathic drug (Oudhia et al. 1998a) useful in case of enuresis, neuralgia, headache, cold borne cough. A tincture is useful in case of bleeding piles (Ghosh 1988). Natives of Chhattisgarh use this weed for treating health problems (Oudhia et al. 1998b). There is a heavy demand of different parts (fresh and dry both) of this weed in national and international drug markets (Oudhia and Tripathi 1999c). Farmers can earn extra income after selling various parts of *Blumea* with the help of co-operatives (Oudhia and Traipathi 1999d). Fresh leaves of *Blumea* are the most valuable part.

Stimulatory allelopathy of *B. lacera* on many agricultural crops such as rice has been reported (Oudhia et al. 1997b, 1998c,d) including rabi and kharif obnoxious weeds such as *Echinocloa colonum*, *Ageratum conyzoides* (Oudhia et al., 1998c), *Chenopodium album*, *Melilotus indica*, *Phalaris minor*, *Cirsium arvense*, and *Spilanthes* (Oudhia et al. 1997a)

Cultivation

Blumea is a late kharif crop. Standard agrotechniques have not been developed. Seeds are generally sown in late August on prepared land with good tilth; fertilizers are not used. Leaves are harvested at time of 50% flowering. Blumea leaf beetle (*Chrysolina madrasae* Jackoby) is the main insect pest (Oudhia 1989, 1997, 1999a,b,c,d; Oudhia & Thakur 1996).

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Boer lovegrass

Gramineae *Eragrostis chloromelas* Steud.

Source: Magness et al. 1971

This is a warm-season bunchgrass, introduced from South Africa in 1932. It is adapted to semidesert areas of the Southwestern States. The grass is palatable, drought resistant, and fairly long lived. It lacks hardiness for more northern areas. Seed of improved varieties is available.

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Punanrnava or Santhi (*Boerhaavia diffusa* Linn.)

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Punanrnava or Santhi (*Boerhaavia diffusa*)

Scientific Name: *Boerhaavia diffusa* Linn. Syn. *B. repens; B. repens* var. *diffusa*
Family: Nyctaginaceae
Family Name: Hog weed, Horse Purslane
Common Indian Names
Gujarati: Dholia-saturdo, Moto-satoda.
Hindi: Snathikari
Canarese: Kommegida
Marathi: Tambadivasu
Sanskrit: Punarnava, Raktakanda, Shothaghni, Varshabhu
Bengali: Punurnava
Tamil: Mukaratee-Kirei
Telugu: Punernava

Habitat: Grows as common weed.

Botanical Description: Please see Table 1

Useful Parts: Root, leaves and seeds.

Medicinal Uses: According to Ayurveda, Punarnava is bitter, cooling, astringent to bowels, useful in biliousness, blood impurities, leucorrhoea, anaemia, inflammations, heart diseases, asthma, alternatives etc. The leaves are useful in dyspepsia, tumours, spleen enlargement, abdominal pains. According to Unani system of medicine, the leaves are appetizer, alexiteric, useful in opthalmia, in joint pains. Seeds are tonic expectorant, carminative, useful in lumbago, scabies. The seeds are considered as promising blood purifier.

Traditional Medicinal Uses: In many parts of India, different parts of Punarnava are used as folk medicine.

Ayurveda Properties: Punarnavastaka, Punaravataila, Punarnavaleha etc.

Chemical Constituents: Punarnava contains b-Sitosterol, a-2-sitosterol, palmitic acid, ester of b-sitosterol, tetracosanoic, hexacosonoic, stearic, arachidic acid, urosilic acid, Hentriacontane, b-Ecdysone, triacontanol etc.

Internet Resources:

Traditional medicinal knowledge about useful herb Punarnava (Boerhaavia diffusa, family Nyctaginaceae) in Chhattisgarh Plains, India
http://botanical.com/site/column_poudhia/138_punarnava.html

Effect of different Homoeopathic drugs prepared from common weeds on radial growth of Oyster mushroom (*Pleurotus membranaceus*) under in vitro conditions
http://botanical.com/site/column_poudhia/99_mushroom.html

Table 1. Major differences between *B. diffusa* and *Boerhaavia elegans*

Characters	*Boerhaavia diffusa*	*Boerhaavia elegans*
Plant	A perennial herb from a fusiform root	An erect glabrous shrub
Stem	Prostrate, decumbent or ascending, 4-10 dm long, rather slender, divaricately branched	Annual, woody below, glabrous above, thinly pubescent near the base, terete
Leaves	Opposite or sub-opposite, two of a node unequal, broadly ovate or suborbicular, obtuse to rounded or subcordate at the base.	Linear-oblong or oblong-lanceolate, obtuse and often mucronulate at the apex
Flowers	In penduncculate, glomerulate clusters arranged in slender, long stalkcked, axillary or terminal corymbs	In large, lax, much branched, leafless, glabrous compound cymes above the leaves
Fruit	Obovoid or sub-ellipsoid, rounded above, slightly cuneate, below, broadly and bluntly 5-ribbed, very glandular throughout	
Flowering and Fruiting	Throughout the year in Indian conditions	September to December in Indian conditions

Bogbean

Menyantheas trifoliata L.

Other common names.—Buck bean, bog myrtle, bog hop, bog nut, brook bean, bean trefoil, marsh trefoil, water trefoil, bitter trefoil, water shamrock, marsh clover, moonflower, bitterworm.

Figure 25.—Bogbean (*Menyanthes trifoliata*)

Habitat and range.—The bogbean is a northern marsh herb occurring in North America as far south as Pennsylvania, Minnesota, and California.

Description.—This herb arises from a long, black, creeping, scaly rootstock, the leaves being produced from the end of the same on erect stems measuring about 2 to 10 inches in height. The leaves consist of three somewhat fleshy, smooth leaflets 1 1/2 to 3 inches long. The flower cluster is produced from May to July on a long, thick, naked stalk arising from the rootstock. It bears from 10 to 20 flowers each, with a funnel-shaped tube terminating in five segments which are pinkish purple or whitish on the outside and whitish and bearded on the inside.

Part used.—The leaves, collected in the spring.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Erythrina fusca Lour.

Syn.: *Erythrina glauca* Willd.
Fabaceae
Gallito, Coral bean, Bois immortelle

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Occasionally planted as a hedge and as a support for the betel vine in Assam and Bengal. Young leaves are eaten, raw or boiled, as a vegetable in Java. In Puerto Rico, trees have been planted in pastures and along fences and roads as ornamental shade trees. Elsewhere, they are used for cacao and coffee shade and living fence posts. Heartwood is light yellow to yellowish-brown and moderately soft. The lightweight wood is weak, not durable, and scarcely suitable for lumber.

Folk Medicine

According to Hartwell (1967–1971) seeds are used in folk remedies for cancer in Annam. Reported to have the same medicinal attributes as *Erythrina indica*, whose bark is used for fever, hepatosis, malaria, rheumatism, toothache, also for boils and fractures. Perry (1980) cites many more uses for *Erythrina indica*. The bark is used for poulticing fresh wounds in Malasia. Boiled roots are taken internally or externally for beri-beri. Grated wood used for hematuria (Perry, 1980). The root is used for rheumatism. Bark and leaves serve as a vermifuge (List and Horhammer, 1969–1979).

Chemistry

Per 100 g, the leaves are reported to contain 60 calories, 81.5 g H_2O, 4.6 g protein, 0.8 g fat, 11.7 g total carbohydrate, 4.1 g fiber, 1.4 g ash, 57 mg Ca, 40 mg P, 1.8 mg Fe, 2,300 μg β-carotene equivalent, 0.24 mg thiamine, 0.17 mg riboflavin, 4.7 mg niacin, and 3 mg ascorbic acid (Leung et al, 1972). Leaves contain (ZMB): 325 calories, 24.9 g protein, 4.3 g fat, 63.3 g total carbohydrate, 22.2 g fiber, 7.6 g ash, 308 mg Ca, 222 mg P, 5.2 mg Fe, 0.91 mg thiamine, 0.52 mg riboflavin, 6.54 mg niacin, and 78 mg ascorbic acid (Duke, 1981b). Seeds contain the alkaloid erythraline. Erysodine, erysonine, erysopine, erysothiopine, eryso- thiovine, crysovine, erythraline, erythramine, erythratine, and hypaphorine are also reported (List and Horhammer, 1969–1979). The similarity in alkaloid and amino acid patterns in *E. fusca* and *E. glauca* were considered by Krukoff (1972) in rendering these species synonymous.

Description

Deciduous armed tree, 10–20 m tall; to 1 m dbh; outer bark grayish, coarse, branches glabrous, sparsely armed with short prickles. Leaves trifoliolate; stipules caducous; petioles 8–18 cm long; rachis 4–8 cm long; petiole and rachis with 2 apical glands; leaflets ±ovate, ±rounded or acute at apex, glabrous above, with white appressed trichomes below; terminal leaflet 8–14 cm long, 7–12 cm wide; lateral leaflets smaller. Flowers thick, mostly 3 per node, in large, terminal, somewhat pendent racemes; pedicels stout, turned away from apex, ca 2 cm long; flowers showy, pale orange; stamens diadelphous, green, gradually arched, about halfway exserted. Legumes 15–20 cm long, 2 cm wide, densely brown-tomentose, pointed at apex, weakly ribbed on margins; seeds several, ellipsoid, dark brown, ca 12 mm long (Croat, 1978).

Germplasm

Reported from the Indochina-Indonesian and Central American Centers of Diversity (Croat, 1978), bois immortelle, or cvs thereof, is reported to tolerate waterlogging. Apparently it will not tolerate shade. ($2n = 42$)

Distribution

Mascarene Islands, from Northeastern India to Java, Polynesia and Sri Lanka. Near sea coasts, along rivers, and in places where soil conditions exclude the true "high evergreen forest" (Burkill, 1966). According to Croat, the species (as *E. fusca*) is widespread in the Old World tropics, while in the Americas (as *E. glauca*), it ranges from Guatemala throughout the Amazon Basin. In Panama, it is known only from Tropical Moist Forest, often forming pure stands in freshwater marshes, in the Canal Zone, Bocas del Toro, Cocle, Darien, and Panama (Croat, 1978). This is the most widespread species in the genus, and the only one occurring (on three continents, undoubtedly dispersed by marine currents (Krukoff, 1972).

Ecology

Estimated to range from Tropical Dry to Wet through Subtropical Dry to Wet Forest Life Zones, this coral bean is estimated to tolerate annual precipitation of 10 to 40 dm, annual temperature of 20 to 28°C, and pH of 6 to 8. According to Krukoff (1972) the species thrives in variety of conditions, seeming to prefer lowlands (seashores, swamps with outlets, low overflow lands, river banks, shores of lakes, etc.).

Cultivation

According to Martin and Ruberte (1975), this is one of the easiest species of *Erythrina* to grow. Like most *Erythrinas*, this probably roots readily from large fence-post sized cuttings. Seeds germinate rather rapidly.

Harvesting

For those risking them as vegetables, the young buds and leaves are probably at their tenderest when leafing out, often in tandem with the commencement of the rainy season.

Yields and Economics

No data available.

Energy

With no hard data available to me, I have no reason to suspect that this species would be any less productive than *E. poeppigiana*, which probably returns ca 25 MT/ha/yr in monoculture, 10 MT/ha in intercropping scenarios. Nitrogen fixing nodules are reported in Hawaii (Allen and Allen, 1981).

Biotic Factors

Croat suggests that hummingbirds pollinate the species, said to produce a copious nectar.

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Complete list of references for Duke, Handbook of Energy Crops

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Boneset

Eupatorium perfoliatum L.

Synonym.—*Eupatorium connatum* Michx.

Other common names.—Thoroughwort, thorough-stem, thoroughwax, wood boneset, teasel, agueweed, feverwort, sweating plant, crosswort, vegetable antimony Indian sage, wild sage, tearal, wild isaac.

Figure 26.—Boneset (*Eupatorium perfoliatum*)

Habitat and range.—Boneset is a common weed in low, wet ground, along streams, on the edges of swamps, and in thickets from Canada to Florida and west to Texas and Nebraska.

Description.—This plant is easily recognized by the peculiar arrangement of the leaves, which are opposite each other and joined at the base, making it appear as though they were one with the stem passing through the center. It is erect, growing rather tall, from 1 to 5 feet in height, with rough, hairy, stout stems. The crowded, flat-topped clusters of flowers are produced from about July to September and consist of small heads of tubular white flowers.

Part used.—The leaves and flowering tops, collected when the plants are in flower, and stripped from the stalk.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

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Borago officinalis L.

Boraginaceae

Borgae

We have information from several sources:

Borage Culture on the Black Soil Zone of Alberta, Canada—R. El Hafid, S.F. Blade, and Y. Hoyano

Borage: A New Crop for Southern Chile—M. Berti, R. Wilckens, S. Fischer, and R. Araos

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Borage: A Source of Gamma Linolenic Acid (Abstract)—James E. Simon, Nancy Beaubaire, Stephen C. Weller, and Jules Janick

Drawing by Mary Lou Overley

New Crops In The UK: From Concept to Bottom Line Profits—Francis H. Nicholls

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Plummer, J.A., J.M. Wann, J.A. Considine, and Z.E. Spadek. 1996. Selection of *Boronia* for essential oils and cut flowers. p. 602-609. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Selection of *Boronia* for Essential Oils and Cut Flowers*

Julie A. Plummer, Joanne M. Wann, John A. Considine, and Z.E. (Ted) Spadek

Several species of *Boronia* (Rutaceae) are endemic to the southwest of Western Australia. They grow in wet or seasonally wet low-lying areas and are usually associated with jarrah (*Eucalyptus marginata* Sm.) forests, paperbark (*Melaleuca parviflora* Lindl.) flats, and creeks. Two species are commercially exploited; *B. megastigma* Nees. (brown boronia) for its essential oils and *B. heterophylla* F. Muell. (red boronia, kalgan) for cut flowering stems (Plummer 1995). In the past total production was from plant material harvested from natural stands. With increasing demand and the need to improve quality these industries have shifted to harvesting cultivated plants.

B. megastigma plants bear a profusion of strongly scented bell-like flowers (Fig. 1). Petals are yellow on the inside, while outer petal color varies from yellow (cv Lutea) through red to dark brown. Outer petal color may be solid or in vertical red (cv Harlequin) or brown stripes (Plummer 1995). Essential oils are extracted from the flowers with hexane to yield about 0.4%-0.8% concrete. Concrete is washed with alcohol or distilled to yield 60% boronia absolute (Guenther 1949; Penfold and Willis 1954). Boronia absolute is valued at between US$4,000 to $10,000/kg, depending on quality and purity. It can be used in perfumes, cosmetics, and as a food flavoring where it enhances most fruit essences (Davies and Menary 1984; Weyerstahl et al. 1994). There are over 150 compounds in boronia concrete. ß-Ionone is by far the most important, but other compounds such as dodecyl acetate enhance the perfume. The monoterpene hydrocarbons, α-pinene, ß-pinene, and limonene detract from the aroma. Three cultivated genotypes have been shown to have a high degree of variability in their essential oil components (Davies and Menary 1984) but the diversity within the species has not been examined.

Cut flowering stems of *B. heterophylla* have been exported from Australia to Japan for 7 years and markets are growing in southeast Asia, Europe, and Canada. *B. heterophylla* is an upright shrub which produces a spectacular display of vibrant pink bell-shaped flowers each about 1 cm long in early spring. Cultivated plants can yield 8-12 stems 12-15 months from planting, 20-30 stems in the third year, and 30-60 stems in the fourth year with a commercial life of 5-6 years. Stems are usually 60 cm long and are picked with >50% of the flowers open (Plummer 1995). Although demand currently exceeds supply, the limited flowering season (1-2 weeks) and lack of flower color options are obstacles to future expansion.

Demand for both boronia absolute from *B. megastigma* and cut flowering stems of *B. heterophylla* is increasing. The export market potential is substantial and is likely to continue its rapid growth. Exports from Western Australia alone are expected to increase by 20% per annum. Boronia exports from Western Australia were valued at US$46,000 FOB (freight on board) in 1992/93 while the total value of boronia exports from Australia was US$180,000 FOB in the same year (Anon. 1994). Current wholesale prices for *B. heterophylla* range from US$2.00 to $3.50 per bunch, depending on supply. Wholesale prices for *B. megastigma* blossom for essential oil production range from US$10 to $15/kg.

Commercial production of both species is dependent on a few cultivars and selection of superior genotypes would be beneficial. The aim of this study was to investigate variation in the content of essential oil components of *B. megastigma* within and between populations, and over different seasons, and to extend the color range and production period of *B. heterophylla*.

METHODOLOGY

Boronia megastigma

For plant sampling in Aug. to Sept. 1993 *B. megastigma* flowers were collected from plants in 13 natural populations and from a yellow flowering selection growing in cultivation. In Aug. to Sept. 1994 flowers were collected from 16 natural populations. Flowers from 25 randomly selected plants were collected from the majority of populations, but where numbers of flowering plants were limited, fewer plants were sampled (n = 24 for the Walpole-2 and Palgarup-1 populations; n

= 20 for the Yallingup population; n = 22 for the Barlee population).

Details of flower color, plant age, and plant vigor were collected for all plants. Plant age was determined using the number of years since the last fire or major soil disturbance as an approximate age. Seedlings were determined as less than 1 year old, young plants 1-2 years, mature plants 2 to 6 years and old plants greater than 6 years. Plant vigor was determined by the density of leaves and flowers on each plant. Weak plants had few flowers and little foliage, average plants had moderate amounts of foliage and flowers, and vigorous plants had abundant flowers and lush green foliage. Oil component contents within each category were compared using analysis of variance and means were separated using Fisher's PLSD. The amount of shading by surrounding vegetation was determined for 273 of the plants sampled in 1993 using a Model-A forest densiometer (Lemmon 1957).

Seven to 10 plants from 12 natural populations initially sampled in 1993 were re-sampled in 1994 in order to investigate the quantity of oil components produced by individual plants over successive years. Comparisons were made using paired 2-tailed t-test.

For oil analysis 12 flowers collected from each plant were extracted with absolute ethanol (10 ml). Collection vials were weighed before and after flower collection and the difference used to determine flower fresh weight. Flowers were extracted for at least 24 h before oil analysis. An aliquot (4 ml) of the extract was analysed without further purification or concentration using a gas liquid chromatograph (Hewlett Packard 5890A) fitted with dual columns (50 m length, 0.25 mm internal diameter BPX70 from SGE International and 50 m length, 0.2 mm internal diameter ULTRA1 from Hewlett Packard) connected to a single injection port and twin ionization detectors. The injector and detector temperatures were set at 275°C. An initial oven temperature of 60°C was held for 5 minutes and then increased at a rate of 8°C min^{-1} to a final temperature of 260°C which was held for 10 min. Ethyl un-decanoate (1 µg ml^{-1}) was used as an internal standard. The quantity (µg g^{-1} fresh weight of flowers) of α-pinene, ß-pinene, limonene, α-ionone, ß-ionone, and dodecyl acetate was determined using the areas produced by the ULTRA 1 column. The BPX70 column was used to confirm the presence or absence of α-ionone, ß-ionone and dodecyl acetate. α-Pinene, ß-pinene, and limonene co-eluted with the solvent peak on this column.

Principal components analyses were performed on the oil data. The first analysis used the oil data from all individuals sampled to plot the orthogonal factor scores and determine the relationship between the different oil components. The second analysis used the mean data for each oil component from each population to determine the relationship between different populations in terms of the 5 oil components.

Boronia heterophylla

New populations of *B. heterophylla* were sought in 1994. Plants were tagged and their flowering period, flower density, flower color, and plant vigor were determined. Cutting material was taken from plants to assess their ease of propagation and subsequent growth and flowering in cultivation.

RESULTS

Boronia megastigma

The 29 *B. megastigma* populations identified cover most of the remaining natural range of the species however, much of this region is now agricultural land (Fig. 2). Flowers from all plants contained ß-ionone. α-Ionone was either absent or present in undetectable amounts and was therefore excluded from further analysis. ß-Pinene was absent from half of the plants, α-pinene from about a quarter of plants and limonene and dodecyl acetate were absent from only a few plants. Oil contents were used to rank each oil component (Table 1). Ranking was determined by a fixed percentage of plants whose oil component quantity fell within the stated range. The extremely high ß-ionone producers (those in the top 5%) contained 803 to 1787 μg g^{-1} of ß-ionone. ß-Ionone was the major essential oil component, followed by dodecyl acetate. α-Pinene and limonene were often present in similar quantities, and ß-pinene was usually the least abundant of the oil components examined.

The mean quantity of oil components varied considerably between populations. α-pinene, ß-pinene and limonene were commonly absent from individual plants, but each of these compounds was present in at least one plant in each population. Location had some influence on the content of the monoterpene hydrocarbons. Southeastern populations had quite high concentrations of α-pinene, ß-pinene, and limonene, while northern populations all had low concentrations. Location was not always a good indicator of the content of oil components. In the Jarrahwood area, Jarrahwood-3 produced more than twice the amount of α-pinene and ß-pinene as Jarrahwood-2 and Jarrahwood-4, even though the three populations are only a short distance apart. Location did not influence ß-ionone and dodecyl acetate. The highest mean ß-ionone content for a population was 736 μg g^{-1} at Albany-1 and the lowest was 227 μg g^{-1} at Porongurup-1.

The quantity of oil components from plants within populations varied considerably. The Walpole-1 population sampled in 1993 was typical of the variation in ß-ionone content within populations. ß-Ionone concentration ranged from very low (175 μg g^{-1}) to extremely high (1342 μg g^{-1}).

The relationship between oil components based on their quantitative presence in plants was investigated using principal components analysis. Results indicated that ß-ionone and dodecyl acetate were closely related and quite distinct from the monoterpene hydrocarbons. The was also a close relationship among the monoterpene hydrocarbons. α-Pinene and ß-pinene, and to a lesser extent, limonene were closely related.

Principal components analysis was also used to investigate the relationship between *B. megastigma* populations based on the mean content of oil components at each site. Results failed to show any distinct relationships between populations. However, among the populations sampled in each year there were certain populations which were closely related in terms of the mean content of the 5 oil components. Some populations in close proximity to each other were similar in oil composition, but others were distinct. Boyup Brook, Palgarup-1 and Palgarup-2 were within 33 km of each other and were closely related (1993 data). Jarrahwood-2 and Jarrahwood-4 were closely related, but Jarrahwood-3 was quite distinct (1994 data).

Canopy cover above *B. megastigma* plants affected concentrations of the monoterpene hydrocarbons but not ß-ionone ($y = 0.6x + 365$; $r^2 = 0.005$) and dodecyl acetate ($y = 0.8x + 273$; $r^2 = 0.009$). Plants shaded by higher densities of canopy cover produced lower concentrations of -pinene ($y = -3x + 267$; $r^2 = 0.09$), ß-pinene ($y = -2.2x + 156$; $r^2 = 0.09$), and limonene ($y = -2.1x + 160$; $r^2 = 0.09$).

Plant age, plant vigor, and flower color each affected the concentration of at least one of the five essential oil components investigated. Similar trends occurred in both years but only 1993 data is presented. Age affected four essential oil components (Table 2). Young plants contained less alpha-pinene and limonene than mature plants and less ß-pinene than seedlings, mature and old plants. Old plants had the most dodecyl acetate. Seedlings had more ß-pinene and limonene, and less ß-ionone and dodecyl acetate than older plants but, due to the low sample size of seedlings, the differences were not significant. Vigorous plants tended to produce more ß-pinene and limonene than weak plants (Table 3). Red flowers contained the lowest concentrations of ß-ionone and dodecyl acetate (Table 4). There was a tendency for red/brown flowers to have less ß-ionone and dodecyl acetate than brown flowers. Yellow flowers contained no ß-pinene.

In plants sampled in both years ß-ionone and dodecyl acetate content differed between the 1993 and 1994 sampling. The mean quantity of ß-ionone and dodecyl acetate was higher in 1994 than 1993, while α-pinene, ß-pinene and limonene content did not differ (Table 5). The mean quantity of the majority of oil components for each population sampled in 1994 was the same as for 1993. Where differences did occur, they could be attributed to either large differences in an individual plant, or numerous small differences in several plants within the population.

Twenty six plants were found to have no α-pinene in at least 1 of the years sampled. Of the plants found to have no α-pinene present in either the 1993 or 1994 analysis, 69% were found to have no α-pinene in both years. No ß-pinene was found in 53 plants in at least 1 of the years sampled. Of these plants, 85% had no ß-pinene in both years. Of the plants lacking limonene, only 21% had no limonene in both years. Many plants consistently had two or more of the hydrocarbon monoterpenes absent, and several were lacking all three.

Boronia heterophylla

Seven populations of *B. heterophylla* were located. A number of known sites no longer contained boronias or they had been recently burnt out by fires. Plants bearing flowers with a wide range of pink tones were identified but white flowers proved elusive. Most petals had solid color but some presented either vertical or horizontal bands of deeper color. Some populations had uniform plants with consistent pink colored flowers whilst others showed considerable variation in both plant form and petal color. Flowering period was very uniform with nearly all plants flowering in early Sept. (early spring, southern hemisphere). The exceptions were one plant which flowered two weeks earlier and others which flowered up to several weeks later than the general population. Some plants proved easier than others to propagate from cuttings. The resulting plants will be assessed in cultivation during their first flowering season in Sept. 1996.

DISCUSSION

Considerable diversity was identified both within and between populations of *B. megastigma* and *B. heterophylla*. In *B. megastigma* flowers, ß-ionone was the major oil component followed by dodecyl acetate. These two compounds impart much of the desirable perfume of boronia absolute and their close association following principle components analysis is promising for the selection of genotypes with very high yields of both compounds. The monoterpene hydrocarbons, α-pinene, ß-pinene, and limonene are undesirable in boronia absolute. These components were also linked but were quite distinct from ß-ionone and dodecyl acetate. These relationships indicate that selection of genotypes which produce very high quality oil with abundant ß-ionone and dodecyl acetate and little or no monoterpenes is possible.

The relationships between ß-ionone and dodecyl acetate and α-pinene, ß-pinene, and limonene is supported by the work of Bussell et al. (1995) on volatile oil ontogeny in *B. megastigma*. The stigma, stamen, and staminode tissue contained dodecanol, ß-ionone, dodecyl acetate, and heptadecene among the principal components. ß-Ionone and dodecyl acetate concentrations were highest in the stigma extracts. Extracts of the combined ovary, nectary, and receptacle tissue contained primarily α-pinene, ß-pinene, and limonene. The petal tissue contained relatively low concentrations of all of the above-mentioned volatile compounds.

The recorded characteristics of *B. megastigma* and *B. heterophylla* varied considerably between populations. Although current populations were quite isolated from one another, this is likely to be a recent event due to a number of factors, such as over-picking, frequent fires, and land clearing for agriculture. Boronia flowers are pollinated by an unidentified small moth (Bussell et al. 1995). It is possible that as populations have become more isolated, the movement of pollinators could be restricted to individual populations or a few close populations. This would result in distant populations becoming more genetically isolated over time. For example *B. megastigma* populations in the southeastern area of their range had quite high concentrations of α-pinene, ß-pinene, and limonene while northern populations all had low concentrations.

Populations in close proximity may remain genetically similar not only due to pollen transfer but also water flow which could wash seeds down river from one population to another. Populations within the same water catchment area, e.g. (*B. megastigma*) Jarrahwood-2 and Jarrahwood-4, appeared closely related, while nearby populations located within different catchment areas e.g. Jarrahwood-3 were occasionally quite distinct. However, location did not always explain the differences between populations. There are many environmental factors which may affect flower color, oil content, and plant vigor.

Canopy cover was used as a crude measure of shading levels. In open conditions with little canopy cover and shade, *B. megastigma* produced high amounts of α-pinene, ß-pinene, and limonene. In dense forest where canopy cover and shade levels were high, monoterpene hydrocarbons were produced in lower quantities. A number of essential oil species have decreased yields when they are grown under shade. In peppermint (*Mentha piperita*) high oil yield, including the production of limonene, results from high light intensity (Clark and Menary 1980). Reduced oil production occurs under low radiation in Japanese mint (*Mentha arvensis*) (Duriyaprapan and Britten 1982). In contrast to our results, experiments by Bussell (1996) showed that 70% shade cloth (30% of ambient light) had no effect on α-pinene and limonene concentrations (ß-pinene was not tested) in three clones of *B. megastigma* and ß-ionone and dodecyl acetate concentrations increased. Although the genetic material used by Bussel (1996) was different, the shade levels much higher and the plants grown under cultivation, these differences highlight the need to further investigate the influence of shading. Light may also affect flower color in *B. heterophylla*. Anthocyanins contribute to red flower color and anthocyanin production in many species is modified by light quality and intensity. Flowers of *B. heterophylla* are known to fade during senescence (Plummer 1995) but the influence of light on pigment intensity remains unknown.

Plant age, vigor, and flower color affected the concentration of oil components in *B. megastigma*. Unfortunately concentrations of oil components produced by seedlings was not a good indication of production in the adult plant. This reduces the possibility of screening seedling material for high quality oil in a breeding program. Red-flowering plants are unlikely to be used in commercial production of oil as they produced low amounts of the favorable compounds, ß-ionone and dodecyl acetate. Plants with yellow flowers produced very little limonene and no ß-pinene but relatively high levels of ß-ionone and dodecyl acetate. Bussell (1996) also found ß-pinene to be absent from yellow flowering *B. megastigma*. Apart from these trends flower color does not appear to be a useful tool in selecting plants with high oil quality.

Some differences in oil content were detected between 1993 and 1994. The concentrations of the undesirable oil components, α-pinene, ß-pinene, and limonene were fairly consistent which permits genetic selection for low or no production. The change in ß-ionone and dodecyl acetate content was only marginal but offers the possibility of environmental manipulation, such as site selection, to increase yield.

Boronia heterophylla plants with a range of solid and striped flower colors, and plants which flower outside the usual two-week flowering period were identified. Most of these plants could be propagated successfully. Plants will need to be examined in cultivation to determine if these characteristics are genetically controlled. Plants will also need to be assessed for their ability to produce numerous high quality stems and withstand the substantial pruning at harvest. Selected plants with these attributes will increase the colour range and harvest period.

Although many of the original populations of *B. megastigma* and *B. heterophylla* no longer exist much variation exists in the remaining plants. Natural pollination of boronias requires the presence of a pollinator moth and her movements tend to ensure out-crossing. Thus the remaining plants probably contain most of the original genetic diversity. Boronias can be manually self and cross pollinated (Plummer and Considine 1995) and a breeding program has commenced. *B. megastigma* plants with high yields of ß-ionone and dodecyl acetate and low or no monoterpene production were identified. Collection from natural stands is inadequate to meet demand and expansion of cultivation is underway. Currently boronia absolute is only used in the food flavoring sector and development of new uses will require expanded production. *B. heterophylla* plants with a range of pink flower tones and different flowering periods were identified. Although these characteristics will need to be confirmed under conditions of commercial cultivation they show promise for the improvement of product quality and the expansion of production of these new crops.

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*Joint contribution of Plant Sciences, Faculty of Agriculture, The University of Western Australia, Nedlands, WA 6907 and the Agricultural Chemistry Laboratory, Chemistry Centre of Western Australia, 125 Hay Street, East Perth, WA 6004, Australia. Research supported in part by the Rural Industries Research and Development Corporation, Sunglow Flowers Pty. Ltd. and Plantex Australia Pty. Ltd.

Table 1. Ranking of the 5 oil components determined using the gas liquid chromatography results from the 718 plants sampled in 1993 and 1994.

		Oil content (µg g^{-1} FW)				
Rank	% of total plants	α-Pinene	ß-Pinene	Limonene	ß-Ionone	Dodecyl acetate
Extremely high	5	420-1001	298-940	264-893	803-1787	577-1291

Very high	5	303-419	207-297	184-263	646-802	518-576
High	10	193-302	140-206	118-183	548-645	427-517
Medium	60	0-192	0-139	33-117	260-547	178-426
Low	10	0	0	25-32	199-259	115-177
Very low	5	0	0	15-24	162-198	84-114
Extremely low	5	0	0	0-14	70-161	0-83

Table 2. The influence of plant age on concentration (μg g^{-1} fresh flower weight) of oil components of *Boronia megastigma*. Mean separation in columns by Fisher's PLSD, 5% level.

	Component (μg g^{-1} FW)				
Plant age	α-Pinene	ß-Pinene	Limonene	ß-Ionone	Dodecyl acetate
Seedling	156ab	231b	125ab	234a	169ab
Young	90a	29a	44a	395a	274a
Mature	159b	93b	99b	382a	297a
Old	144ab	87b	60ab	391a	364b

Table 3. The influence of plant vigour on concentration (μg g^{-1} fresh flower weight) of oil components of *Boronia megastigma*. Mean separation in columns by Fisher's PLSD, 5% level.

	Component (μg g^{-1} FW)				
Plant vigor	α-Pinene	ß-Pinene	Limonene	ß-Ionone	Dodecyl acetate
Weak	120a	76ab	48a	411a	347a
Average	145a	80a	84a	383a	303a
Vigorous	207a	161b	157b	379a	265a

Table 4. The influence of flower colour on concentration (μg g^{-1} fresh flower weight) of oil components of *Boronia megastigma*. Mean separation in columns by Fisher's PLSD, 5% level.

	Component (μg g^{-1} FW)				
Flower color	α-Pinene	ß-Pinene	Limonene	ß-Ionone	Dodecyl acetate
Yellow	287a	0	27a	380ab	273abc
Red	121a	100a	86a	263a	172a
Red/brown	140a	79a	84a	378b	280b
Brown	157a	88a	90a	407b	338c

Table 5. Mean ± SE quantity of oil components from flowers of *Boronia megastigma* sampled in 1993 and 1994 (n = 109).

	Component (μg g^{-1} FW)

Year	α-Pinene	ß-Pinene	Limonene	ß-Ionone	Dodecyl acetate
1993	157±17	86±11	80±7	415±16	323±16
1994	142±15	81±10	84±7	452±16	398±17

Fig. 1. Young (2-year-old) *Boronia megastigma* plant in cultivation in Nannup, Western Australia.

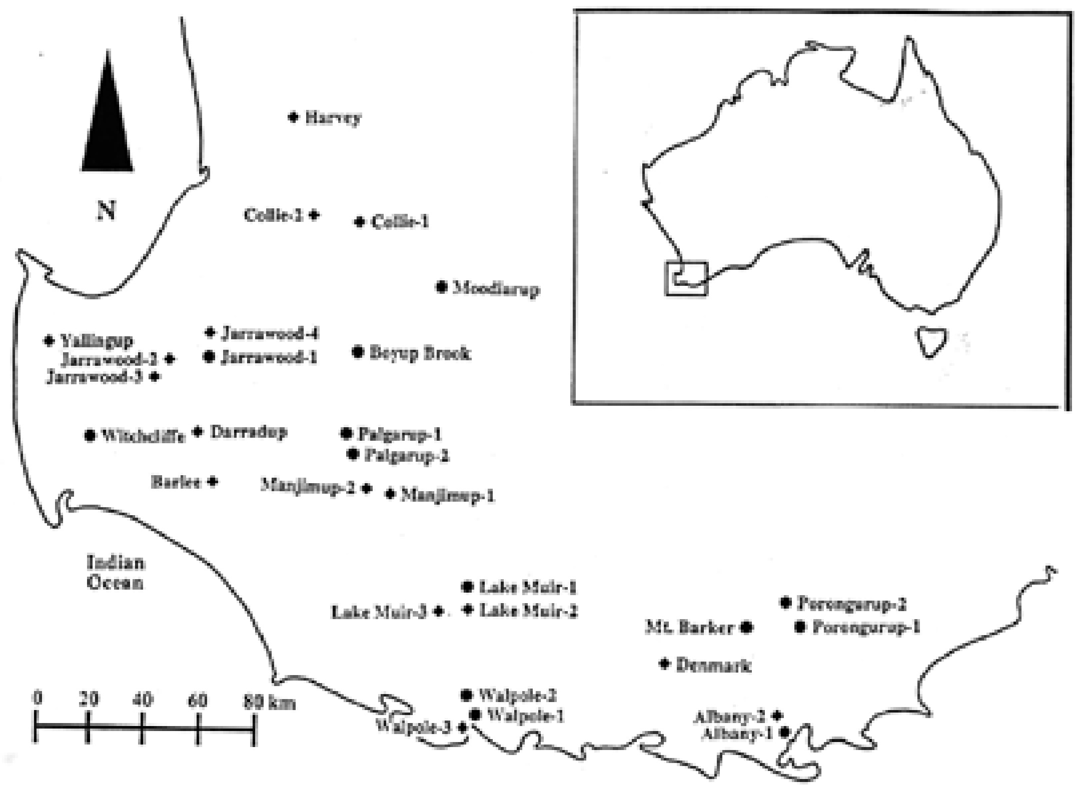

Fig. 2. *Boronia megastigma* populations in the south west of Western Australia. l denotes populations sampled in 1993, and u denotes populations sampled in 1994.

Last update August 25, 1997 aw

Lagenaria siceraria (Mol.)

Cucurbitaceae

Cucuzzi, Spaghetti squash, Bottle gourd, *Doodhi, Hue, Kampyo*

We have information from several sources:

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Side-oats grama

Gramineae, Poaceae *Bouteloua curtipendula* (Michx.) Torr.

Source: Magness et al. 1971

This is a long-lived native grass, widely distributed, but most abundant in the Central and Southern Great Plains. It produces short rhizomes and tends to a bunch-type growth. The leaves are about 6 inches long and under 0.25 inch wide. Flower stems may reach to 3 feet. It produces an abundance of leafy forage well liked by all classes of livestock. Hay of good quality is produced if mowed sufficiently early. It is adapted to wide ranges of soil and climate. Seedling vigor is good, and stands are readily established by seeding. Generally, side-oats grama is seeded in mixtures with other grasses. Several varieties of superior local adaptation are in the trade.

Last update June 28, 1996 bha

Grama grasses

Gramineae *Bouteloua* sp.

Source: Magness et al. 1971

Some 18 species of *Bouteloua*, the grama grasses, are native in the United States, mainly throughout the Great Plains and Western States. They are summer growers, and the amount of growth produced is dependent on available moisture. Most species cure naturally, so growth from a previous season is palatable for livestock. They are prized as forage producers on range and pasture land. The three most valuable species are side-oats grama, black grama, and blue grama.

Last update February 18, 1999 by ch

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Mimosa scabrella Benth.

Syn.: *Mimosa bracatinga*
Mimosaceae
Bracatinga

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Regarded as a useful living fence post or ornamental avenue tree. Useful for reforestation. It sheds copious leaves forming a good humus. Makes an excellent fuel wood. Though its pulp is inferior to *Eucalyptus saligna* it is promising for printing and writing papers (fibers average 1.1–1.2 mm long). Used for coffee shade in Guatemala, where Standley and Steyermark (1946) say, "The coffee plantations shaded by bracatinga are very handsome, for the trees are uniform in height, their crowns far above the coffee bushes... The bracatinga has been much advertised in tropical America in recent years as a tree suitable for reforestation...until better trees could take its place."

Folk Medicine

No data available.

Chemistry

I find no data on this species. *Mimosa hostilis* reportedly contains the hallucinogen N,N-dimethyltryptamine, and is used in making a beverage which translates "Wine of Jurema." Interestingly, this species is called catinga instead of bracatinga.

Description

Unarmed tree to 15 m tall, 40 cm in diameter, with sparse broad crown, the trunk branching shortly above the base; bark whitish, young branchlets lepidote. Leaves bipinnate; the pinnae mostly 5–7 pairs; leaflets 25–35 pairs, oblong-linear, obtuse, stellate, subterminal peduncles ca 1.5 cm long, the heads about 7.5 mm in diameter. Sepals glabrous, ca 1.2 mm long. Corolla 4-lobed, stellate tomentose, ca 3.5 mm long. Stamens 4. Pods sessile, oblong-linear, obtuse, verrucose-tomentose 20–25 x 5–6 mm 2–4-jointed. Seeds castaneous, 3–4 mm long.

Germplasm

Reported from the South American Center of Diversity, bracatinga, or cvs thereof, is reported not to tolerate wet soils which tend to stunt its growth.

Distribution

Native to the cool subtropical Parana plains of Southeastern Brazil although Standley and Steyermark (1946) have reported its introduction into Guatemala. Small plots have been established in Argentina, Colombia, Ethiopia, Guatemala, Jamaica, Mexico, Portugal, El Salvador, Senegal, Spain, Venezuela, and Zaire.

Ecology

Estimated to range from Tropical to Subtropical Moist Forest Life Zones. Grows in many types of well-drained soils. Grows at 2,400 m in Guatemala.

Cultivation

Easily planted by seed, 3–4 seed sown in depressions 3–4 cm deep. Spaced at 2–3 m. Readily cultivates in plantations, even at exceptionally close spacings (NAS, 1979).

Harvesting

Some plantations have been harvested on rotations of only 3 years.

Yields and Economics

May attain 15 m tall in 3 years, 8–9 m in 2 years, and 5 m in 14 months.

Energy

Before the advent of the diesel, bracatinga was grown to fuel Brazilian railroads. Although the plant is reported to fix nitrogen, Allen and Allen (1981) do not cite it as a nodulated species.

Biotic Factors

Agriculture Handbook No. 165 lists the following diseases for *Mimosa* spp.: *Cylindrosporium* sp. (leaf spot), *Lipocystis caesalpiniae* (rust), *Meliola bicornis* and *Meliola denticulata* (black mildew), *Phymatotrichum omni-vorum* (root rot), *Ramularia mimosae* (leaf spot), *Ravenelia dysocarpae* (rust), and *Ravenelia fragrans* (rust). Golden (p.c. 1984) reports the nematode *Meloidogyne incognita acrita.*

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Bracheri mutica (Forsk.) Stapf.

Syn.: *Panicum barbinode* Trin. *Panicum purpurascens* Raddi *Panicum muticum* Forsk.

Poaceae

Paragrass

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update July 3, 1996 by aw

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Proso millet

Broomcorn millet, Hog millet, Hershey millet

Gramineae, (Poaceae)

***Panicum miliaceum* L.**

Source: Magness et al. 1971

Proso millet is the only millet grown as a grain crop in the United States. Other millets as foxtail, Japanese or barnyard, and pearlmillet or cattail are grown mainly for forage or pasture and are listed under Grass Forage and Pasture Crops.

Proso millet is probably grown on not more than 150,000 acres in the United States, though actual data are unavailable. Most production is in the Northern Plains and other short-growing season areas. In Asia, Africa and Russia, grain millet is an important food crop, but is less important than formerly as other adapted grains are more desirable. Since proso millet will mature a grain crop in from 60 to 75 days after seeding, and is low in moisture requirement, it will produce some food or feed where other grain crops would fail.

Millets have been grown in Asia and North Africa since prehistoric times, and little is known of their origin. They probably came originally from Eastern or Central Asia. They were important in Europe during the middle ages before corn and potatoes were known there. Today they are of minor importance in Western Europe.

Proso millet grows up to four feet with stout, erect stems which may spread at the base. Stems and leaves are hairy. The panicle or flower head is rather open, like oats, and drooping. In different varieties it may be spreading, one-sided, or erect. The branches in the panicle bear spikelets only toward the tips. Each spikelet has two unequal glumes and a single flower. The flower consists of the lemma and palea, enclosing the stamens and pistil. As in oats, the lemma and palea adhere to and are a part of the threshed grain. The ripened seed is small (about 2 mm. wide and 2.5 mm. long), ovate and rounded on the dorsal side. Seeds range in color from white or cream to yellow, brown or nearly black. The seeds do not mature uniformly and shattering of those first ripe often occurs before others are mature. For this reason the crop is usually mowed and cured in the swath or windrow prior to combining.

As food in Old World countries, millet is used as a meal for making baked foods, as a paste from pounded wet seeds or as boiled gruel. As feed the grain is eaten readily by livestock, and is equal to or superior to oats in feed value. It should be ground for livestock feed. It is also used in poultry and bird seed mixes.

A related species is brown top millet, *P. ramosum* L.,-*Brachiaria ramosa* (L.) Stapf., which is sometimes seeded for game bird pasturage in the Southeastern States.

Last update September 22, 1996

Mustards

Brassicaceae, or Cruciferae

We have information from several sources:

Herbs: An Indexed Bibliography. 1971-1980—J.E. Simon, A.F. Chadwick and L.E. Craker

Midwest Vegetable Production Guide for Commercial Growers 2000

Mustard: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Black Mustard In: Potential of Fanweed and Other Weeds as Novel Industrial Oilseed Crops—Patrick M. Carr

Handbook of Energy Crops. 1983. James A. Duke. unpublished
Brassica juncea
Brassica nigra
Sinapis alba

The Herb Hunters Guide—A.F. Sievers. 1930.

Potential of Sugar Beet Nematode-Resistant Radishes and Mustard for Use in Sugar Beet Rotations—James M. Krall, David W. Koch, Fred A. Gray, and Li Mei Yun

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

New Crops for Canadian Agriculture—Ernest Small

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Magness, et al., 1971. Food and Feed Crops of the United States.
Black mustard and Condiment mustards
White mustard
Tuberous rooted Chinese mustard

Brassica rapa L.

Syn.: *Brassica campestris* L.

Brassicaceae or Cruciferae

Turnip, chinese cabbage, field mustard, seven top, shogun, turnip greens, turnip rape

We have information from several sources:

Asian Vegetables: Selected Fruit and Leafy Types—Marita Cantwell, Xunli Nie, Ru Jing Zong, and Mas Yamaguchi

Comparison of Somatic and Sexual Interspecific Hybridization for the Development of New Brassica Vegetable Crops.—R.H. Ozminkowski Jr. and P.S. Jourdan

Growing and Marketing Chinese Vegetables in Central Kentucky— Wenwei Jia, Mary Witt, and John Strang

Evaluating Chinese Cabbage Cultivars for High Temperature Tolerance—I-Mo Fu, Carol Shennan, and Gregory E. Welbaum

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Turnip: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Midwest Vegetable Production Guide for Commercial Growers 2000

Cole Crops production links

Brassica food crops. In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Chinese group
- Pekinensis group
- Rapifera group

- Ruvo group
- White mustard
- Tyfon or Holland Greens

Rapeseed and Canola

Carr, P.M. 1993. Potential of fanweed and other weeds as novel industrial oilseed crops. p. 384-388. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Potential of Fanweed and Other Weeds as Novel Industrial Oilseed Crops*

Patrick M. Carr

Diversification has been suggested as a possible strategy for improving the financial condition of United States crop producers (Jolliff and Snapp 1988; Jolliff 1989). Agricultural production of industrial feedstocks, for example, would open additional markets to farmers who typically grow only food and feed crops. In some instances, farm production of industrial feedstocks could be quite profitable since high-value specialty chemicals are contained in the seeds of some plants (Hinman 1986).

While crambe, (*Crambe abyssinica* Hochst.), ironweed [*Vernonia galamensis* (Cass.) Less.], and several other plant species have been identified as promising industrial crops (Princen 1983), few studies have evaluated the potential of present weed species as sources of high-value specialty chemicals and industrial feedstocks (Clopton and Triebold 1944; Shultz et al. 1983). There are several weeds that are well adapted to growing conditions in different regions of the United States and could be grown as sources of industrial chemicals if domesticated. While a plant may contain desirable chemicals or have valuable properties, it is unknown if these plant species could be developed for field production. The objective of this research was to evaluate the agronomic potential of four weeds occurring in the Northern Great Plains: fanweed [*Thlaspi arvense* (L.)], black mustard [*Brassica nigra* (L.) Koch], wild mustard [*Brassica kaber* (DC.) Wheeler], and hare's ear mustard [*Conringia orientalis* (L.) Dumort]. These four weeds were studied since previous work indicated that each contained valuable specialty chemicals (Appelqvist 1971), or were related to other plant species which were sources of valuable chemicals. The potential of *Euphorbia lagascae* Spreng., as a field crop was also considered since past research indicates it may have potential as an industrial crop (Krewson and Scott 1966), even though this plant species is neither native to, nor naturalized in, the United States.

METHODOLOGY

1990

A field evaluation was conducted under dryland management at the Carrington Research/Extension Center (47°30' N, 99°7' W) in central North Dakota. Seed samples of a single accession of black mustard, hare's ear mustard, and *Euphorbia lagascae* were obtained from the USDA/ARS National Center for Agricultural Utilization Research in Peoria, Illinois, while seed of wild mustard and fanweed were collected from wild stands. Seed of each species along with crambe, an industrial crop which is grown in North Dakota, was planted in nonreplicated 1.4 m^2 plots on May 17. The agronomic potential of each species was rated on the basis of its ease of establishment, rate of growth, initiation and duration of flowering, susceptibility to lodging and pests, seed development (determinate or indeterminate), susceptibility of seeds to shatter, and other factors. Height of 10 plants of each species was measured prior to harvest. A 0.7 m^2 area was harvested by hand for determination of dry matter, grain yield, and seed weight.

1991

The six plant species included in the 1990 field experiment were each planted in 8.2 m^2 plots in a randomized complete block design with four replicates. The agronomic potential of each plant species was evaluated as described. A sunfleck ceptometer (Decagon Devices, Inc., Pullman, WA) was used to quantify the amount of photosynthetically active radiation (PAR) that was intercepted by the plant canopy in plots of two replicates on selected dates during the growing season. Plants in a 1.9 m^2 area from the central portion of each plot were harvested for determination of dry matter, grain yield, and seed weight. Seed oil content and fatty acid distribution of the oil were determined for a representative sample of each species by mass spectroscopy at the Food and Cereal Science Laboratory at North Dakota State University, in a manner previously described (Riveland 1991).

RESULTS AND DISCUSSION

Fanweed

Fanweed (*syn*. stinkweed, field pennycress, pennycress) was rated as having excellent potential as a new crop if established in the fall (Table 1). Poor germination of spring-sown fanweed seed was a problem. As a result, yield of fanweed was low when planted in the spring. Metzger (1990) reported that exposure to temperatures of 0° to 10°C for 3 to 6 weeks can break the dormancy of fanweed seed. Dormancy can be broken if seed is scarified by scratching the seedcoat (Best and McIntyre 1975), although this was not true for spring-sown seed in this study. Broadcast planting rather than seed drilling is desirable, since exposure to light seems to enhance seed germination. Overwintering fanweed plants were in full-flower by mid-May, while other plant species were still seedlings. Hence, seed production by most fanweed plants was completed prior to the relatively hot, dry conditions which developed by mid-July during 1990 and 1991.

Seeds, contained in pods, tended to shatter as plant moisture levels declined; however, plants could be swathed to minimize harvest loss from shattering and to promote uniform seed maturation. If swathed, fanweed could be harvested in mid-June in the Northern Great Plains, possibly enabling a second crop to be planted in the field during the same growing season. Double cropping would likely be possible in more southern portions of its range in North America.

Individual fanweed plants established in the fall produced an average of 1,600 seeds, translating into an estimated yield of about 1,500 kg/ha for both years. This yield is similar to that reported in Montana during the 1940s when fanweed was experimentally grown under irrigated management (Clopton and Triebold 1944), and to seed production estimates of wild stands in Canada (Best and McIntyre 1975). Seed yields in excess of 1,300 kg/ha are not unusual when seed from wild fanweed stands is grown in the northern United States.

Fanweed demonstrated potential as an industrial crop on the basis of seed oil content and composition (Table 2). Fanweed seed contained about 26% oil by weight; the oil, in turn, was close to 40% erucic acid (22:1). Erucic acid is an unusual fatty acid with several industrial applications (Van Dyne et al. 1990). While the level of erucic acid in the seed produced by crambe was greater than that produced by fanweed, consideration of pests, crop rotations, and other factors could make fanweed a promising candidate for new crop development.

Black Mustard

Black mustard was rated as having very good to excellent agronomic potential. Plants were easy to mechanically sow and manage. Growth was vigorous and large plants developed (Table 1). Seed production was underway by early July; the seeds which developed were contained in pods from 1.3 to 1.9 cm long which tended to shatter as plant moisture levels declined. Plants would probably need to be swathed prior to harvesting. Black mustard may fit as a short season crop in some crop rotations in the Northern Great Plains.

Black mustard produced relatively large amounts of seed (>1,200 kg/ha) during 1990 and 1991 (Table 1). In 1991, close to 1,900 kg/ha of seed was produced, making black mustard the highest yielding species evaluated. By comparison, yield of crambe averaged 1,820 kg/ha in 1991. Unlike fanweed, seed dormancy was not a serious problem with black mustard, so relatively good plant stands were fairly easy to establish in the spring.

Black mustard produced seed that was 32% oil (Table 2). Of this, roughly 40% was erucic acid. As with fanweed, black mustard demonstrated potential as an industrial crop, even though crambe seed contained greater amounts of erucic acid.

Wild Mustard

Wild mustard (charlock, kaber mustard) was considered to have very good to excellent agronomic potential. Plants were easy to mechanically sow and manage, and seeds appeared to lend themselves to mechanical harvesting methods. As with fanweed and black mustard, seeds of wild mustard were susceptible to shattering so plants would probably be swathed prior to harvesting the seed if grown on a field-scale.

Wild mustard produced roughly 2,000 kg/ha of seed during 1990 and 1991 (Table 1). Individual plants produced an average of 2,076 seeds which were contained in pods approximately 2.5 cm in length. The seed contained about 26% oil but failed to be comprised of a high percentage of highly valued fatty acids (Table 2). For this reason, wild mustard was considered to have low potential as an industrial crop.

Hare's Ear Mustard

Hare's ear mustard (*syn*. hare's mustard) was considered to have moderate agronomic potential. Plants were generally easy to mechanically sow and manage. However, about 15% of the stand was destroyed by an unknown pathogen in 1991. Plants were short (<40 cm) and some seed pods were less than 10 cm above the soil surface (Table 1). This could present difficulties in the mechanical harvesting process. Seed could be harvested without first swathing the plants since seed pods were not susceptible to shattering.

Hare's ear mustard produced relatively low quantities of seed in 1990 and 1991 field evaluations; yields averaged 901 kg/ha in 1990 and only 549 kg/ha in 1991 (Table 1). Individual plants produced an average of 590 seeds which were contained in seed pods about 5 cm in length.

Hare's ear mustard produced seed containing about 30% oil, with close to 30% of the oil being comprised of erucic acid (Table 2). Other research indicates that the oil contains additional fatty acids with industrial applications (Appelqvist, 1971). It seems that further consideration of hare's ear mustard as an industrial crop is warranted.

Euphorbia lagascae

Euphorbia lagascae was considered to have the lowest agronomic potential of all plant species. Seed development was indeterminate and fruits containing the seed burst violently as the seed approached maturity. Still, this plant species was agronomically attractive in several respects. The seed was large and easy to mechanically sow. Seedlings grew rapidly and were easy to manage.

Grasshoppers and other insect pests did not appear to feed on *Euphorbia lagascae*. Improvements in seed retention are needed.

Euphorbia lagascae produced an abundance of seed in 1990 and 1991 field evaluations, but much of the seed could not be collected due to seed shattering. Hence, harvested seed only amounted to about 200 kg/ha during 1990 and 150 kg/ha during 1991 (Table 1). Further studies are needed to assess seed yields when plants are swathed prior to harvesting.

Euphorbia lagascae produced seed which contained over 50% oil by weight. Past research determined that the oil contained over 50% vernolic acid (K. Carlson 1991 pers. commun.), making it a promising candidate for new crop development if genetic improvements and/or management practices could enhance the mechanical harvestability of seed.

Weed Control

Weeds were a problem and had to be removed by hand throughout the growing season. Effective weed control strategies must be developed for each plant species. The plant canopy produced by crambe intercepted more than 90% of the incident PAR after June 13 in the 1991 field evaluation (Fig. 1). Only small amounts of PAR could penetrate the canopy after this date and reach weed seedlings which were developing underneath. This may explain why weed pressure was much greater in hare's ear mustard than in crambe plots, since more than 50% of the incident PAR reached weed seedlings developing under a canopy of hare's ear mustard through most of the growing season.

SUMMARY

Fanweed, black mustard, hare's ear mustard, and *Euphorbia lagascae* contain fatty acids with important industrial applications. These plants have varying degrees of potential as novel industrial crops. Fanweed is adapted to growing conditions in the Great Plains and seems suited to field production methods. Approximately 1,500 kg/ha of seed was produced in 1990-91 field evaluations in North Dakota. This seed contained about 180 kg/ha of erucic acid, an unusual fatty acid with several industrial uses. Black mustard and hare's ear mustard also produced seed containing erucic acid, but these weed species appeared to have less potential than fanweed as industrial crops when agronomic factors were considered. Seed harvesting difficulties with *Euphorbia lagascae* and failure of wild mustard seed oil to contain high-value fatty acids presently limit their potential as industrial crops.

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Table 1. Selected agronomic characteristics of weed species evaluated during 1990 and 1991 in central North Dakota.

	Date established		Duration of flowering		Lodging[z]		Plant ht (cm)		Seed yield (kg/ha)		Seed weight (g/100 seed)	
Plant	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Fanweed	June 19	May 13	July 15-Aug 13	June 7-July 1	0.5	0.5	43	27	200	119	0.09	0.07
	Sept 1	Aug 25	May 20-June 15	May 13-June 15	0.5	0.5	28	67	1628	1414	0.08	0.08

Black mustard	May 27	May 10	June 29-Aug 8	June 13-Aug 20	1.0	1.0	176	126	1243	1875	0.17	0.16
Wild mustard	May 27	Apr 29	June 8-July 26	June 5-Aug 14	1.0	1.0	67	83	2005	1849	0.24	0.25
Hare's ear mustard	June 11	May 26	July 9-July 29	June 3-July 21	1.0	1.0	37	27	901	549	0.16	0.19
Euphorbia lagascae	May 29	May 15	July 6-Sept 20	June 12-Sept 28	1.0	1.0	72	42	201	147	0.91	1.18
Crambe	May 24	Apr 26	June 26-July 31	June 1-July 29	1.0	1.0	89	61	1997	1820	0.64	0.62

[z]0 = none, 1 = severe.

Table 2. Fatty acid acid composition of the seed oil.

	Fatty acid composition (% of total seed oil)					
Plant	16:0	18:0	18:1	18:2	20:0	22:1
Black mustard	4.8	0.0	14.3	17.9	14.0	37.6
Wild mustard	3.9	2.2	35.7	22.7	17.6	6.4
Crambe	1.4	0.8	14.0	6.2	1.0	62.9
Fanweed	2.7	0.0	13.8	20.2	9.0	37.8
Hare's ear mustard	2.5	0.0	5.8	27.5	2.2	26.9

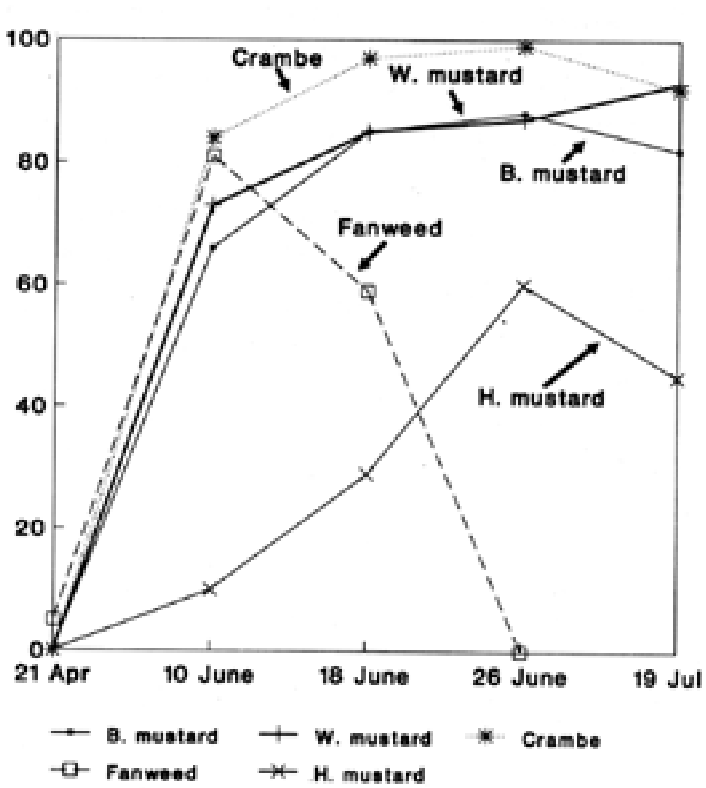

Fig. 1. Percent of photosynthetically active radiation intercepted by the plant canopy.

Last update September 12, 1997 aw

Brassica napus L.

Brassicaceae, or Cruciferae

Canadian turnip, Kale, Rutabaga, Rape, Swede, Swedish turnip, Yellow turnip

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Rutabaga: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Salad Rape, Colza
- Rutabaga, Swede, Swedish Turnip (Napobrassica group)
- Hanover Salad(Pabularia group)
- Siberian Kale(Pabularia group)

Rapeseed, Rapeseed Oil, Canola

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Brassica oleracea L.

Brassicaceae or Cruciferae

We have information from several sources:

Asian Vegetables: Selected Fruit and Leafy Types - Chinese Broccoli and Choy Sum —Marita Cantwell, Xunli Nie, Ru Jing Zong, and Mas Yamaguchi

Comparison of Somatic and Sexual Interspecific Hybridization for the Development of New *Brassica* Vegetable Crops—Richard H. Ozminkowski, Jr. and Pablo S. Jourdan

Brussels Sprouts as an Alternative Crop for Southwest Virginia—Gregory E. Welbaum

Midwest Vegetable Production Guide for Commercial Growers 2000
Broccoli, Cabbage, Cauliflower, and Brussels Sprouts
Collards and Kale

Cole Crops production links

Brassica food crops In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Collards
- Common kale
- Cauliflower
- Cabbage
- Brussels Sprouts
- Kohlrabi
- Broccoli
- Chinese Broccoli

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Choy Sum, Chinese Cabbage

Cruciferae *Brassica parachinensis* Bailey

Source: Magness et al. 1971

This oriental vegetable is very similar in growth habit and culture to Chinese cabbage, which see. However, it is grown for the flowering stalk. The entire plant with the flowering stalk may be harvested and marketed. In exposure of edible parts daring growth the plant is comparable to sprouting broccoli.

Last update February 18, 1999 by ch

Vieira, R.F. 1999. Conservation of medicinal and aromatic plants in Brazil. p. 152–159. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Conservation of Medicinal and Aromatic Plants in Brazil

Roberto F. Vieira*

THE BRAZILIAN VEGETATION

Approximately two thirds of the biological diversity of the world is found in tropical zones, mainly in developing countries. Brazil is considered the country with the greatest biodiversity on the planet, with nearly 55,000 native species distributed over six major biomes (Fig 1): Amazon (30,000); Cerrado (10,000); Caatinga (4,000); Atlantic rainforest (10,000), Pantanal (10,000) and the subtropical forest (3,000).

The Brazilian Amazon Forest (tropical rainforest) covers nearly 40% of all national territory, with about 20% legally preserved. This ecosystem is rather fragile, and its productivity and stability depend on the recycling of nutrients, whose efficiency is directly related to the biological diversity and the structural complexity of the forest (Anon. 1995). Giacometti (1990) estimated that there are about 800 plant species of economic or social value in the Amazon. Of these, 190 are fruit-bearing plants, 20 are oil plants, and there are hundreds of medicinal plants (Berg 1982).

The "Cerrado" is the second largest ecological dominion of Brazil, where a continuous herbaceous stratum is joined to an arboreal stratum, with variable density of woody species. The cerrados cover a surface area of approximately 25% of Brazilian territory and around 220 species from cerrado are reported as used in the traditional medicine (Vieira and Martins 1998).

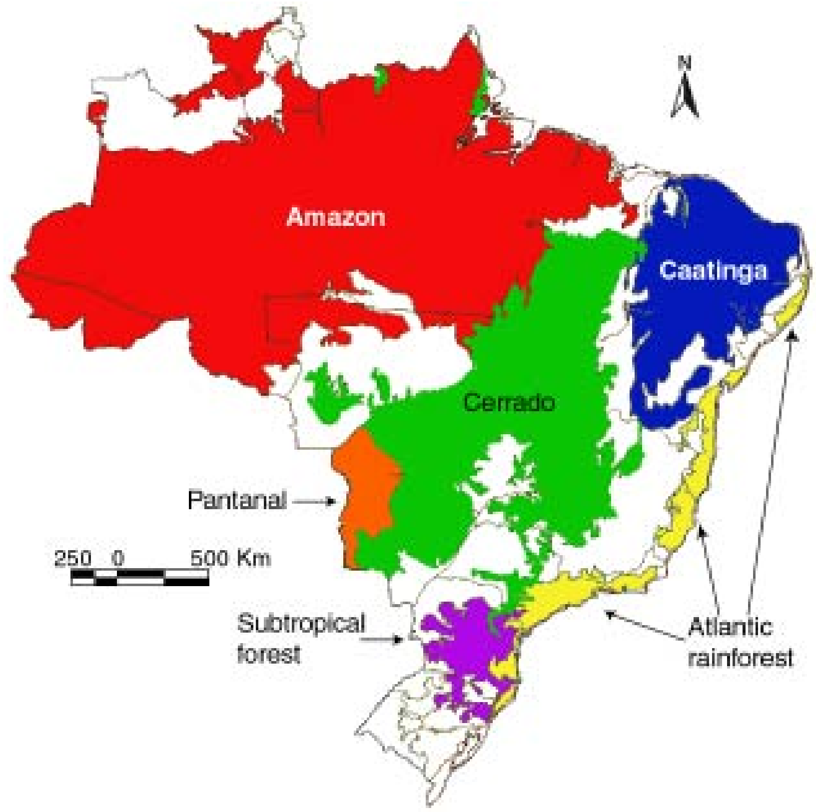

Fig. 1. Major biomes of Brazil, source: Embrapa, Cenargen.

The "Caatinga" extends over areas of the states of the Brazilian Northeast and is characterized by the xerophitic vegetation typical of a semi-arid climate. The soils that are fertile, due to the nature of their original materials and the low level of rainfall, experience minor runoff (Anon. 1995). Various fruit species and medicinal plants have their centers of genetic diversity in this region, and the use of local folk medicines is common. Several important aromatic species are reported for this region (Craveiro et al. 1994), such as *Lippia* spp. and *Vanillosmopsis arborea*.

The Atlantic Forest extends over nearly the whole Brazilian coastline, and is one of the most endangered ecosystems of the world, with less than 10% of the original vegetation remaining. The climate is predominantly hot and tropical, and precipitation ranges from 1,000 to 1,750 mm. The land is composed of hills and coastal plains, accompanied by a mountain range (Anon. 1995). Several important medicinal species are found in this region, such as *Mikania glomerata, Bauhinia forficata, Psychotria ipecacuanha*, and *Ocotea odorifera*.

The territory of the Meridional Forests and Grasslands includes the mesophytic tropical forests, the subtropical forests, and the meridional grasslands of the states of southern Brazil. The climate is tropical and subtropical, humid, with some areas of temperate climate. The naturally fertile soils, associated with the mild climate, allowed a rapid colonization during the last century, mainly by European and, more recently, by Japanese immigrants (Anon. 1995). Several medicinal plants, such as chamomile (*Matricaria recutita*), calendula (*Calendula officinalis*), lemon balm (*Melissa officinalis*), rosemary (*Rosmarinus officinalis*), basil (*Ocimum basilicum*), and oregano (*Origanum vulgare*), were introduced and adapted by immigrants.

The Pantanal is a geologically lowered area filled with sediments which have settled in the basin of the Paraguay River. Pantanal flora is formed by species from both Cerrado and Amazon vegetation. More than 200 species useful for human and animal consumption as well as for industrial use have been recorded in this region (Anon. 1995).

GERMPLASM CONSERVATION

In the last decade, serious efforts to collect and preserve the genetic variability of medicinal plants have been initiated in Brazil. The National Center for Genetic Resources and Biotechnology—Cenargen, in collaboration with other research centers of Embrapa (Brazilian Agricultural Research Corporation), and several universities, has a program to establish germplasm banks for medicinal and aromatic species (Table 1).

Table 1. List of institutions, germplasm collections of medicinal and aromatic plants, accessions, curator, and contact.

Institution	Major germplasm collections	No. accessions	Curator	Contact
Agronomic Institute of Paraná	*Pfaffia*	Unknown	P. Guilherme	www.pr.gov.br/iapar
Brasília Botanical Garden	Medicinal plants from cerrado	165	A. Lucia	Jardim Botanico de Brasilia, Lago Sul, Brasilia, DF
Embrapa–Genetic Resources and Biotechnology	*Phyllanthus, Pilocarpus, Stevia, Solanum,* plants from cerrado	335	T. Dias, R. Vieira	www.cenargen.embrapa.br
Embrapa–Ocidental Amazon	*Croton cajucara*, general collection of medicinal and aromatic plants	Unknown	A. Franco	www.embrapa.br/cpaa, Rodovia Am - 010, km 24, CP 319, 69048-660, Manaus
Embrapa–Oriental Amazon	*Psychotria, Pilocarpus*	109	I. Rodrigues	Trav. Dr. Enéas Pinheiro s/n, Marco, CP 48 66095-100, Belém, PA
Maranhão State Univ.	*Pilocarpus*	27	G. Silva	Campus Universitário Paulo VI, CP 09, São Luis-MA
São Paulo State Univ., Botucatu	*Lippia, Ocimum*	Unknown	L. Ming	Unesp, Faculdade de Ciencias Agrarias, Departamento de Agronomia, Botucatu, SP

Univ. of Brasilia	*Pfaffia*, *Mentha* spp., Labiatae, *Phitolacca dodecandra*	Unknown	J. Kleber	Universidade de Brasília, Departamento de Agronomia, CP 04364, 70000, Brasília, DF
Univ. of Campinas, Cpqba	*Maytenus*, *Artemisia*, *Phyllanthus*, *Pfaffia*, *Cordia*, *Stevia*	330	P. Melillo	Unicamp, Cpqba, C.P. 6171, Campinas, SP
Univ. of Ceará	Aromatic plants: *Lippia*, *Croton*, *Cymbopogon*	224	F. Mattos	Lab. de Produtos Naturais/UFC, Campus do Pici, 60021-970, Fortaleza,CE
Univ. of North Fluminense	*Psychotria*	10	E. Martins	Universidade Estadual do Norte Fluminense, Lab. de Melhoramento Genetico Vegetal, Av. Alberto Lamego, 2000, Horto, 28015-620, Campos dos Goytacazes, RJ
Univ. of Paraná	*Maytenus*	78	M. Scheffer	Universidade Federal do Parana, Escola de Florestas, Departamento de Silvicultura e Manejo, Rua Bom Jesus, 650, Juveve, 80035-010, Curitiba, PR

The first step is to establish criteria to define a species priority, based on economic and social importance, markets, and potential genetic erosion. Vieira and Skorupa (1993) proposed the following criteria to define priority, as follows: (1) species with proven medicinal value including those containing known active substance(s) or precursor(s) used in the chemical–pharmaceutical industry with proven pharmacological action, or at least demonstrating pre-clinical and toxicological results; (2) species with ethnopharmacological information widely used in traditional medicine; and which are threatened or vulnerable to extinction; (3) species with chemotaxonomical affinity to botanical groups which produce specific natural products.

Conservation of threatened germplasm includes seed banks, field preservation, tissue culture, and cryopreservation. Seed storage is considered the ideal method; seeds considered orthodox can be dried and are able to be preserved at sub-zero temperatures (–20°C), while recalcitrant seeds, including most tropical species, lose their seed viability when subjected to the same conditions. Maintenance of the germplasm in field collections is costly, requires large areas, and can be affected by adverse environmental conditions. Tissue culture or cryopreservation techniques can be also considered in some cases.

The next step is to decide which germplasm conservation method will be applied: ex situ or in situ. In an ex situ procedure, the germplasm is collected from fields, markets, small farms, and other sites, in form of seeds, cuttings, underground systems, and sprouts. The collected samples should represent the original population with passport data and herbarium vouchers. In a long term, mutation can take place over the years in a cold chamber or in vitro conservation. In contrast, in situ conservation maintains population in its preserved natural area, allowing the evolutionary process to continue, although genetic reserves are subject to anthropogenic action and environmental effects. Most in situ conservation has focused in forest species, with some medicinal species included, such as *Pilocarpus microphyllus* and *Aniba roseodora*. The establishment of genetic reserves in Brazil has relied on National Parks and conservation areas established by the environmental protection agency of Brazil, Ibama.

There are now five forest genetic reserves in Brazil: one in the Amazon Tropical Rainforest, state of Para; one in the Caatinga, state of Minas Gerais; two in the Cerrado in the Federal District, and one in the Meridional Forest (Subtropical) in the state of Santa Catarina. Four other genetic reserves are being created; two in the Atlantic Forest in the states of Rio de Janeiro and Espirito Santo, one in the Caatinga in the state of Piaui, and another in the Tropical Humid Forest in transition with Cerrado in the state of Minas Gerais (Anon. 1995). These reserves aim to conserve the most endangered species and those of greatest economic interest, including medicinal and aromatic plants.

The Brazilian program on medicinal germplasm conservation has three foci: (1) ethnobotanical studies; (2) germplasm collection and characterization; and (3) in situ conservation. Ethnobotanic and phytogeographic studies on the medicinal flora of Cerrado have been able to identify and collect genetic material for conservation. About 110 species used in traditional medicine were reported in the Cerrado region (Vieira et al. 1998). Bibliography review and a herbaria search were carried out allowing an estimation of the medicinal potential of each species studied, their geographic distribution, and period of fruit maturation.

In 1994, a cooperative project between the Brasília Botanical Garden and Embrapa/Cenargen was established. An in vivo collection of medicinal plants from Cerrado, now contains 161 accessions (Dias et al. 1995). The collection has facilited phytochemical and pharmacological studies of this plant materials, and an anti-inflamatory agent has been identified on *Lychnophora salicifolia* (Miguel et al. 1997).

PRIORITY SPECIES

A few germplasm collections of medicinal and aromatic plants have been established in Brazil (Table 2). The following species, listed alphabetically, have been recognized as priority for germplasm conservation.

Table 2. List of medicinal and aromatic species with high priority for germplasm collection and conservation in Brazil.

Species	Common name	Habit	Active substance/pharmacological action	Region	Conservation form
Achyrocline satureioides L.	Macela	Herb	Hypotensive, spasmolytic	Cerrado	Field collection

Ageratum conyzoides L.	Mentrasto	Herb	Anti-inflammatory	Ruderal	Field collection
Aniba roseodora Ducke	Pau rosa	Tree	Linalool	Amazon forest	In situ
Astronium urundeuva (Fr. All.) Engl.	Aroeira	Tree	Anti-inflammatory, anti-ulceric	Cerrado	In situ, cold chamber
Baccharis trimera DC.	Carqueja	Herb	Hepatic disturbs	Ruderal	Field collection
Bauhinia forficata L.	Pata de Vaca	Tree	Diabetes	Atlantic forest	Cold chamber
Caryocar brasiliensis Camb.	Pequi	Tree	Anti-inflamatory	Cerrado	In situ
Copaifera langsdorffi Desf.	Copaiba	Tree	Oil, anti-inflamatory	Cerrado	In situ, cold chamber
Croton cajucara Benth.	Sacaca	Herb	Linalool	Amazon	Field collection
Croton zehntneri Pax et Hoff.	Cunha	Shrub	Anetol, eugenol	Caatinga	Field collection
Datura insignis B. Rodr.	Toe	Shrub	Escopolamina	Amazon forest	Cold chamber
Dimorphandra mollis Benth.	Faveiro	Tree	Rutin, anti-hemorragic	Cerrado	Cold chamber
Echinodorus macrophyllus (Kunth.) Mich	Chapeu de Couro	Herb	Diuretic	Cerrado	Field collection, cold chamber
Jatropha elliptica (Pohl) Baill.	Batat de Tiu	Shrub	Jatrophone	Cerrado	In situ, field collection
Lippia spp.	Alecrim pimenta	Shrub	Source of volatile oils, anti-microbial	Caatinga	Field collection
Lychnophora ericoides Mart.*; L. salicifolia* Mart.	Arnica do Cerrado	Shrub	Volatile oils	Cerrado	Field collection, in situ
Mandevilla vellutina Mart.		Shrub	Anti-inflamatory, bradykynin antagonist	Cerrado	In situ, field collection
Maytenus ilicifolia Mart. ex. Reiss; *M. aquifolium* Mart.	Espinheira Santa	Tree	Anti-ulceric	Meridional forest	Cold chamber, in situ

Mikania glomerata Spreng.	Guaco	Herb	Bronchitis, coughs	Atlantic forest	Field collection
Ocotea odorifera (Vell.) Rohwer	Canela Sassafraz	Tree	Safrol, metileugenol	Atlantic forest	In situ
Operculina macrocarpa (L.) Farwel	Batata de Purga	Herb	Purgative	Caatinga	Cold chamber
Piper hispidinervum DC.	Pimenta longa	Herb	Safrol	Amazon	Cold chamber, field collection
Pfaffia paniculata (Martius) Kuntze	Ginseng brasileiro	Herb	Antitumor compounds	Margins of Parana river	Cold chamber, field collection
Phyllanthus niruri L.	Quebra pedra	Herb	Hepatitis B, renal calculus	Ruderal	Cold chamber
Pilocarpus microphyllus Stapf.	Jaborandi	Shrub	Pilocarpine	Amazon forest	Cold chamber, in situ
Psychotria ipecacuanha(Brot.) Stokes	Ipecac	Herb	Emetin, cefaline	Amazon and Atlantic forest	Cold chamber, in situ
Pterodon emarginatus Vogel	Sucupira	Tree	Analgesic, antinoceptive, cercaricide	Cerrado	In situ, cold chamber
Solanum mauritianum Scopoli	Cuvitinga	Shrub	Solasodine	Ruderal, southeast and southern Brazil	Cold chamber
Stryphnodendron adstringens (Mart.) Coville	Barbatimao	Tree	Tannin, anti-inflamatory	Cerrado	In situ, cold chamber
Tabebuia avellanedae (Lor.) ex. Griseb.	Ipe roxo	Tree	Lapachol	Cerrado	In situ
Vanillosmopsis arborea (Aguiar) Ducke	Candeia	Shrub	Bisabolol	Caatinga	In situ, field collection

Maytenus ilicifolia Martius ex Reiss., Celastraceae (Espinheira Santa)

Espinheira santa is a small shrub evergreen tree reaching up to 5 m height. It is native to many parts of southern Brazil, mainly in Paraná and Santa Catarina states.

Leaves of *Maytenus* species are used in the popular medicine of Brazil for their reported antiacid and antiulcerogenic activity. The effects of a boiling water extract of equal parts of *M. aquifolium* and *M. ilicifolia* leaves have been tested in rats and mice. Attempts to detect general depressant, hypnotic, anticonvulsant, and analgesic effects were reported by Oliveira et al. (1991). The potent antiulcerogenic effect of espinheira santa leaves was demonstrated effective compared to two leading anti-ulcer drugs, Ranitidine and Cimetidine (Souza-Formigoni et al., 1991). Toxicological studies demonstrated the plant's safety.

Seeds of *Maytenus ilicifolia* can be classified as orthodox and stored at –20°C in long-term cold chambers (Eira et al. 1995). The Forestry Department of the University of Paraná began a project in 1995 to study the genetic variability of natural populations of *Maytenus ilicifolia* and 78 accession were collected in the states of Parana, Santa Catarina, and Rio Grande do Sul. Field collections are maintained at the university campus (Scheffer et al. 1998). Although cultivation of *M. ilicifolia* is the object of several studies in Brazil, a research focus on in situ conservation and sustainable systems of harvesting are required.

Pfaffia paniculata Martius, Amaranthaceae (Brazilian Ginseng)

Pfaffia is a large, shrubby ground vine, which has a deep root system. *Pfaffia* is well known in Central and South America with over 50 species growing in the warmer tropical regions of the area and has been exploited for more than 15 years. The species grow in the borders of Paraná river, but predatory collection has greatly reduced the natural populations.

In Brazil, *Pfaffia* is known as *para tudo,* which means "for all things" and also as Brazilian ginseng, since it is widely used like American and Asian ginseng (*Panax* spp.). The active substances are found in the roots.

This action is attributed to the anabolic agent, beta-ecdysterone as well as three novel ecdysteroid glycosides which are found in high amounts in *Pfaffia*. This species is such a rich source of beta-ecdysterone. The extraction methods employed to obtain it from this root is protected by a Japanese patent (Nishimoto et al. 1988).

The root of *Pfaffia* contains about 11% saponins. These saponins include a group of novel chemicals called pfaffosides as well as pfaffic acids, glycosides, and nortriperpenes. These saponins have clinically demonstrated the ability to inhibit cultured tumor cell melanomas and help to regulate blood sugar levels (Takumoto et al. 1983; Nishimoto 1984). The pfaffosides and pfaffic acid derivatives in *Pfaffia* have been patented as antitumor compounds in two Japanese patents (Japanese Patent 84184198, Oct. 19, 1984 by Rohto Pharmaceutical Co., Ltd.).

Few accessions of *Pfaffia* are available in any of the present field collections. This species requires an immediate recollection to preserve the plant. Due to its economic importance a germplasm collection and characterization of its chemical constituents, is fully warranted.

Phyllanthus niruri L., Euphorbiaceae (Quebra Pedra)

Quebra pedra is a small erect annual herb growing up to 30 to 40 cm. height. Although several species are recognized by this common name, *P. niruri* and *P. sellovianus* are the most scientifically studied. The antispasmodic activity of alkaloids in *Phyllanthus sellovianus* explained the popular use of the plant for kidney and bladder stones. The alkaloid extract demonstrated smooth muscle relaxation specific to the urinary and biliary tract which facilitates the expulsion of kidney or bladder calculi (Calixto 1984; Santos 1994, 1995)

Quebra pedra has gained world-wide attention due to its effects against Hepatitis B (Thyagarajan 1982; Mehrotra 1990; Yeh, et al. 1993; Wang 1995). Recent research on quebra pedra reveals that its antiviral activity extends to the human immunodeficiency virus (HIV). The HIV-1 reverse transcriptase inhibition properties of *P. niruri* can be obtained with a simple water extract of the plant (Qian-Cutrone 1996). There have been no side effects or toxicity reported in any of the clinical studies or in its many years of reported use in herbal medicine.

Several species, called quebra pedra, contain the same or similar active compounds. A germplasm collection to study the genetic and chemical variation, as well as the seed physiology of this species is necessary and warranted.

Pilocarpus microphyllus Stapf., Rutaceae (Jaborandi)

Jaborandi is an indigenous name (*ia-mbor-end*) of this species. *Pilocarpus microphyllus* contain the highest pilocarpine content in the leaves. The plant is an understory species, 6 to 8 m in height, of the pre-Amazonian rain forest in the states of Pará, Maranhão, and Piauí.

Pilocarpine is an imidazolic alkaloid that stimulates the secretions of the respiratory tract, the salivary, lachrymal, gastric and other glands, weakens the heart action, accelerates the pulse rate, increases intestinal peristalsis and promotes uterine contractions (Morton 1977). In the treatment of glaucoma, the alkaloid pilocarpine acts directly on cholinergic receptor sites, thus mimicing the action of acetylcholine. Intraocular pressure is thereby reduced, and despite its short-term action, pilocarpine is the standard drug used for initial and maintenance therapy in certain types of primary glaucoma (Lewis and Elvin-Lewis 1977). Recently, the US Food and Drug Administration approved pilocarpine for use to treat post-irradiation xerostomia (dry mouth) in patients with head and neck cancer (Pinheiro 1997).

The exploration of this product, due to its high economic value, has led to great scientific interest in research and development effects for domestication and conservation. Pinheiro (1997) reports that the price of jaborandi leaves has reached US$4.00/kg. The wild harvest or collection of leaves from wild *P. microphyllus* has been carrying out to such an extent that it has significantly reduced the natural populations, and this species is included in the official list of endangered plants from Brazilian flora (Anon. 1992).

In 1991, the Cenargen initiated a project for recollecting and conservation of the genetic variability of *Pilocarpus microphyllus* and related species. From 1991 to 1993, two collection expeditions were undertaken, covering the states of Pará and Maranhão. A total of 27 accessions were collected in form of seeds and seedlings (Vieira, 1993). A germplasm bank of Jaborandi was established at Maranhão State University, São Luis, and at Embrapa—Ocidental Amazon, Belém, Pará State.

Studies on the methodology of *P. microphyllus* conservation led to the conclusion that seeds of this species are considered orthodox. Seeds can be dried down to 6–8% moisture content and be conserved for a long period at –18°C and 5% relative humidity (Eira et al. 1993). A seed sample of all collected accessions is being maintained at Embrapa, Cenargen.

Native populations of *P. microphyllus* have suffered from anthropogenic activity, with plants of shorter size than normal due to intensive harvesting of leaves. It will be challenge to stimulate the management and cultivation of this species in its native habitat. Although seeds can be preserved for long periods, in situ conservation must be initiated and natural reserves established. This species can be only found in indigenous areas, and some private lands.

Psychotria ipecacuanha (Brot.) Stokes, Rubiaceae (Ipecac)

Psychotria ipecacuanha (Brot.)Stokes [= *Cephaelis ipecacuanha* (Brot.) A.Rich.] is a shrub, whose medicinal value relates to the production of emetine in the roots. Ipecac is found in the humid forests of Central America, Colombia, southern part of the Amazon Forest in the States of Rondônia, Mato Grosso, and Atlantic forest, in the States of Bahia, Espírito Santo, Minas Gerais, and Rio de Janeiro (Skorupa and Assis 1998).

Ipecac as a powerful emetic, is used in gastrointestinal diseases, diarrhea, and intermitent fevers. It is employed as an expectorant, in bronchitis, broncopneumonia, asthma and mumps, and also as a vasoconstrictor. In 1959, dihydroxi-emetine, an emetine analogue, was presented as an amoebicide due to its reduced toxic effect on cardiac muscle (Lewis and Elvin-Lewis 1977).

The global production of ipecac averages 100 t a year, originated mainly from Nicarágua, Brazil and India (Husain 1991). Considering the economic and medicinal values of ipecac, the deforestation of the areas of occurrence and the extrativist nature of its production, in 1988, Cenargen has began a program for the recollecting and conservation of the genetic variability of this species. From 1988 to 1991, five collecting expeditions were undertaken, covering the States of Rondonia, Mato Grosso, Pernambuco, Bahia, Espirito Santo, Rio de Janeiro, and Minas Gerais, and a total of 86 accessions were collected (Skorupa and Assis 1998) and now maintained in field germplasm banks at Embrapa—Ocidental Amazon, Belém, Para, and at Florestas Rio doce, Linhares, Espirito Santo. Recently, other germplasm collections was established at the University of North Fluminense, which contains 10 accessions originated from the Atlantic Forest area (states of Rio de Janeiro and São Paulo).

Solanum mauritianum Scop., Solanaceae (Cuvitinga)

The steroidal alkaloids of the Solanaceae are compounds of considerable pharmaceutical interest as starting materials for the synthesis of steroid compounds such as anticontraceptive steroids and corticosteroids. The world demand for steroid precursors continues to increase while some of the traditional sources of steroidal raw material, such as yams (*Dioscorea* spp.) of Mexico and Central America, are becoming rapidly depleted (Roddick 1986). Solasodine is a chemical analog of diosgenin, and may be a substitute for this drug.

There are around 1,100 species of *Solanum* in South America, and *S. mauritianum* is among the species with the highest solasodine content (Vieira and Carvalho 1993). *Solanum mauritianum* is a subtropical shrub which grow all over southern Brazil. The solasodine content of *S. mauritianum* was evaluated in green fruits of natural populations growing on two different soils. High contents of solasodine were found in both population of *S. mauritianum* (from 2% to 3.5% of total dry weight) (Vieira 1989). Germplasm collections are needed to continue the study of genetic and environmental variation of solasodine, and to provide foundation study for future development programs.

Exotic Species

Although the major focus of germplasm conservation is on native species, several exotic, introduced and adapted species have been widely used and cultivated in Brazil. Many of them, such as lemongrass [*Cymbopogon citratus* (D.C.) Stapf.] and aloe (*Aloe* spp.), are cultivated in backyard gardens. Others, such as picão-preto (*Bidens pilosum* L.), mastruço (*Chenopodium ambrosioides* L.), and mentrasto (*Ageratum conyzoides* L.), whose adaptation through the years, has allowed a spontaneous wide distribution throughout the country, have had their use well disseminated (Dias 1995). In southern Brazil, due to favorable cultural and environmental conditions, several exotic species are cultivated in large areas. These include chamomile (*Matricaria recutita*), calendula (*Calendula officinalis*), rosemary (*Rosmarinus officinalis*), *Duboisia* sp., and Japanese mint (*Mentha arvensis*), all of which are deserving of collection and preservation due to the use of their natural products and the agricultural-based industries that produce these crops. The germplasm collection of exotic species also needs to be expanded to provide genetic resource for species adapted in Brazil. Although Brazil is not their genetic center of origin, different chemotypes have been naturalized (Mattos, pers. commun. 1994) and need to be conserved. One example is *Coleus barbatus*, which was introduced from Africa, and is clonally propagated in Brazil. However, several volatile oils chemotypes are found in Brazil for this species, probably due to different introductions from Africa in the past.

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Brazilian Guava

Psidium guineense Sw.

Psidium molle Bertol

Psidium schiedeanum Berg.

Psidium aracá Raddi

This guava relative has been the subject of much confusion, beginning with its scientific name, *Psidium guineense* Sw., based on the botanist Swartz' belief that it originated on the Guinea Coast of Africa. For a long time it was considered distinct from the guisaro, *P. molle* Bertol (syn. *P. schiedeanum* Berg.), but now these names as well as *P. aracá* Raddi, are treated as synonyms of *P. guineense*, and all the corresponding colloquial names should be applied to this one confirmed species.

In Brazil the popular names are *aracá, aracá do campo,* or *aracahy;* in the Guianas it is called wild guava or *wilde guave.* Among other regional names are: *guabillo, huayava, guayaba brava* and *sacha guayaba* (Peru); *allpa guayaba* (Ecuador); *guayaba de sabana, guayaba sabanera* and *guayaba agria* (Venezuela); *guayaba*, or *guayaba acida, guayaba hedionda, chamach, chamacch, pataj* and *pichippul* (Guatemala); *guisaro*, or *cas extranjero* (Costa Rica); *guayabita, guayaba arraijan,* and *guayabita de sabana* (Panama); *guayabillo* (El Salvador). The name, *guayaba agria*, seems to be the only one employed in Mexico. In California it is called either Brazilian or Castilian guava.

Description

The Brazilian guava is a relatively slow-growing shrub 3 to 10 ft (1-3 m) tall; sometimes a tree to 23 ft (7 m); with grayish bark, hairy young shoots and cylindrical or slightly flattened branchlets. The evergreen, grayish leaves, 1 1/3 to 5 1/2 in (3.5-14 cm) long and 1 to 3 1/8 (2.5-8 cm wide), are stiff, oblong, elliptic, ovate or obovate, sometimes finely toothed; scantily hairy on the upperside but coated beneath with pale or rusty hairs and distinctly dotted with glands. Flowers, borne singly or in clusters of 3 in the leaf axils, are white and have 150 to 200 prominent stamens. The fruit, round or pear-shaped, is from 1/8 to 1 in (1-2.5 cm) wide, with yellow skin, thick, pale-yellowish flesh surrounding the white central pulp, and of acid, resinous, slightly strawberry-like flavor. It contains numerous small, hard seeds and is quite firm even when fully ripe.

Distribution

The most wide-ranging guava relative, *P. guineense* occurs naturally from northern Argentina and Peru to southern Mexico, and in Trinidad, Martinique, Jamaica and Cuba, at medium elevations. It is cultivated to a limited extent in Martinique, Guadeloupe, the Dominican Republic and southern California. Trials in Florida have not been encouraging. At Agartala in Tripura, northeast India, this plant has become thoroughly naturalized and runs wild.

Cultivars

While no named cultivars have been reported, this species has been crossed with the common guava and the hybrids are dwarf, hardy and bear heavy crops.

Soil

The plant will not develop satisfactorily on light sandy soil.

Food Uses

This guava is suitable for baking and preserving. It makes a distinctive jelly which some consider superior to common guava jelly.

Other Uses

The **wood** is strong and used for tool handles, beams, planks and agricultural instruments. The **bark,** rich in tannin, is used for curing hides.

Medicinal Uses: In the interior of Brazil, a decoction of the bark or of the roots is employed to treat urinary diseases, diarrhea and dysentery. In Costa Rica, it is said to reduce varicose veins and ulcers on the legs. A leaf decoction is taken to relieve colds and bronchitis.

Related Species

The Pará guava has been known as *Britoa acida* Berg. Calvacante now shows this binomial as a synonym of *Psidium acutangulum* DC. and gives the Brazilian vernacular name as *aracá-pera*. Cruz (1965) calls it *araca piranga, aracandiva, aracanduba* and *goiabarana*. Le Cointe shows it as *araca comum do Pará* and he describes *P. aracá* Raddi as a separate species. In Bolivia, *P. acutangulum is* known as guabira; in Peru, as *ampi yacu, puca yacu, guayava del agua*.

The shrub or tree ranges in height from 26 to 40 ft (8-12 m). Its branchlets are quadrangular and winged near the leaf base. New growth is finely hairy. The leaves, with very short petioles, are elliptical, 4 to 5 1/2 in (10-14 cm) long, 1 1/2 to 2 3/8 in (4-6 cm) wide, rounded at the base, pointed at the apex. The long-stalked, white, 5-petalled flowers, with more than 300 stamens, are borne singly or in 2's or 3's in the leaf axils. The fruit is round, pear-shaped or ellipsoid, 1 1/4 to 3 3/16 in (3-8 cm) wide, pale-yellow, with yellowish-white, very acid but well-flavored pulp containing a few hard, triangular seeds. The crop ripens in the spring.

The tree occurs wild and cultivated at low and medium elevations throughout Amazonia and from Peru to Colombia, Bolivia, Venezuela and the Guianas. Some specimens have been grown in southern Florida in the past under the name *P. aracá.* The fruit is eaten mixed with honey or made into acid drinks or preserves.

Of recent interest as a possible new crop is *Eugenia stipitata* McVaugh, treated by Calvacante as a variable species, but separated by McVaugh *(Flora of Peru,* Vol. XIII, Pt. 4, No. 2, 1958) into 2 subspecies, as follows:

E. stipitata subsp. *stipitata* McVaugh, called *pichi* in Peru, *araca-boi* in Brazil, is a tree to 40 or 50 ft (12-15 m) tall, with short-petioled, opposite, broad-elliptic leaves, pointed at the apex, 3 to 7 in (7.5-18 cm) long and 1 1/3 to 3 1/4 in (3.4-8.25 cm) wide, with indented veins on the upper surface, densely hairy on the underside, faintly dotted with oil glands on both sides. The flowers, in compound, axillary racemes, are white, hairy, 3/4 in (2 cm) wide, with numerous prominent stamens.

According to horticulturists and Calvacante, the fruit is somewhat like a small guava; very aromatic, round to oblate, less than 2 oz (56 g) in the wild, up to 4 3/4 in (12 cm) wide under cultivation and weighing as much as 14 1/2 oz (420 g) or even 28 oz (800 g). The skin is thin and delicate; the pulp soft, juicy, very acid, containing 8 to 10 irregular-oblong or kidney-shaped seeds to 1 in (2.5 cm) long and 5/8 in (1.5 cm) wide. Ascorbic acid content has been reported as 38 to 40 mg per 100 g of edible portion. The fruiting season is February to May around Belem, Brazil. There may be 4 crops a year in Peru and Ecuador. The tree is native and abundant in the wild in Amazonian regions of Peru, Ecuador and Brazil. The fruit is eaten by the Indians and the tree is being cultivated experimentally in Peru and Ecuador and a collection of 360 seedlings has been established at Manaus. Seeds germinate in 4-12 months.

Seedlings grow slowly at first, are transplanted in about 6 months. They begin to fruit 18 months later. Yields of 12.7 tons per acre (28 T/ha) have been obtained in Peru. The tree is subject to leafspot and the fruit is prone to attack by fruit flies. The fruit loses flavor when cooked; is quick-boiled for jam. A Peruvian grower is exporting the frozen pulp to Europe.

Subspecies *sororia*, called *rupina caspi* in Peru, is a shrub or small tree to 10 ft (3 m) high with elliptic leaves 3 1/2 to 5 in (9-12.5 cm) long, 1 to 1 3/4 in (2.5-4.5 cm) wide with barely visible veins; minutely hairy beneath or hairless when fully mature; and having a few dark dots. The flowers are 1/2 in (1.25 cm) wide with 75 stamens. The fruit is oblate, 5/8 in (1.6 cm) wide, velvety, acid, with numerous kidney-shaped seeds, 1/8 to a little over 1/4 in (3-7 mm) long. McVaugh shows as native to Peru, Ecuador, Bolivia and Colombia.

Triticum aestivum L.

Poaceae
Common wheat, Bread wheat

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Common wheat, best known and most widely cultivated of the wheats, is cultivated for the grain, used whole or ground. Fine ground, it is the source of flour for the world's breadmaking. Main use is for flour and bread-stuffs known by various names throughout the world. Grain also is the source of alcoholic beverages, beer, industrial alcohol made into synthetic rubber and explosives. Bran from flour milling also an important livestock feed; germ is valuable addition to feed concentrate. Grain fed to livestock whole or coarsely ground. Starch is used for pastes and sizing textiles. Straw made into mats, carpets, baskets, and used for packing material, cattle bedding, and paper manufacturing. Some wheat is cut for hay. Wheat grown for grain crop is also used for pasture before the stems elongate and as a temporary pasturage; it is nutritious and palatable.

Folk Medicine

According to Hartwell (1967–1971), the seeds are used in folk remedies for cancers, corns, tumors, warts, and whitlow. Reported to be antivinous, bilious, demulcent, discutient, diuretic, emollient, excipient, intoxicant, laxative, useful as a poultice, restorative, sedative, used as a shampoo and vulnerary, common wheat is a folk remedy for burns, cancer, diarrhea, dysentery, ecchymosis, epistaxis, fertility, fever, flux, gravel, hematuria, hemoptysis, hemorrhage, incontinence, leprosy, leucorrhea, menorrhagia, neurasthenia, nightsweat, perspiration, scald, tumor, warts, whitlow, and wounds (Duke and Wain, 1981).

Chemistry

Per 100 g, the grain is reported to contain 326–335 calories, 11.57–14.0 g H_2O, 9.4–14.0 g protein, 1.8–2.5 g fat, 69.1–75.4 g total carbohydrate, 1.8–2.3 g fiber, 1.7 g ash, 36–46 mg Ca, 354–400 mg P, 3.0–4.3 mg Fe, 370–435 mg K, 0.43–0.66 mg thiamine, 0.11–0.12 mg riboflavin, and 4.3–5.3 mg niacin. The grain contains allantoin plus uricase; sinapic acid has been isolated from wheat germ. The grain is said to cause poisoning in stock, though no toxic principle has been found. Wheat can absorb toxic concentrations of selenium but "selenium" wheat rarely causes poisoning (Watt and Breyer-Brandwijk, 1962). One kg of grain contains 0.03 mg As_2O_3; grain also contains Mg, Mn, Zn, Fe, and Cu. Amino acid composition is shown in the Table from the Wealth of India.

Essential amino acids in wheat proteins (after Wealth of India)

	Inner endosperm (%)	Outer endosperm (%)	Bran (%)	Germ (%)	Whole wheat (%)
Arginine	2.92	4.50	7.53	6.20	3.81
Histidine	1.65	1.74	1.68	3.03	1.65
Isoleucine	7.02	6.56	4.50	5.23	6.97
Leucine	9.14	7.98	6.52	7.33	8.27
Lysine	1.92	2.60	3.87	5.44	2.80
Methionine	1.12	1.40	1.09	1.28	1.32
Phenylalanine	3.95	3.43	2.45	2.47	3.68
Threonine	2.56	2.72	2.85	6.28	2.78
Tryptophan	0.93	1.12	1.83	0.90	1.03
Valine	3.65	4.02	4.10	4.20	4.00

Wheat germ oil is rich in tocopherols (vit. E) and essential fatty acids. Sitosterol, ergosterol, and campesterol, phospatidic and glyceroinositophosphatidic acids, phytoglycolipid, serine, etc., are also reported. Wheat contains ca 1% pectin. Wheat bran oil is also high in tocopherols, 68% of which is epsilon-tocopherol. Alpha-tocopherol, which has the highest vit. E activity of the tocopherols, constitutes only 11% of the tocopherols in the bran oil. Much more detail on wheat chemistry can be found in the Wealth of India (C.S.I.R., 1948–1976). Fresh forage contains 30–35% DM, of which (ZMB) 8.6–23.3% is CP, 15.1–21.5% CF, 6.1–11.6% ash, 1.8–3.7% EE, and 40.1–66.0 NFE. Straw, on the other hand, contains 92.0% DM, of which 3.1% is CP, 45.4% CF, 10.2% ash, 1.1% EE, and 40.2% NFE. Indian hay (ZMB) contained 5.1% CP, 35.1% CF, 7.2% ash, 1.3% EE, and 51.3% NFE; Indian silage 3.5% Cp, 39.4% CF, 14.6% ash, 0.5% EE, and 42.0% NFE (Gohl, 1981). Leaf protein isolate contains (g/16g N): methionine, 2.39; tryptophane, 1.41; histidine, 1.97; arginine, 9.16; and total lysine.

Description

Annual grass; culms simple, erect, hollow or pithy, glabrous, up to 1.2 m tall; leaves flat, narrow, 20–38 cm long, about 1.3 cm broad; spikes long, slender, dorsally compressed, somewhat flattened; rachis tough, not separating from spikelet at maturity; spikelets 2–5-flowered, relatively far apart on stem, slightly overlapping, nearly erect, pressed close to rachis; glumes keeled in upper half, firm, glabrous, shorter than the lemmas; lemmas awned or awnless, less than 1.3 cm long; palea as long as the lemma, remaining entire at maturity; caryopsis free-threshing, soft or hard, red or white. Hexaploid.

Germplasm

Reported from the China-Japan, Hindustani, and Central Asia Centers of Diversity, wheat, or cvs thereof, is reported to tolerate alkali, bunt, disease, drought, herbicide, hydrogen flouride, high pH, laterite, low pH, mildew, salt, nematodes, phage, rust, smog, smut, and virus (Duke, 1978). This species is the source of most US wheat cvs, there being >200 named cvs cultivated in the United States. Many other cvs exist elsewhere. Since so many cvs are available, one should consult the agricultural agent of a particular region to ascertain which ones are best for, that particular area. No attempt will be made here to describe these cvs, except to indicate they are classified in the following manner: Hard red spring wheats yielding high quality bread flour; Hard red winter wheats producing superior bread flours; Soft red winter wheats yielding flour for cakes and biscuits; Durum wheat hybrids yielding hard kernels made into semolina for macaroni products; red durum hybrids used in mixed wheat flours; white wheats yielding grain for breakfast foods, flour for cakes, pastries, and crackers, and various mixed wheats used mostly for feeds for livestock. The spring and winter types constitute about 95% of the wheat grown in the United States. ($2n$ = 42.)

Distribution

T. aestivum known only under cultivation; its nativity has been lost. Briggle (1981) states, "The precise origin of the wheat plant as we know it today is not known. Wheat evolved from wild grasses, probably somewhere in the Near East. A very likely place of origin is the area known in early historical times as the Fertile Crescent—a region with rich soils in the upper reaches of the Tigris-Euphrates drainage basin.

Ecology

Ranging from Boreal Moist to Rain through Tropical Very Dry to Dry Forest Life Zones, wheat is reported to tolerate annual precipitation of 1.9 to 25.0 dm (mean of 162 cases = 7.9), annual temperature of 4.9 to 27.8°C (mean of 162 cases = 13.4), and pH of 4.5 to 8.3 (mean of 141 cases = 6.5) (Duke, 1978). Adapted to a wide variety of climatic conditions. Principal wheat-growing areas of the world have similar growing conditions: the Russian prairies, the fertile pampas of Argentina, the Wheat belt of United States, all have fertile dark soils rich in nitrogen; rather hot, cloudless summers; rainfall which, although low, is well-distributed. A good wheat soil has physical structure which holds together, making good water retention and favorable conditions for nitrate formation. Hot, humid conditions are unfavorable for wheat-growing.

Cultivation

Propagation by seeds. Use minimum number of tillage operations to help prevent soil compaction and restriction of root and water penetration. The two principal purposes for preparing a seedbed are the development of nitrates and the conservation of moisture. In areas where rainfall is limited, as in western Kansas, summer fallowing is the most successful method for storing and conserving soil moisture. Good summer fallow is one in which the soil is kept free of plant growth and the soil surface is kept open to permit rapid penetration of moisture, and cloddy to prevent wind and water erosion. Avoid excessive turning up of new soil because such tillage dries out the soil. Start first tillage in spring as soon as weeds begin to grow, usually about May 1. After the first tillage, cultivate soil only enough to prevent weed growth and to maintain a rough surface. In some areas stubble mulch tillage method of fallowing is practiced, by which enough residue is anchored to soil surface to protect the crop and soil from wind and water erosion. Contour and stripe planting may be used. Cultivation of soil well in advance of seeding hastens the decay of organic matter, thus liberating nitrogen and making it available to plants as nitrates. Early seedbed preparation is necessary for highest yields. Crop rotation of fallow, wheat, and sorghum is an excellent practice in some areas. Date of planting wheat seed depends on the locality, type of wheat, and the hessian fly problem. Rates of seeding differ with the type of wheat, size of seed, and locality, varying from 22–100 kg/ha, generally 33 kg/ha is recommended. Local agents should be consulted about weed control. Irrigated wheat averages 86.25 bu/ha instead of 65.5 bu/ha. Wheat uses about 60 cm of water throughout the growing season. The type of fertilizer used should be determined by a soil test. The three main types being nitrogen, phosphorus, and potash. However, moisture, rather than plant food nutrients, is the limiting factor in production in most seasons under dryland farming. Yield response to nitrogen fertilizer is determined by moisture, soil, type of seedbed, and crop stand. Nitrogen may be supplied with anhydrous ammonia, nitrogen solution, or in dry forms as ammonium nitrate, urea or in mixed fertilizers. Phosphate is best supplied with superphosphate or in a mixed fertilizer. Potassium is best supplied with muriate of potash or in a mixed fertilizer. Nitrogen fertilizer and potash may be broadcast and worked into the seedbed before seeding or applied at time of seeding by using a combination fertilizer-grain drill, or applied as a top-dressing during the winter just prior to spring growth. Superphosphates are usually placed in the row with the seed (Reed, 1976).

Harvesting

Winter wheat is most widely used for temporary pasture crop. It can be grazed without apparent injury to the grain crop, provided it is not grazed severely over an extended period of time, or too late in the spring. Pasturing should not begin in fall until plants have become firmly rooted. Grazing should be discontinued just before plants begin to grow erect in preparation for jointing. Harvesting the grain should be delayed until the wheat is sufficiently mature to store well, with moisture content of 13.5% or less under ordinary conditions. Wheat is harvested with combine properly adjusted to minimize grain losses. Storage bins should be cleaned and treated before grain is placed in them. Seed storage to 3 years in dry storage bins.

Yields and Economics

In general, yields of wheat vary from 40.4 to 65.1 bu/ha, with higher yields up to 85 bu/ha obtained with irrigation. Yields depend on climatic conditions, variety or cultivar of wheat planted, size of kernel, and number of kernels per head. Production figures presented by Briggle (1981) showed Iran rather low with 1,100 kg/ha ranging to West Germany with 4,110 kg/ha, cf the US with 2,040 kg/ha. In the US, Ohio was high with 3,162 kg/ha compared with South Dakota at 1,608 kg/ha. In 1979 the world low production yield figure was 160 kg/ha in Jordan, the international production was 1,782 kg/ha, and the world high production yield was 7,000 in U.A.E. (FAO, 1980a). Dibb (1983) compares US yields of 2,100 kg/ha to 1,300 kg/ha in the developing countries and a world reported record of 14,500 kg/ha. Wheat is one of the most important food plants of man. It enters into international trade more than any other food. World production in 1971 was 303 million metric tons. Major producers are, in order, United States, USSR, China, Canada, France, Italy, Indian Union, Argentina, Australia, and Pakistan. The economic stability of many nations is affected by the exchange in wheat and other commodities (Reed, 1976).

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges from 4 to 18 MT/ha. Chaff is estimated to constitute 25% of the grain. Wheat straw is calculated at 1/2–2 times grain yield, more frequently, 1 1/2 times. However, in some countries, wheat biomass averages more than 6 MT/ha, double this if double cropped. The highest phytomass figure to date in our files is 18 MT/ha/yr. Australians figure that methanol produced from wheat stubble is about 7 times as expensive per GJ as Kuwaite oil, but half as expensive as ethanol from wheat grain ($A 1.25 per GJ for oil, 8.8 for methanol from stubble, 14.1–15.4 for ethanol from grain) (Boardman, 1980). Research reiterated by Palz and Chartier (1980) indicated that straw from winter wheat, summer wheat, winter barley, summer barley, winter rye, and oats all gave calorific values based on moisture-free dry matter of 17.04 (± 5%) MJ/kg, or based on air dry matter 15.06 (± 3.5%) MJ/kg. High N fertilization raised calorific values by ca 425 KJ/kg. Increasing moisture content from 14 to 20% reduced calorific value by 9%. Since straw available as feedstock is normally air-dry, a calorific value of 15 MJ/kg is assumed by Palz and Chartier (1980) for all cereal varieties and species. The assumed grain straw ratio for:
wheat is 1.23

barley is 1.45
oats is 1.16
rye is 0.70
other cereals are 1.10
Elsewhere Palz and Chartier assume 17.5 MJ/kg as the typical energy value for the dry matter of herbaceous materials. Reducing Kvech's (1979) numbers by 10% to convert approximately to DM yields for residues, we have the following figures for Kourim, Czechoslovakia, rounded to the nearest MT: *Medicago sativa*, 7; *Trifolium pratense*, 4; *Vicia faba*, 4; *Avena sativa*, 3; *Lolium perenne*, 3; *Secale cereale*, 3; *Trifolium repens*, 3; *Triticum aestivum*, 3; *Brassica Tapa*, 2; *Hordeum vulgare*, 2; *Phacelia tanacelifolia*, 2; *Beta vulgaris*, 1; *Sinapis alba*, 1; *Solanum tuberosum*, 1. The harvest index of cereals in general is ca 0.36, meaning that 64% of total above ground crop production is residue, at least 1/3 of which should be left in the field. 'Prior' barley has the HI ranging from 0.48 to 0.41 with increasing N fertilizer levels. Wheat usually runs about 0.30 to 0.35 HI. Rice often has a high HI, while grain sorghum generally has a low HI. The 'Green Revolution' cereals with short straw and high grain yields have relatively high HI. Biomass engineers might prefer a low HI. The estimated cost of ethanol and methanol from cereal grains is $0.35 per liter, and $0.16 per liter; the overall energy efficiency, i.e. the ratio of the energy value of the gross liquid fuel output to the total energy inputs including feedstocks is 0.34 for ethanol and 0.40 for methanol. For each ton of ethanol produced from cereal grains, there is another ton of dry distiller's residue, valued in the U.S. as animal feed (Stewart et al. 1979). Briggle's figures show that fertilizer constitutes the biggest energy input for spring wheat, 2,102,000 Btu/ha out of a total energy input of 5,646,000 Btu/ha, compared with 3,401,000 out of 7,478 for winterwheat. Preplanting required 1,025,000 Btu/ha for spring wheat, 994,000 for winterwheat; planting takes 268,000–235,000, fertilizer application 10,000–57,000, pesticide application 18,000–44,000, pesticides 14,000–60,000, irrigation 146,000–953,000, harvesting 257,000–398,000, truck 271,000–368,000, grain handling 7,000–15,000, farm pickup 763,000–800,000, farm auto 220,000–233,000, electricity and overhead, 42,000, miscellaneous 54,000 to 326,000 Btu/ha (Briggle, 1981). Briggle's earlier work (1980) showed wide variation in output/input ratios, the highest ratio (4.64) representing hard red spring wheat yields of ca 4.7 MT/ha (equiv. 15,500,000 kcal/ha) from energy inputs of only 3,350,000 kcal/ha in Idaho, the lowest ratio being 0.43, representing Texan winter wheat yields of ca 2.4 MT/ha. Energy inputs ranged from 2–18 million kcal/ha and yields from ca 1,000 to 5,000 kg. Briggle (1980) adds that wheat is an energy frugal crop, produced with the energy equivalent of less than 5 barrels oil/ha compared to corn at closer to 10 barrels and potatoes at nearly 25.

Biotic Factors

Wheats are attacked by many fungi and other organisms. Some cvs are resistant to the various rusts, smuts, and virus diseases. The most important fungal diseases of wheats are the following. Extension agents should be consulted concerning diseases in an area before growing wheat. Also cvs should be selected for growing which are resistant to such diseases. Fungal diseases of wheat: Rusts (Stem or Black rust, *Puccinia graiminis* f. sp. *tritici*; Leaf or Brown rust, *P. recondita*; Stripe or Yellow rust, *P. glumarum*); Smuts (Bunt or Covered smut, *Tilletia caries* and *T. foetida*; Dwarf Loose smut, *Ustilago tritici*); Mildews (Downy mildew, *Sclerospora macrospora*; Powdery mildew, *Erysiphe graminis* f. sp. *tritici*); Root rots (Common root rot, *Helminthosporium* spp. and

Fusarium spp.; Take-all root rot, *Ophiobolus graminis;* Browning root rot, *Pythium* spp.); Foot rots (Eye spot, *Cercosporella herpotrichoides;* Snow mold, *Fusarium* spp.); Blights and Scabs (Head blight or scab, *Fusarium* spp.; Rhizoctonia blight, *Rhizoctonia* spp.; Typhula blight, *Typhula* spp.; Anthracose, *Colletotrichum graminicola*; Kernel smudge, *Helminthosporium* spp., *Alternaria* spp.); Blotches (Glume blotch, *Septoria nodorum*; Leaf blotch, *S. tritici*; Speckled leaf disease, *Leptosphaeria avenaria* f. sp. *triticea;* Ergot, *Claviceps purpurea*. Diseases caused by bacteria include the following: *Pseudomonas atrofaciens* (Basal glume rot or bacterial black-tip) and *Xanthomonas transluscens* f. sp. *undulosa* (Black shaff). Diseases caused by viruses include the following: Wheat mosaic, Wheat streak mosaic, Wheat striate mosaic, and Yellow dwarf. Insect pests encountered in various areas include: English grain aphid is the most common aphid affecting wheat, attacking the heads and being very damaging when populations become high prior to the late-dough stage. Other insects and cutworms, darkling beetles, hessian fly, and salt marsh caterpillars, may cause damage during the seedling stage. A great number of species of nematodes have been isolated from wheats in various parts of the world. Where nematodes are a problem, the agricultural agent should be consulted.

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 17.51 to 16.49 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the **straw** contained 71.30% volatiles, 8.90% ash, 19.80% fixed carbon, 43.20% C, 5.00% H, 39.40% O, 0.61% N, 0.11% S, 0.28% Cl, and undetermined residue.

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 16.20 to 15.16 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the **dust** contained 69.85% volatiles, 13.68% ash, 16.47% fixed carbon, 41.38% C, 5.10% H, 35.19% O, 3.04% N, 0.19% S, and undetermined residue.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Friday, January 9, 1998 by aw

Broccoli Raab

Rapa, Rapini, Taitcat, Italian turnip, Broccoli turnip

Cruciferae *Brassica campestris* L. (Ruvo group)

Source: Magness et al. 1971

This plant is grown for its tender leaves and flowers shoots which are used as greens or pot herbs. Plants develop rather rapidly and are harvested before the flower buds open. General growth habit and exposure of edible parts are similar to spinach.

Season, seeding to harvest: About 60 days.

Production in U.S.: No data, very limited.

Use: As pot herb.

Part of plant consumed: Entire top, leaves, stems and flower buds.

Last update February 18, 1999 by ch

Brome grasses

Gramineae *Bromus* sp.

Source: Magness et al. 1971

Some 43 species of *Bromus* are native in the United States. Some of these are important forage sources, others are troublesome weeds. Most bromes are highly palatable during succulent growth, even the ones classed as weeds. The leaf blades are flat, and the seed heads are open, spreading panicles. Species of major value in agriculture are field bromegrass, California brome, rescuegrass, smooth brome, mountain brome, cheatgrass, downy brome, Japanese chess, and hairy chess.

Last update February 18, 1999 by ch

California brome

Gramineae *Bromus carinatus* Hock. and Arn.

Source: Magness et al. 1971

This is a bunchgrass native in the Rocky Mountain and Pacific Coast regions.
The plant grows up to 4 feet. Leaf blades are up to 8 inches long, about 0.5 inch wide. It produces large quantities of leafy forage, relished by all kinds of livestock while immature. The mature foliage is less palatable, but the seed heads are palatable and nutritious. The plant is relatively short lived.

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Mountain brome

Gramineae *Bromus marginatus* Nees

Source: Magness et al. 1971

Mountain brome is a bunchgrass native to the Rocky Mountain and Pacific Coast regions. Plants grow to 4 feet, with leaves up to 12 inches long and about 0.25 inch wide. Leaf blades are flat, and haily underneath. Growth starts early in the spring, producing much leafy forage relished by livestock. Because of rapid seedling growth and a well-branched, deep root system, mountain brome is excellent where a rapid cover development is needed. This grass is frequently seeded with alfalfa or sweet clover in the Pacific Northwest. The mixture is ideal both for prevention of erosion and as a well balanced animal diet. Stands of mountain brome grass are readily established by seeding.

Last update February 18, 1999 by ch

Bromus inermis Leyss.

Syn.: *Zerna inermis* (Leyss.) Lindm.
Bromus glabrescens Honda
Bromus tatewakii Honda

Poaceae

Smooth bromegrass

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Field bromegrass

Gramineae *Bromus arvensis* L.

Source: Magness et al. 1971

This is a winter annual grass introduced from Europe in the late 1920's and now grown in the Cornbelt and eastward. When seeded in late summer it develops an extensive fibrous root system, making it excellent for erosion control. It is winter hardy and grows rapidly the following spring. The seeds ripen in midsummer and the plants die. Although most used for erosion control and soil improvement, it furnishes palatable pastilrage during the spring.

Last update February 18, 1999 by ch

Minor annual brome grasses

Gramineae *Bromus* sp.

Cheatgrass (Chess) *B. secalinus* L.
Downy brome (Bronco grass) *B. tectorum* L.
Japanese chess *B. japonicus* Thunb.
Hairy chess *B. commutatus* Schrad.

Source: Magness et al. 1971

These are all winter annual grasses that are widely distributed in pasture and range lands and may be troublesome weeds in grain fields. They are prolific seed producers and may become dominant in overgrazed perennial pastures. For a short period in spring they furnish good pasturage. None of these is seeded commercially.

Last update February 18, 1999 by ch

Rescuegrass

Gramineae, Poaceae *Bromus willdenowii* Kunth.

Source: Magness et al. 1971

This bunch grass is native in Argentina, but was introduced into the Southern States around 1850. It is now naturalized there in many areas. It is a short-lived perennial, adapted to humid areas with mild winters. Plants reach up to 3 feet, with leaves up to a foot long and about 0.25 inch wide. Young plants are pubescent, but mature plants are sparingly so. Growth occurs throughout the winter, the plants becoming mature in early summer. On strong soils, a good amount of forage palatable to livestock is produced. Seed is produced in quantity, and stands are readily obtained by seeding.

Last update July 1, 1996 bha

Bruguiera gymnorrhiza (L.) Savigny

Syn.: *Bruguiera conjugata* Auct.
Rhizophoraceae
Burma mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The heavy wood (sp. grav. 0.87–1.08) is durable but hard to saw and work. It is used for construction, furniture, houseposts, and pilings (Little, 1983). Thousands of tons of Bruguiera wood chips are exported annually from Indonesia, Sabah, and Sarawak for pulp and for rayon manufacture (NAS, 1980a). Fruits are eaten, but not when anything better is available. More often, they are chewed as astringent with the betel quid. Chinese in Java make a sweetmeat therefrom. Dutch Indians use the bark to flavor raw fish. The leaves and peeled hypocotyls are eaten in the Moluccas after soaking and boiling (Hou, 1958). The phlobaphene coloring matter is used in China and Malaya for black dye (Burkill, 1966). In South Africa, the tree has been planted to stabilize dunes and in freshwater swamps.

Folk Medicine

Reported to be astringent (Duke and Wain, 1981), the bark is used for diarrhea and fever in Indonesia (Perry, 1980). Cambodians use the astringent bark for malaria (Burkill, 1966).

Chemistry

In Burma, leaves may contain 18.3% H_2O, 13.5% tannin; outer cortex (small trees) 14.6 and 7.9, outer cortex (large trees) 14.2 and 10.8; twig bark 13.1 and 14.8, bole bark (small trees) 16.3 and 31.7, while the bole bark of large trees contains 12.5% H_2O, 42.3% tannin. Bark contains from ca 4–32% tannin, 12.77–53.12% according to Watt and Breyer-Brandwijk (1962) and the Wealth of India (C.S.I.R., 1948–1976).

Toxicity

Eating too much (bark) is dangerous (Burkill, 1966).

Description

Evergreen tree 8–25(-35) m high, with straight trunk 40–90 cm in diameter, buttressed at base, and with many upright pneumatophores rising to 45 cm from long horizontal roots. Bark gray to blackish, smooth to roughly fissured, thick; inner bark reddish. Leaves opposite, elliptical, 9–20 cm long, 5–7 cm wide, acute at both ends, entire, without visible veins, thick, leathery, glabrous. Petiole 2–4.5 cm long. Flowers single in leaf axile 3–4 cm long, usually drooping on stalk of 1–2.5 cm, red to yellowish or cream-colored, with red to pink-red bell-shaped hypanthium. Calyx with 10–14 very narrow, leathery lobes. Petals 10–14, 13–15 mm long, white turning brown, each with 2 narrow lobes ending in 3–4 bristles. Stamens 2, nearly hidden, at base of each petal. Pistil with inferior 3–4-celled ovary, each cell with 2 ovules, style slender; stigma with 3–4 short forks. Berry drooping, ovoid or turbinate, 2–2.5 cm long. Seed 1, viviparous, finally 1.5–2 cm in diameter (Little, 1983).

Germplasm

Reported from the Hindustani, Africa, Australian, and Indonesian-Indochina Centers of Diversity, Burma mangrove, or cvs thereof, is reported to tolerate alkali, disease, high pH, insects, pest, salt, shade, waterlogging (NAS, 1980a; Little, 1983). ($2n = 18$)

Distribution

Tropical South and East Africa, Madagascar, Seychelles, Sri Lanka, southeastern Asia, Ryukyu; throughout Malaysia to Philippines, Australia, Micronesia, and Polynesia. Introduced into Hawaii (Little, 1983).

Ecology

Estimated to range from Tropical Moist to Rain through Subtropical Moist to Rain Forest Life Zones, Burma mangrove is reported to tolerate annual precipitation of 10 to 80 dm, annual temperature of 20 to 26°C, and pH of 6.0 to 8.5. One of the largest trees in the Malayan mangroves, usually on drier well-aerated soils toward the landward side, often dominating, with occasional stems >35 m tall. It is probably the longest lived of the mangroves. It can stand "any amount of shade" (Hou, 1958). Mostly on brackish or saline silts of depositing shores and marshes.

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In Avicennia and Rhizophora, direct seeding results in ca 90% survival.

Harvesting

Mostly harvested from natural stands. Species of Rhizophoraceae, growing only from the tips of the branches, are often killed by indiscriminate lopping of branches (NAS, 1980a). After felling, its regeneration is often very scant and there is danger of overgrowth by Acrostichum (but once seedlings have established themselves, the "fern acts rather as a nurse, forcing the seedling up.") (Hou, 1958).

Yields and Economics

Good mangrove stand can show annual productivity of (-25) MT/ha/yr, but for firewood purposes, I would reduce that to 10–20(-25) m^3 /ha/yr, figuring that at optimal rather than average. Litterfall may account for 1/3–1/2 of aboveground productivity. Because of the heaviness of the wood, mangrove is generally more valuable than other species.

Energy

Wood widely used for charcoal and fuel (Little, 1983). For charcoal, the tree seems to rank with Rhizophora, with an even higher calorific value. According to WOI, the calorific value of moisture-free sapwood is 5,169 cals, heartwood 5,079.

Biotic Factors

No data uncovered.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, December 30, 1997

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Buffalograss

Gramineae *Buchloe dactyloides* (Nutt.) Engelm

Source: Magness et al. 1971

Buffalograss, a native species, is the dominant grass in parts of the Great Plains. It is a fine-leaved, sod-forming perennial, generally only 6 to 8 inches high, with leaves 3 to 6 inches long and less than 0.125 inch wide. It spreads by surface runners to form a dense sod, Growth starts in late spring and continues through the summer. It is very palatable and stands grazing well. It is readily established either by seeding or by sod pieces, and is valuable both as pasture and for erosion control. The species is unisexual, about half the plants being female and producing seed; and half male, the flowers of which produce only pollen.

Last update February 18, 1999 by ch

Fagopyrum esculentum Moench (syn. *F. sagittatum* Gilib.) Common Buckwheat

Fagopyrum tataricum Geartn. Tartary Buckwheat

Fagopyrum cymosum L. Perennial Buckwheat

Polygonaceae

Buckwheat, beech wheat, *bochweit, boechweite*, buckwheat grits, buckwheat groats, Japanese buckwheat, *kasha*, Silverhull, Tartary

NewCROP has buckwheat information at:

Buckwheat: Pseudocereal and Nutraceutical—Steven Edwardson

Storage, Processing, and Quality Aspects of Buckwheat Seed.—Giuseppe (Joe) Mazza

Structure and Chemical Composition of Developing Buckwheat Seed. —Obendorf, R.L., M. Horbowicz, and D.P. Taylor

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

New Crops for Canadian Agriculture—Ernest Small

Buckwheat:—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Buckwheat —from Magness J.R. et al. 1971. Food and Feed Crops of the United States.

Buckwheat Leaves Eaten as a Famine Food

And outside links to more buckwheat info:

Minn-Dak Growers, Ltd.

Buckwheat Genetic Resources in the Himalayas: Their Diversity, Conservation and Use

Buckwheat: A Multi-Purpose, Short-Season Alternative—University of Missouri Agricultural publication G4290

Buckwheat—by Clayton G. Campbell from the International Plant Genetic Resources Institute

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Cucurbita foetidissima HBK

Cucurbitaceae

Buffalo gourd, Calabazilla, Missouri gourd

We have information from several sources:

Arid-land Industrial Crops—Anson E. Thompson

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Bugleweed

Lycopus virginicus L.

Figure 27.—Bugleweed (*Lycopus virginicus*)

Other common names.—Buglewort, sweet bugleweed, American water hoarhound, carpenter's herb, green archangel, gypsyweed, Paul's betony, woodbetony, wolf foot, purple archangel, water bugle, gypsywort, gypsy herb, Virginia hoarhound.

Habitat and range.—Bugleweed is a native herb frequenting wet, shady places from Canada to Florida, Missouri, and Nebraska.

Description.—This herb has long, threadlike runners and a bluntly 4-angled, smooth, slender, erect stem from 6 inches to 2 feet in height. The leaves are about 2 inches in length, pointed, rather narrow, and dark green or of a purplish tinge. The whitish flowers, which appear from about July to September, are small, tubular, and bell-shaped, and are produced in dense clusters in the axils of the leaves. They are followed by four nutlets. The plant has a rather pleasant, mintlike odor, but a disagreeable bitter taste.

Part used.—The entire herb, gathered during the flowering period.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Love grasses

Teff

Gramineae, (Poaceae) *Eragrostis* sp.

Source: Magness et al. 1971

Some 250 species of *Eragrostis*, the love grasses, are known - with about 40 native in the United States. Only a few have agricultural value. Some species produce abundant growth on soils of low fertility and are valuable for protection of eroding sites. The species of most value in the United States are Boer lovegrass, Weeping lovegrass, Lehmann lovegrass, and Sand lovegrass.

Last update September 22, 1997

Burnet

Rosaceae *Sanguisorba minor* Scop,

Source: Magness et al. 1971

The plant is a hardy perennial 1 to 2.5 feet in height, with long compound leaves, each with 6 to 10 pairs of small leaflets. It is sometimes grown in gardens for the fresh young Ieaves which are used in salads. While it has long been listed in gardening manuals, it is not grown commercially in U.S., and so far as known not in other countries.

Last update June 26, 1996 by aw

Juglans cinerea L.

Juglandaceae

Butternut

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Butternut accessions from the National Germplasm Repository, Corvallis, Oregon

Walnuts, *Juglans* spp.

Conocarpus erectus L.

Combretaceae
Button mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The heavy wood (sp. grav. 1-0) is durable and takes a fine polish. Durable in water, it is used for barges, boats, and maritime construction. Though suceptible to dry-wood termites, it is also used for crossties, fences, and turnery. Describing it as keeping well underground and in salt water, Irvine (1961) notes it is used for piling and firewood. Bark has been used for tanning leather. Sometimes introduced as an ornamental evergreen.

Folk Medicine

Reported to be astringent, styptic, and tonic, button mangrove is a folk remedy for anemia, catarrh, conjunctivitis, diabetes, diarrhea, fever, gonorrhea, headache, hemorrhage, orchitis, pricklyheat, swellings, and syphilis (Duke and Wain, 1981; Irvine, 1961; Morton, 1981). The leaves are eaten, or their decoction drunk, for fever (Irvine, 1961).

Chemistry

Bark contains 16-18% tannin.

Description

Evergreen tree to 6 m tall, 20 cm in diameter, with spreading crown. Bark gray or brown, becoming rough, furrowed, thick; inner bark light brown. Leaves alternate, lanceolate, or ellipticaL, 3-8 cm long, 1.5-3 cm broad, leathery and slightly fleshy, long-pointed at both ends, not entire, yellow-green on both surfaces, usually with several gland-dots near vein angles on lower surface. Petiole 3-10 mm long, slightly broad and winged with 2 gland-dots. Flower clusters mostly 3-8 cm long at end of twigs and in leaf axils, of several small heads, about 5 mm in diameter on slender stalks. Flowers many in each ball, 2 mm long, mostly bisexual. Bisexual flowers have hairy, grayish, 2-winged tubular base, cuplike green calyx with 5 lobes, 5-10 protruding stamens, and inferior ovary with slender style. Male flowers lack tubular base and pistil but have longer stamens. Multiple fruits rounded, 10-12 mm in diameter, purplish-brown. Drupes many, scalelike, dry, 3 mm long, 2-winged (Little, 1983).

Germplasm

Reported from the African and Middle and South American Centers of Diversity, button mangrove, or cvs thereof, is reported to tolerate diseases, insects light frosts, pests, salt, and waterlogging (NAS, 1980a; Little, 1983).($2n$ = 24)

Distribution

Bermuda and Bahamas through West Indies to central Florida. From northern Mexico southward on Atlantic Coast to Brazil and on Pacific Coast to Ecuador including Galapagos and northwestern Peru. Western tropical Africa from Senegal to Zaire. Not widely introduced (Little, 1983).

Ecology

Estimated to range from Tropical Dry to Rain through Subtropical Dry to Rain Forest Life Zones, button mangrove is reported to tolerate annual precipitation of 8.7 to 21.5 dm (mean of 2 cases = 15.1), annual temperature of 25.8 to 26.0°C (mean of 2 cases = 25.9), and estimated pH of 6 to 8.5. It can surely tolerate much higher annual precipitation and annual temperature down to 17deg.C (without heavy frost). Usually in brackish or saline silts of depositing shores, marshes, and stream banks.

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In Avicennia and Rhizophora direct seeding results in ca 90% survival. The plants can be grown on dry land away from seashores. They can be propagated from cuttings as living fenceposts (Little, 1983).

Harvesting

No data available.

Yields and Economics

Good mangrove stand can show annual productivity of 10-20(-25) MT/ha/yr, but for firewood purposes, I would reduce that to 10-20 (-25) m^3 /ha/yr, figuring that at optimal, rather than average. Because of the heaviness of the wood, a cubic meter of mangrove is generally more valuable than other species. Litterfall may account for 1/3-1/2 of aboveground productivity.

Energy

The wood "has high calorific value as fuel but is most widely used for high-grade charcoal (Morton, 1981). Little (1983) says it makes a good slow-burning fuel and charcoal.

Biotic Factors

Suceptible to attack by dry-wood termites (Little, 1983).

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[Complete list of references for Duke, Handbook of Energy Crops]

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last update July 8, 1996

Button-Snakeroot

Eryngium aquaticum L.

Synonym.—*Eryngium yuccifolium* Michx.

Figure 31.—Button-snakeroot (*Eryngium aquaticum*)

Other common names.—Eryngium, eryngo, water eryngo, corn snakeroot, rattlesnake master, rattlesnake-weed, rattlesnake flag.

Habitat and range.—Although sometimes occurring on dry land, button-snakeroot usually inhabits swamps and low, wet ground from Connecticut and the pine barrens of New Jersey to Illinois and South Dakota and south to Texas and Florida.

Description.—This plant has grasslike, rigid, parallel-veined leaves 1 to 2 feet in length and about one-half inch in width. The stout furrowed stem reaches a height of from 2 to 6 feet and is generally unbranched except near the top. . The insignificant whitish flowers are borne in dense, stout-stemmed heads from June to September. The stout rootstock is very knotty, with numerous short branches, and produces many thick, rather straight roots.

Part used.—The rootstock, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, March 13, 1998 by aw

Shea butter

Bambuk butter

Sapotaceae *Butyrospermum parkii* (Don) Kotschy

Source: Magness et al. 1971

This fat is obtained from nuts of the above species, which is a large tree native to West Africa. The dried fruit consists of a thin shell, enclosing an egg shaped seed. The seeds are about 3 grams in weight. The kernels contain about 50 percent of a non-drying fat. Both nuts and the fat are exported to Europe as well as used locally. In Europe, the fat is used as a cooking fat, in the manufacture of margarine, and as a substitute for cacao butter. The press cake or extracted meal is fed to cattle.

Last update June 28, 1996 bha

Byrsonima crassifolia HBK.

Byrsonima cubensis Juss.

Malpighia crassifolia L.

Malpighiaceae

Nance

We have information from several sources:

South American fruits deserving further attention—Campbell, R.J. 1996. p. 431-439. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Nance—Julia Morton, Fruits of warm climates

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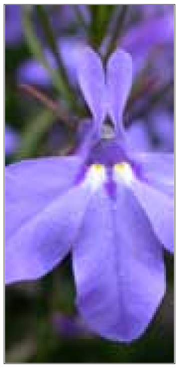
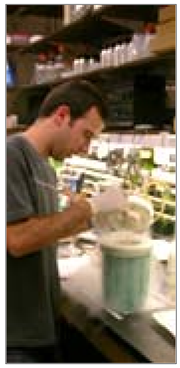
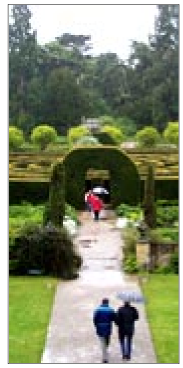
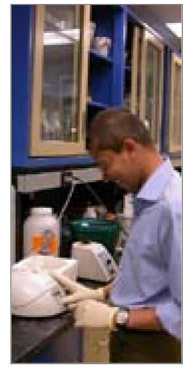
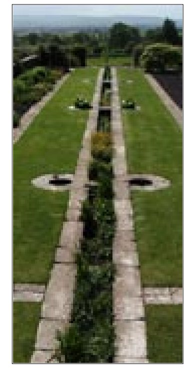

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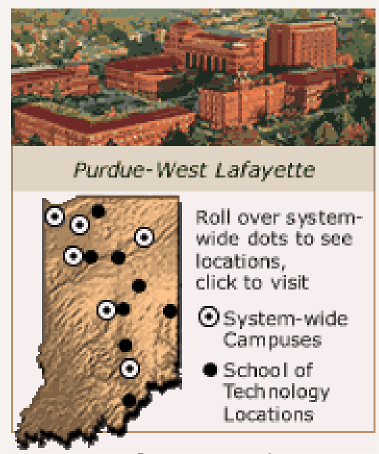

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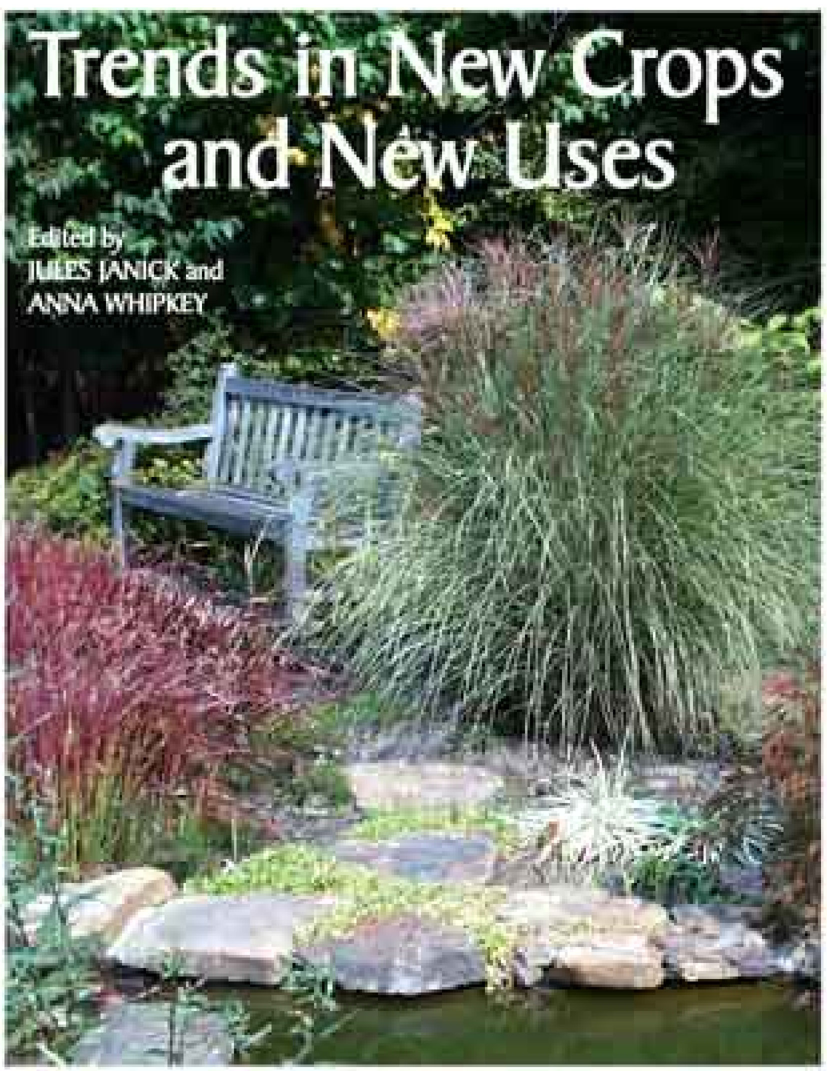
Proceedings of the fifth National Symposium New Crops and New Uses: Strength in Diversity

Jules Janick and Anna Whipkey (eds.). 2002. ASHS Press, Alexandria, VA



The issue of crop diversity has never been more urgent. Present day agriculture is faced with an erosion of crop variability as the trend toward monoculture persists throughout the world. As a result farmers face increased risks, both biologic and economic, due to a combination of market forces and subsidies that leads inexorably away from rather than toward diversity. An expected doubling of world population continues to be a looming specter upon the horizon, while at the same time, ironically, over-production in the developed world leads to a collapse of small farmers and rural communities. The issue of agricultural sustainability is ever present, especially on fragile soils. In addition, there are new geopolitical pressures brought about by the increasing demands of an oil-based economy. There have been many solutions proposed but the balance still eludes us. Genetic and management solutions to increase production is necessary for the developing world but aggravate overproduction in the developed world. New industrial uses for crops could increase demand and farmer income. Many suggest that a move to a bio-based economy could solve two problems: reduce our dependence on imported petroleum while providing new opportunities to farmers. New crop alternatives could lead to new options for both consumers and farmers. The strategies above are not mutually exclusive.

This book, the fifth of a series, is based on the symposium entitled New Crops and New Uses: Strength in Diversity held Nov. 8 to 11, 2001 in Atlanta, Georgia and organized by the Association for the Advancement of Industrial crops (AAIC), the Purdue University Center for New Crops and Plant Products, the Thomas Jefferson Agricultural Institute, and the New Uses Council, Inc. It supplements four other proceedings: Progress in New Crops (1990, Timber Press, Portland, Oregon); New Crops (1993, Wiley Press, New York), Advances in New Crops, (1996, ASHS Press, Alexandria, Virginia), and Perspectives on New Crops and New Uses (1999, ASHS Press, Alexandria, Virginia). These volumes represent an encyclopedic compendium of new crop information useful to growers, marketers, and researchers.

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- 68020 processor
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The New Crop Compendium is now available from the office of Distance Education Services at Purdue University.

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*any New Crop Proceeding author
†shipping charges are per order, not per disk

HELP
How to use the NewCROP site

To access crop information:

1. Use **CropINDEX** if you already know the name of the crop or species, or just want to browse.

   CropINDEX, is an extensive alphabetical list of all common and scientific crop names held on this site, but does not include **Famine Foods** entries which are indexed separately.

2. Or use **CropSEARCH**, for keyword subject searching.

   The CropSEARCH locates crops by name, topic, uses, geography, commodity, author citations, etc; and locates any terms entered.

To access special topics:

There are a number of specialized subject areas that are embedded in new crops:

1. Famine Foods - These are unconventional food sources used in times of desperation.
2. Aromatic, Herbal and Medical Plants
3. The following publications can be found on the NewCROP website:
   - Trends in New Crops and New Uses. 2002. Proceedings of the Fourth National Symposium New Crops and New Uses: Strength in Diversity. Jules Janick and Anna Whipkey (eds.). ASHS Press, Alexandria, VA. 599 pages.
   - Perspectives on New Crops and New Uses. 1999. Proceedings of the Fourth National Symposium New Crops and New Uses: Biodiversity and Agricultural Sustainability. Jules Janick (ed.). ASHS Press, Alexandria, VA. 528 pages.
   - Progress in New Crops. 1996. Proceedings of the Third National Symposium NEW CROPS: New Opportunities, New Technologies. Jules Janick (ed.). ASHS Press, Alexandria, VA. 660 pages.
   - New Crops. 1993. Proceedings of the Second National Symposium NEW CROPS: Exploration, Research, Commercialization Jules Janick and J.E. Simon (eds.). Wiley

and Sons, Inc., New York. 710 pages.

- Advances in New Crops. 1990. Proceedings of the First National Symposium NEW CROPS: Research, Development, Economics. Jules Janick and J.E. Simon (eds.). Timber Press, Portland, Oregon. 560 pages.
- Fruits of Warm Climates. 1987. Julia F. Morton. J.F. Morton, Pub. 20534 SW 92 Ct., Miami Fl 33189. 505 pages.
- Handbook of Energy Crops. 1983. James A. Duke.
- The Alternative Field Crops Manual. 1992. University of Minnesota.
- Neglected Crops: 1492 from a Different Perspective. 1994. FAO. Rome.
- Famine Foods. 1995. Robert (Bob) L. Freedman Orinda, CA 94563. Unpublished. 500+ pages.
- Food and Feed Crops of the United States 1971. J.R. Magness, G.M. Markle, C.C. Compton. Interregional Research Project IR-4, IR Bul. 1 (Bul. 828 New Jersey Agr. Expt. Sta.).
- Savory Herbs: Culture and Use. 1946. M.S. Lowman, and M. Birdseye. Farmer's Bulletin No. 1977. USDA, Washington, DC.
- The Herb Hunters Guide. 1930. A.F. Sievers, Misc. Publ. No. 77. USDA, Washington DC.

To email queries to the New Crop discussion group:

Enroll in the NewCROP discussion group - you can post specific crop questions to the approximately 400 members of this group.

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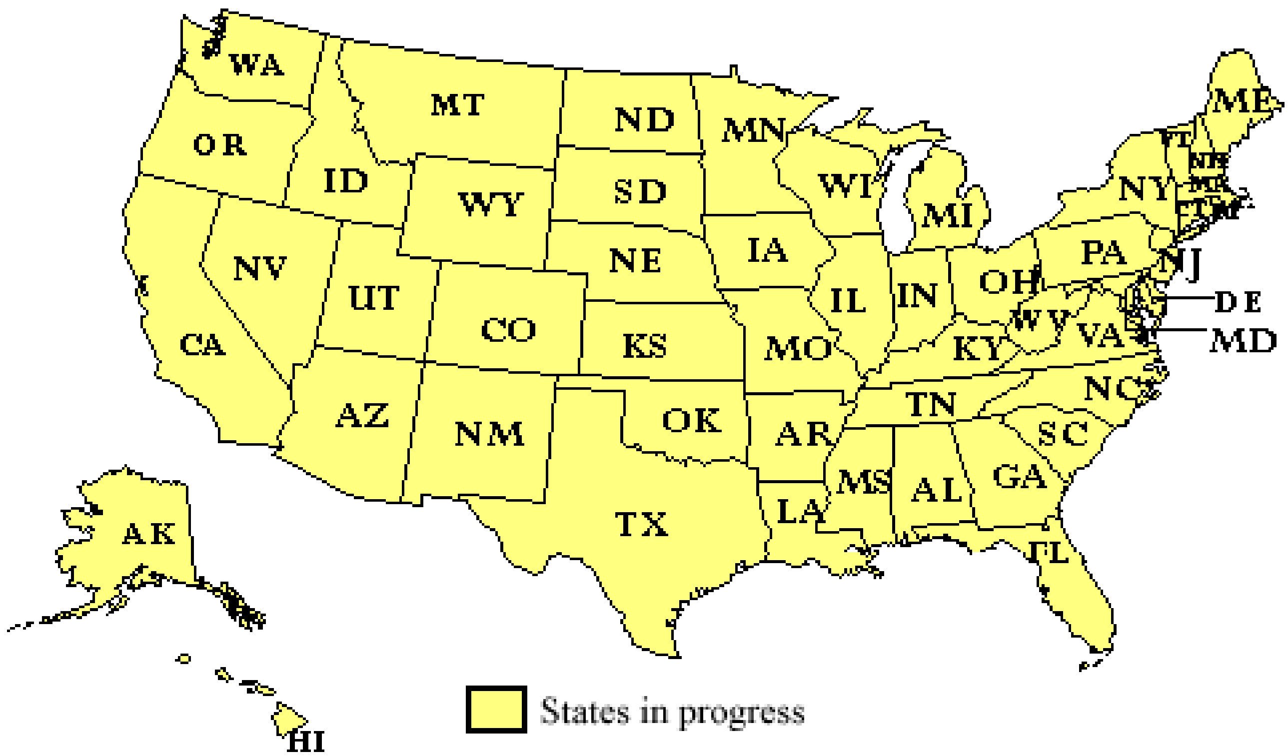
CropMAP

A New Crop Information System

[About CropMAP](#)



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CropREFERENCE

- **Policy Papers**
- **New Crop Monographs 1980 1995** Jane Gates' compilation of National Agricultural Library New Crop References.
- **New Crop References** from Noel Vietmeyer of the National Academy of Sciences. A compilation of BOSTID New Crop resources.

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Floral Ornamentals

- **Commercial Field Grown Cut and Dried Flower Production/Marketing**
  96 pages. Free information booklet.
  ATTRA
  P.O. Box 3657
  Fayetteville AR 72702
  tel: 800-346-9140
- **Professional Guide to Herbaceous Perennials**
  Professional Plant Growers Association (PPGA)
  P.O. Box 27517
  Lansing MI 48909-0517 USA
  tel: 800-647-7742

Landscape Ornamentals

- Dirr, Michael.A and Charles Heiser Jr. 1987. **The Reference Manual of Woody Plant Propagation, from Seed to Tissue Culture**. Varsity Press, Inc., Athens,Georgia.

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Periodicals—Journals

"Devoted to Past, Present and Future Uses of Plants by People"—Published quarterly for the Society for Economic Botany by the New York Botanical Garden.

Diversity—"A News Journal for the International Genetic Resources Community" Published quarterly.
4905 Del Ray Avenue, Suite 401
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Newsletter of the Center for Alternative Plant and Animal Products
University of Minnesota.
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1970 Folwell Ave.
St. Paul MN 55108 USA
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CropEXPERT

Directory of Crop Experts

Last update Tuesday, March 09, 1999 by aw

Announcements

Calendar of Upcoming Events

An International Training Program on Essential Oils, Medicinal & Aromatic Plants: From Sourcing / Production to Product Development And from Quality to Health Properties

A Week Long Intensive Course Covering: Essential Oils and Medicinal/Aromatic Plants and Science Driven Marketing

July 26 August 03, 2004
Rutgers University,
New Brunswick, NJ, USA

New Use Agriculture and Natural Plant Products Program
James E. Simon: jesimon@aesop.rutgers.edu
Regisration: http://aesop.rutgers.edu/~ocpe/courses/current/lf0802ca05.html
Brochure

New Crops 2004
Second Australian New Crops Conference

in association with ACOTANC-2004 (Australasian Conference on Tree and Nut Crops)

September 20-25, 2004
University of Queensland Gatton
80km west of Brisbane, Queensland, Australia

www.newcrops.uq.edu.au/nc2004/index.html www.uq.edu.au/gatton/

archive.dstc.edu.au/brisbane/

Agriculture Network Information Center

New Zealand Institute for Crop & Food Research Ltd.

NewCROP DISCUSSION GROUP

Jules Janick *Coordinator*

To Subscribe

Follow this link to the Majorcool E-mail List Manager site.

Fill in Your email address and Find newcrops. Click Go.

Overview

WELCOME to our NewCROP DISCUSSION GROUP. To facilitate communication between newcrops researchers, Purdue launched this NewCROP email list in April of 1995. We hope that this system will continue to act as a stimulus for real interaction–which is the purpose of all electronic communication groups.

For those new to such an electronic mail system, the main purpose of an e-mail list is to create a vehicle for rapid and easy communication over the Internet. An e-mail list permits all subscribers to communicate regularly with each other–and for free. This electronically based mail system functions very simply: subscribers can write in and ask questions, make announcements, and raise other issues for discussion to the group. Every subscriber receives this information. Any or all subscribers receiving this new mail item can file it for their own information, or opt to respond and reply. The reply is automatically sent to the entire group, unless noted otherwise, and this often leads to more responses and a lively electronic debate. The art of writing remains alive and well via electronic mail! Such a system is highly effective if it is used by the subscribers. Basic information such as sourcing new germplasm, identifying those researching a particular area all can be quickly handled via this system. This type of electronic mail is known as "mailing list", and is not an electronic bulletin board, but a mail system.

Policies

From the past years experience, we must ask that subscribers refrain from using the mailing list as a vehicle for political action and polemics of any kind, and refrain from profanity.

Do not send attachments.

Please do not post announcements about papers unless it is in response to an inquiry.

This list is not a place to post classified ads. Although inquiries about marketing and markets may be appropriate for this list please do not treat it as a commercial marketing site.

Using the New CROP DISCUSSION GROUP

To send a message to the group send E-mail to: newcrops@purdue.edu

Please administrative questions to: owner-newcrops@purdue.edu, not the list.

This discussion group is managed by an automated mailing list management program called Majordomo. You can get detailed explanations of "documented" commands which Majordomo understands by asking for "help" from Majordomo (send a message containing just the word "help" as the message text to majordomo@purdue.edu).

NewCrop mailing list Archives

A searchable archive of the NewCrop DISCUSSION GROUP is now available. The archive contains messages from 4/25/95 to 12/2/1999.

*At the discretion of the archive maintainer, off-topic posts, "spam", etc. will be removed from the archive.

We welcome news, inquiries, announcements and all other discussion.

Jules Janick

NewCROP Home Page

A Guide to Medicinal and Aromatic Plants

Welcome to the Medicinal and Aromatic Plant home page, sponsored by the Center for New Crops and Plant Products. The **Guide to Medicinal and Aromatic Plants** has several main components:

Plant/Crop Descriptors	The plant/crop descriptors are general monographs providing background information about each herb plant. Plants are listed in alphabetical order by common and Latin names.
Guide to Herb Varieties	The Guide to Herb Varieties provides a listing of herb varieties available from commercial sources.
Sources of Herb Seeds and Plants	The herb seed and plants directory provides a guide to public and commercial sources of these plants.
Botanical Companies Database	Searchable database of companies in the botanical products industry. This project was funded in part by ASNAPP
Flavor, Fragrance and Essential Oils Companies Database	Searchable database of companies in the flavor, fragrance and essential oils industries. This project was funded in part by ASNAPP
Links to Other Web Sites	Links provides a direct bridge and listing to other related web sites.

You can also find:

Aromatic, Spice, and Medicinal Plants	General information about this site, instruction for use, acknowledgments, a comment/suggestion form, and information on contacting our personnel.
NewCROP	This will bring you into our main new crop server (NewCROP) of which this site can be considered a subset built to highlight information on these commodities of plants. NewCROP offers the most comprehensive library and compilation of new and alternative crop information available on the world-wide web.

We hope that this web site will provide technical assistance to you in your search for sound scientific information about medicinal, spice and aromatic plants, and in particular be of benefit in the introduction and production of these unique and fascinating specialty crops and natural plant products.

Crop Index|Search Engine|New Crop Home Page

Phytosanitation Agencies Listed by Country

Addresses and Links to Regulatory Bureaus

- **FAO's Global Plant Quarantine Program**
- **USDA Foreign Agriculture Service (FAS) Field Office Directory for any country**

Table of Countries

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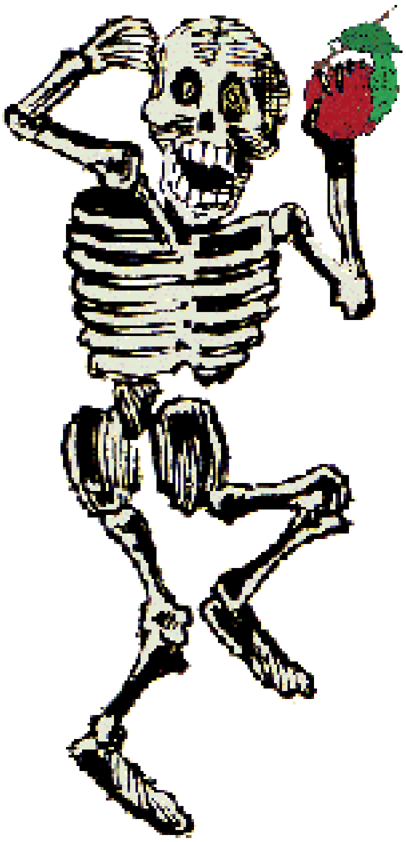
Senegal	Seychelles	Sierra Leone
Singapore	Slovak Republic	Slovenia
Solomon Islands		South Africa
South Korea	Spain	Sri Lanka
St. Kitts-Nevis	St. Lucia	St. Vincent & Grenadines
Sudan	Suriname	Swaziland
Sweden	Switzerland	Syria
Taiwan	Tajikistan	Tanzania
Thailand	Togo	Tokelau
Tonga	Trinidad & Tobago	Tunisia
Turkey	Turkmenistan	Turks & Caicos Islands
Tuvalu	Uganda	Ukraine
United Arab Emirates	United Kingdom	United States APHIS
Uruguay	Uzbekistan	Vanuatu
Venezuela	Vietnam	Wallis & Fortuna Islands
Yemen	Yugoslavia	Zaire
Zambia	Zimbabwe	

Other Territories, Regions or Special Zones Having Plant Quarantine Regulations

American Samoa	Hawaii	Norfolk Island
Puerto Rico		

New additions and useful information to this web site may be directed to Ben Alkire
Tel: 765-494-6968, Fax: 765-494-0391

Last update, June, 2000 by bha



Famine Foods:

by Robert (Bob) L. Freedman
Orinda CA 94563
email: namdeerf@ispwest.com

The Famine Foods Database:

> Plants that are not normally considered as crops are consumed in times of famine. This botanical-humanistic subject has had little academic exposure, and provides insight to potential new food sources that ordinarily would not be considered.

Search the Famine Foods Database

Plant family index

Famine Foods listed by *Genus* and *species*

List of references

Other Famine Foods websites

Ethiopia: Famine Food Field Guide

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New Crop Links

Related Web Sites

- Agriculture
- Arboreta, Botanical Gardens, Museums
- Botanical Information
- Horticulture and Gardening
- Genetic Resources
- Landscape & Ornamental
- Libraries
- Mailing lists & Newsgroups
- Marketing
- Organizations & Societies
- New Crops & New Uses Organizations
- Newsletters
- Universities including extension services
- Miscellaneous

Agriculture

- AgNIC (Agriculture Network Information Center) is a distributed network that provides access to agriculture-related information, subject area experts, and other resources.
- E-Answers is a searchable Web site that provides reliable, research-based information on a wide range of Extension or Outreach-oriented subjects.
- Web-agri The Premier Agricultural Search Engine
- CGIAR Consultative Group on International Agricultural Research
- Aggie Horticulture Crop Production and Gardening Information
- OSU WebGarden includes a Factsheet Database of over 9,400 links to agronomic and horticultural factsheets from the United States and Canada. Covers all aspects of growing plants from both the homeowner's perspective and the commercial producer.
- ProCrop - COLD CLIMATE CROPS ProCrop was designed by an Extension

Specialist/Crop Production at Devils Lake, North Dakota. It contains over 700 short articles concerning production of small grains and row crops in North Dakota.

- DLO-NL the Netherlands organization for agricultural research
- Indiana Toxic Plant IndicesThis is a database of Indiana Plants Poisonous to Livestock and Pets. It is maintained by the Cooperative Extension Service, Purdue University, West Lafayette, Indiana
- Tropical grasses and legumes Database from the FAO
- Tropical Feeds Database from the FAO
- National Seed Storage Laboratory
- InfoMine: Biological, Agricultural and Medical Resources
- Cover Crops for Sustainable AgricultureResearch on cover crops for sustainable agriculture developed or published by the Exploration of Cover Crops for Sustainable Agriculture by the International Development Research Centre in Ottawa, Canada.
- Agro-Tech Communications from Memphis, Tennessee. The company specializes in the dissemination of technologies concerning the industrial utilization of agricultural fiber and developing marketing strategies to enhance the potential of agri-business and industrial clients.
- The Dogwood Alliance Our Mission is to preserve and restore native forest ecosystems in the southeastern United States while sustaining the human communities that depend on these ecosystems.
- ILDIS International Legume Database & Information Service
- Leguminosen zur Kornnutzung
- CLIMA is the Cooperative Research Centre for Legumes in Mediterranean Agriculture.
- New Agriculturist On-line Reporting agriculture for the 21st century.
- UDSA Agricultural Research Service
- Minnesota Institute for Sustainable Agriculture
- Sustainable Farming Association of Minnesota The SFA is a farmer-run, nonprofit organization based in Minnesota.
- Carolina Farm Stewardship Association
- ILABIB A Growing Bibliography for Lupin Researchers
- Association for Temperate Agroforestry seeks to catalyze technical innovation and adoption of agroforestry in the temperate zone through a variety of research and educational activities.
- New Agriculturist Reporting Agriculture for the 21st Century
- CDMS, Inc. has an ag-chemical database of labels and MSDS.
- Urban Agriculture Notes by City Farmer Canada's Office of Urban Agriculture
- International Institute of Tropical Agriculture

- Northern Territory Department of Primary Industry and Fisheries, Australia
- ASNAPP agribusiness in sustainable natural African plant products
- Value-Enhanced Grains (VEG) encourages the growing opportunity to provide new solutions to the farm, feed and food sectors--both economically and environmentally
- Oilcrop.com CNAP and Springdale Crop Synergies in the UK. It provides information on 12 UK oil crops; including seed oil characteristics, uses, pathway of synthesis and agronomy issues.

Arboreta, Botanical Gardens, Museums

- National Botanic Gardens Biodiversity Server (Australia)
- The Finish Museum of Natural History An extensive collection of plant related internet sites.
- The New York Botanical Garden
- Royal Botanical Gardens, Kew

Botanical Information

- An **Extensive** Collection of Botanically Related URLs This is the site to visit when looking for governmental and institutional organizations world-wide.
- National Genetic Resources ProgramThe Germplasm Resources Information Network (GRIN) web server provides germplasm information about plants, animals, microbes and invertebrates within the National Genetic Resources Program of the U.S. Department of Agriculture's Agricultural Research Service (ARS).
- American Indian Ethnobotany DatabaseThis is an electronic database containing food, drug, dye, fiber and other plants used by Native North American Peoples (a total of over 47,000 items). 291 Native American groups and 3,895 species from 243 different plant families are represented.
- Indiana Toxic Plant Indices This is a database of Indiana Plants Poisonous to Livestock and Pets. It is maintained by the Cooperative Extension Service, Purdue University, West Lafayette, Indiana
- Cornell University's Poisonous Plants Information Database.
- International Organization for Plant Information
- A bibliographic database for the genus *Lathyrus*
- Invasive Species Related Links from USGS
- Centre for Plant Biodiversity Research and Australian National Herbarium
- Cyber Flora This site concerns itself with plants of the northeast, meaning Georgia to the Mississippi River, north to Canada.
- The Gymnosperm Database provides basic information (sometimes only a name) for all

species and higher-ranked taxa of the gymnosperms, i.e., conifers, cycads, and their allies.

Genetic Resources

- IPGRI International Plant Genetic Resources Institute

Horticulture and Gardening

- Exotic Fruits Vegetables Produce Products from Frieda's Inc.
- California Rare Fruit Growers, Inc. The CRFG has a general interest in all aspects of fruit growing with a primary focus on semitropical fruits and uncommon fruits and vegetables.
- Tropical Fruits (from Hawaii) Here you will find tropical fruit information: How to choose, use, and store tropical fruits, as well as descriptions.
- Asian Vegetable Website of the Plant Sciences Group, Primary Industries Research Centre, Central Queensland University. This site addresses issues related to Asian vegetable production including: Quality assessment; Seed companies; Markets for Asian vegetables; Description of growing locations
- Aggie Horticulture Crop Production and Gardening Information
- OSU WebGarden includes a Factsheet Database of over 9,400 links to agronomic and horticultural factsheets from the United States and Canada. Covers all aspects of growing plants from both the homeowner's perspective and the commercial producer.
- Horticulture Solutions Series University of Illinois, College of Agricultural, Consumer and Environmental Sciences, Cooperative Extension Service.
- University of Minnesota Horticultural Science
- A Modern Herbal by Mrs M. Grieve The hyper-text version of **A Modern Herbal**, first published in 1931, by Mrs. M. Grieve, contains Medicinal, Culinary, Cosmetic and Economic Properties, Cultivation and Folk-Lore of Herbs.
- MidFEx MidFEx, short for Midwest Fruit Explorers, is a non-profit organization of amateur backyard fruit growing enthusiasts.
- NewCROPs Medicinal-AromaticPLANTS links
- Fungi Perfecti® specializes in the distribution of cultures, tools and technologies for the cultivation of gourmet and medicinal mushrooms
- Cornell Center for Fungal Biology
- Herbs Australia The gateway to the herb industry in Australia.
- Tropical Fruit News Magazine Online
- Fruits for the Future is a 3 year project which aims to facilitate technology transfer to farmers through media, by distributing extension manuals emphasising products, marketing and processing as well as production.
- International Study Programs in Horticultural, Landscape, Environmental and Food

Sciences for foreign students at The University of Horticulture and Food Industry, Budapest (Hungary).

- SBE's Exotic Plant and Garden Seed Catalog
- Seedsaving and Seedsavers Resources
- SeedSwappers.com
- What Tree is That?National Arbor Day Foundation.
- Leaf and Twig Keys, Virginia Tech
- The Fruit Pages: everything you want to know about fruit!
- the Mississippi State University Organic Fruit and Vegetable Web Page
- International Potato Center (CIP)
- Northern Nut Growers Association
- Indiana Nut Growers Association

Landscape & Ornamental

- PLANT the Purdue Landscape and Nursery Thesaurus
- I PLANT, the Illinois Plant, Landscape and Nursery Technology web site
- Landscape Plants: Images, Identification, and Information Oregon State University
- Horticopia a CD-ROM product that offers an extensive collection of images and comprehensive coverage of North American ornamental plants, complete with plant information, and searching

Libraries

- National Agricultural Library of the United States. One great place to begin a New Crops search!
- Hunt Institute for Botanical Documentation (Hunt Botanical Library)
- Massachusetts Horticulture Society Library

Mailing lists and Newsgroups

- NewCROP Mailing List on-going discussions between new crops researchers and enthusiasts
- Internet Directory for Botany - ListServers and Newsgroups
- Mycology news group news://bionet.mycology
- Rare Fruit News Online http://www.rarefruit.com/
-

Marketing

- USDA Agricultural Marketing Service
- Openair-Market Net: The World Wide Guide to Farmers' Markets, Street Markets, Flea Markets and Street Vendors
- emarketfarm Resources for farmers' markets and market farmers
- Market Information System from the Food and Resource Economics Department, University of Florida.
- Today's Market Prices is a commercial site devoted to agricultural information from around the world.
- Global Agribusiness Information Network The Web's Most Comprehensive Source of FREE Ag Market Information
- Farms.com online markets for agriculture
- agfibertechnology.com, to provide farmers, processors and manufacturers timely information about agricultural fibers and their role in emerging biobased industries
- Organic Trade Association growers, shippers, processors, brokers, distributors and retailers working to promote organic products in the marketplace
- STATpub.com Market Intelligence for the World's Agriculture Industry Since 1988
- Value-Enhanced Grains (VEG) encourages the growing opportunity to provide new solutions to the farm, feed and food sectors--both economically and environmentally
- Southern African Natural Products Trade Association

Organizations & Societies

- CropORGANIZATIONS - NewCROP's Directory of crop organizations by botanical family, country, and discipline
- The Association for the Advancement of Industrial Crops
- Society for Economic Botany
- American Society for Horticultural Science
- International Society for Horticultural Science *Acta Horticulturae*
- Crop Science Society of America
- FAO Plant Production and Protection Division
- Links to worldwide germplasm organizations
- The Cucurbit Network Dedicated to promoting conservation and understanding of the Cucurbitaceae through education and research.
- Natural Resources Institute - University of Greenwich, UK

New Crops and New Uses Organizations

- Thomas Jefferson Agricultural Institute
- The Association for the Advancement of Industrial Crops
- ATTRA - Appropriate Technology Transfer for Rural Areas
  from Fayetteville, Arkansas.
- The Australian New Crops Project
- California Rare Fruit Growers, Inc. The CRFG has a general interest in all aspects of fruit growing with a primaryfocus on semitropical fruits and uncommon fruits and vegetables.
- New Uses Council ("New Industrial Uses for Agricultural Materials")
- MidFEx MidFEx, short for Midwest Fruit Explorers, is a non-profit organization of amateur backyard fruit growing enthusiasts.
- National Genetic Resources ProgramThe Germplasm Resources Information Network (GRIN) web server provides germplasm information about plants, animals, microbes and invertebrates within the National Genetic Resources Program of the U.S. Department of Agriculture's Agricultural Research Service (ARS).
- Germplasm sources
- Missouri Alternatives Center
- National Non-Food Crops Centre provides a single, independent and authoritative source of information on the use and implementation of non-food crop products and technologies in the United Kingdom.
- Plants for a Future is a project based in Devon and Cornwall which seeks to gather together and disseminate information on the many useful properties of plants, particularly those plants which are less common in today's society. Search their database of over 7000 plant species.
- Southern African New Crop Research Association
- Canadian Agricultural New Uses Council
- Center for Alternative Plant & Animal Products University of Minnesota
- The Institute for Local Self-Reliance (ILSR) is a nonprofit research and educational organization that provides technical assistance and information on environmentally sound economic development strategies.
- New Crop Opportunities Center at the University of Kentucky
- IPGRI International Plant Genetic Resources Institute

Newsletters

- NewCropNEWS Newsletter of the Purdue University Center for New Crops and Plant Products

- the Australian New Crops Newsletter
- The Carbohydrate Economy

Universities including extension services

- Cornell Cooperative Extension
- CES Illinois Horticulture Solutions Series
- University of Florida extension
- North Carolina Horticulture Information Leaflets
- University of Nebraska Horticulture Department
- Washington State University Cooperative Extension Service

Miscellaneous

- Food and Nutrition Internet Index FNII is a searchable Web site describing and indexing food and nutrition resources available on the Internet

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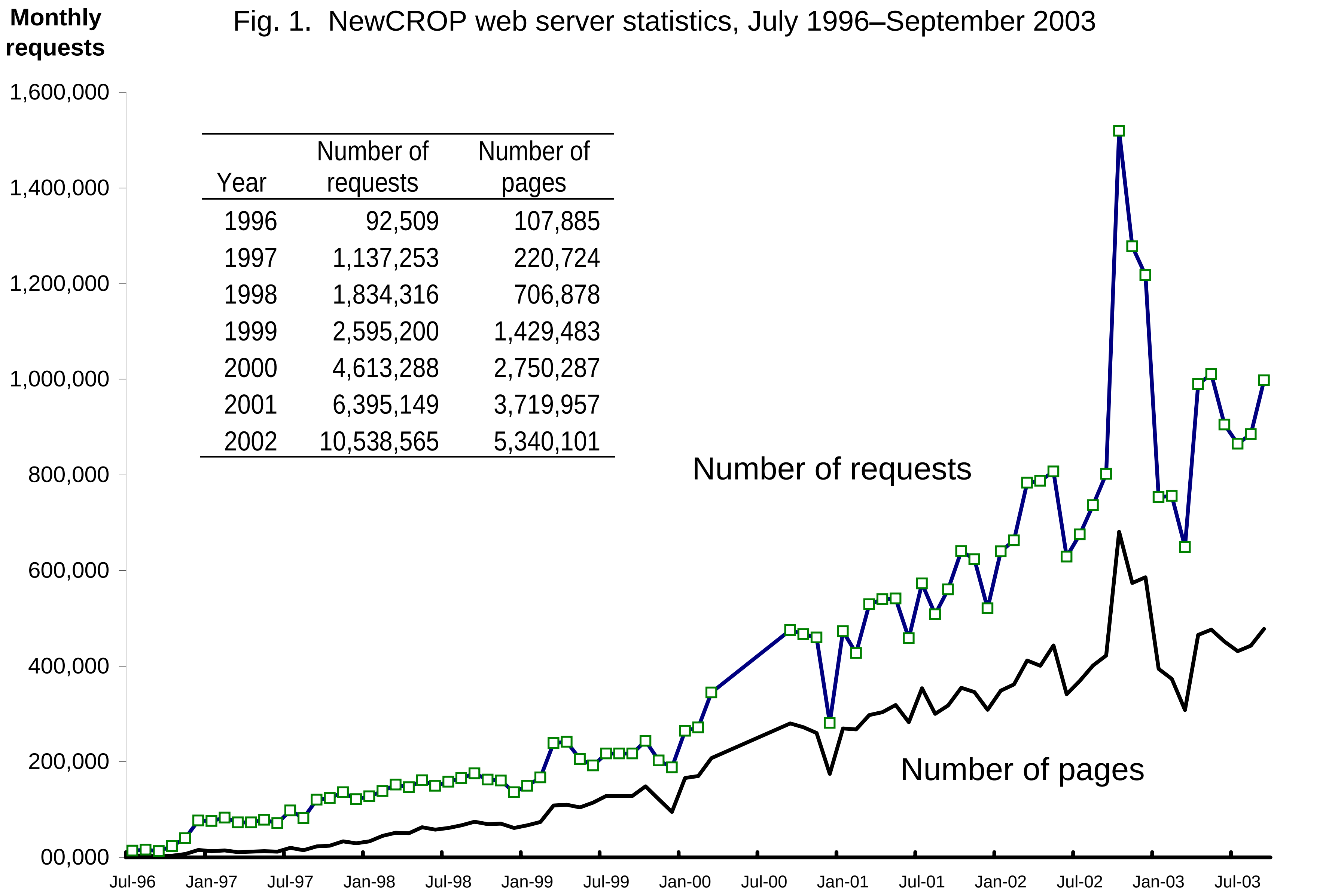
Fig. 1. NewCROP web server statistics, July 1996–September 2003



Year	Number of requests	Number of pages
1996	92,509	107,885
1997	1,137,253	220,724
1998	1,834,316	706,878
1999	2,595,200	1,429,483
2000	4,613,288	2,750,287
2001	6,395,149	3,719,957
2002	10,538,565	5,340,101

About The Author


Photo by Frank D. Venning

JULIA F. MORTON is Research Professor of Biology and Director of the Morton Collectanea, University of Miami, a research and information center devoted to economic botany. She received her D.Sc. from Florida State University in 1973 and was elected a Fellow of the Linnean Society of London in 1974. She has conducted extensive field studies for the U.S. National Institutes of Health and the Department of Defense, has served as horticultural development consultant in Florida and tropical America, and, since 1954, has been consultant for the Poison Control Centers in Florida. In 1978, she was selected as the First Distinguished Economic Botanist by the international Society for Economic Botany. She served as President of the Florida State Horticultural Society in 1979. She is a member of the Board of Trustees of Fairchild Tropical Garden, Miami, and of the Board of Directors of the Florida National Parks and Monuments Association. She is the author of 10 books and co-author of or contributor to 12 others; has written 94 scientific papers and co-authored 27 others; has produced 2 full-color wall charts of poisonous plants; a set of Survival Cards for Southeast Asia and a 157-page report on the Survival-related Flora and Fauna of the Mekong for the U.S. Department of Defense. She is well known as a lecturer on toxic, edible and otherwise useful plants.

Morton, J. 1987. Date. p. 5–11. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Date

Phoenix dactylifera

Most of the dozen or more species of the genus *Phoenix* (family Palmae) are grown as ornamental palms indoors or out. Only the common date, P. *dactylifera* L., is cultivated for its fruit. Often called the edible date, it has few alternate names except in regional dialects. To the French, it is *dattier;* in German, it is *dattel;* in Italian, *datteri;* or *dattero;* in Spanish, *datil;* and, in Dutch, *dadel.* The Portuguese word is *tamara.*

Description

The date is an erect palm to 100 or 120 ft (30.5-36.5 m), the trunk clothed from the ground up with upward-pointing, overlapping, persistent, woody leaf bases. After the first 6 to 16 years, numerous suckers will arise around its base. The feather-like leaves, up to 20 ft (6 m) long, are composed of a spiny petiole, a stout midrib, and slender, gray-green or bluish-green pinnae 8 to 16 in (20-40 cm) long, and folded in half lengthwise. Each leaf emerges from a sheath that splits into a network of fibers remaining at the leaf base. Small fragrant flowers (the female whitish, the male waxy and cream colored), are borne on a branched spadix divided into 25 to 150 strands 12 to 30 in (30-75 cm) long on female plants, only 6 to 9 in (15-22.5 cm) long on male plants. One large inflorescence may embrace 6,000 to 10,000 flowers. Some date palms have strands bearing both male and female flowers; others may have perfect flowers. As the fruits develop, the stalk holding the cluster may elongate 6 ft (1.8 m) while it bends over because of the weight. The fruit is oblong, 1 to 3 in (2.5-7.5 cm) long, dark-brown, reddish, or yellowish-brown when ripe with thin or thickish skin, thick, sweet flesh (astringent until fully ripe) and a single, cylindrical, slender, very hard stone grooved down one side.

Origin and Distribution

The date palm is believed to have originated in the lands around the Persian Gulf and in ancient times was especially abundant between the Nile and Euphrates rivers. Alphonse de Candolle claimed that it ranged in prehistoric times from Senegal to the basin of the Indus River in northern India, especially between latitudes 15 and 30. There is archeological evidence of cultivation in eastern Arabia in 4,000 B.C. It was much revered and regarded as a symbol of fertility, and depicted in bas relief and on coins. Literature devoted to its history and romance is voluminous. Nomads planted the date at oases in the deserts and Arabs introduced it into Spain. It has long been grown on the French Riviera, in southern Italy, Sicily and Greece, though the fruit does not reach perfection in these areas. Possibly it fares better in the Cape Verde Islands, for a program of date improvement was launched there in the late 1950's. Iraq has always led the world in date production. Presently, there are 22 million date palms in that country producing nearly 600,000 tons of dates annually. The Basra area is renowned for its cultivars of outstanding quality. The date has been traditionally a staple food in Algeria, Morocco, Tunisia, Egypt, the Sudan, Arabia and Iran. Blatter quotes the writer, Vogel, as stating: "When Abdel-Gelil besieged Suckna in 1824, he cut down no fewer than 43,000 trees, to compel the town to surrender; nevertheless, there are still at least 70,000 left."

In 1980, production in Saudi Arabia was brought to nearly a half-million tons from 11 million palms because of government subsidies, improved technology, and a royal decree that dates be included in meals in govern ment and civic institutions and that hygienically-packed dates be regularly available in the markets. Farmers receive financial rewards for each offshoot of a high-quality date planted at a prescribed spacing. The Ministry of Agriculture has established training courses throughout the country to teach modern agricultural methods, including mechanization of all possible operations in date culture, and recognition and special roles of the many local cultivars. In West Africa, near the Sahara, only dry, sugary types can be grown.

Bonavia introduced seeds of 26 kinds of dates from the Near East into northern India and Pakistan in 1869; and, in 1909, D. Milne, the Economic Botanist for the Punjab, introduced offshoots and established the date as a cultivated crop in Pakistan. The fruits ripen well in northwestern India and at the Fruit Research Center in Saharanpur. In southern India, the climate is unfavorable for date production. A few trees around Bohol in the Philippines are said to bear an abundance of fruits of good quality. The date palm has been introduced into Australia, and into northeastern Argentina and Brazil where it may prosper in dry zones. Some dates are supplying fruits for the market on the small island of Margarita off the coast from northern Venezuela. Seed-propagated dates are found in many tropical and sub-tropical regions where they are valued as ornamentals but where the climate is unsuitable for fruit production.

In November 1899, 75 plants were sent from Algiers to Jamaica. They were kept in a nursery until February 1901 and then 69 were planted at Hope Gardens. The female palms ultimately bore large bunches of fruits but they were ready to mature in October during the rainy season and, accordingly, the fruits rotted and fell. Only occasionally have date palms borne normal fruits in the Bahamas and South Florida.

Spanish explorers introduced the date into Mexico, around Sonora and Sinaloa, and Baja California. The palms were only seedlings. Still, the fruits had great appeal and were being exported from Baja California in 1837. The first date palms in California were seedlings planted by Franciscan and Jesuit missionaries in 1769. Potted offshoots from Egypt reached California in 1890 and numerous other introductions have been made into that state and into the drier parts of southern Arizona around Tempe and Phoenix. In 1912, Paul and Wilson Popenoe purchased a total of 16,000 offshoots of selected cultivars in Algeria, eastern Arabia and Iraq and transported them to California for distribution by their father, F.O. Popenoe who was a leader in encouraging date culture in California. It became a profitable crop, especially in the Coachella Valley. There are now about a quarter of a million bearing trees in California and Arizona.

Varieties

It would be impractical to deal in depth with date cultivars here. Paul Popenoe listed 1,500 and provided descriptions of the fruit and palm, as well as the history and significance, of the most important, country by country, in 90 pages of his book, *The Date Palm*, written in 1924 but published in 1973 and readily available. In Iraq, there are presently 450 female cultivars, the most important of which are: 'Zahdi' (43% of the crop; low in price); 'Sayer' 23% of the crop and high-priced); 'Halawi' (13% of the crop and high-priced); 'Khadrawi (6% of the crop and high-priced); also 'Khastawi, 'Brem', and 'Chipchap'. Sawaya and colleagues (1983) have reported on the sugars, tannins and vitamins in 55 major date cultivars of Saudi Arabia.

The following, with brief comments, are the dates most commonly grown:

'Barhi'— introduced into California in 1913 from Basra, Iraq; nearly cylindrical, light amber to dark brown when ripe; soft, with thick flesh and rich flavor; of superb quality. For shipment needs refrigeration as soon as picked, then curing and special packing.

'Dayri' (the "Monastery Date")—introduced into California from convent grounds in Dayri, Iraq, in 1913; long, slender, nearly black, soft. Palm requires special care. Not grown extensively in California.

'Deglet Noor'—a leading date in Algeria and Tunisia; and in the latter country it is grown in inland oases and is the chief export cultivar. It was introduced into California in 1900 and now constitutes 75% of the California crop. It is semi-dry, not very sweet; keeps well; is hydrated before shipping. Much used for cooking. The palm is high yielding but not very tolerant of rain and atmospheric humidity.

'Halawy' ('Halawi')—introduced into California from Iraq; soft, extremely sweet, small to medium; may shrivel during ripening unless the palm is well-watered. It is especially tolerant of humidity.

'Hayany' ('Hayani')—the cultivar most extensively planted in Egypt; but not exported. Introduced into California in 1901, and is sold fresh; is not easy to cure. The fruit is dark-red to nearly black; soft. The palm is one of the most cold-tolerant.

'Khadrawy' ('Khadrawi')—important in Iraq and Saudi Arabia, and is grown to some extent in California and Arizona. It is the cultivar most favored by Arabs but too dark in color to be popular on the American market, though it is a soft date of the highest quality. It is early-ripening; does not keep too well. This cultivar is the smallest edible date palm grown in the United States and it is fairly tolerant of rain and humidity.

'Khastawi' ('Khustawi'; 'Kustawy')—the leading soft date in Iraq; sirupy, small in size; prized for dessert; keeps well. The palm is large and vigorous and produces its offshoots high on the trunk in California. The fruit is resistant to humidity.

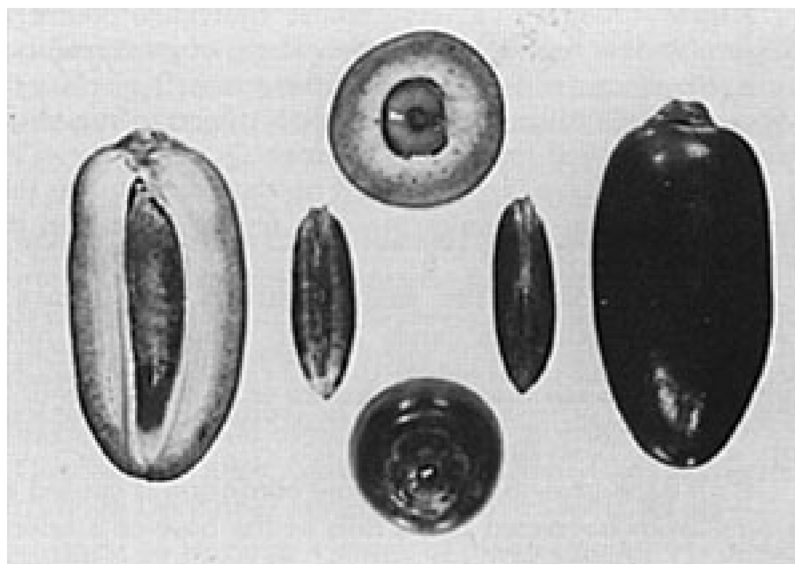
'Maktoom'—introduced into California from Iraq in 1902; large, red-brown; thick-skinned, soft, mealy, medium sweet; resistant to humidity.

'Medjool'—formerly exported from Morocco; 11 off-shoots imported into California from Bou Denib oases in French Morocco in 1927; is now marketed as a deluxe date in California; is large, soft, and luscious but ships well.

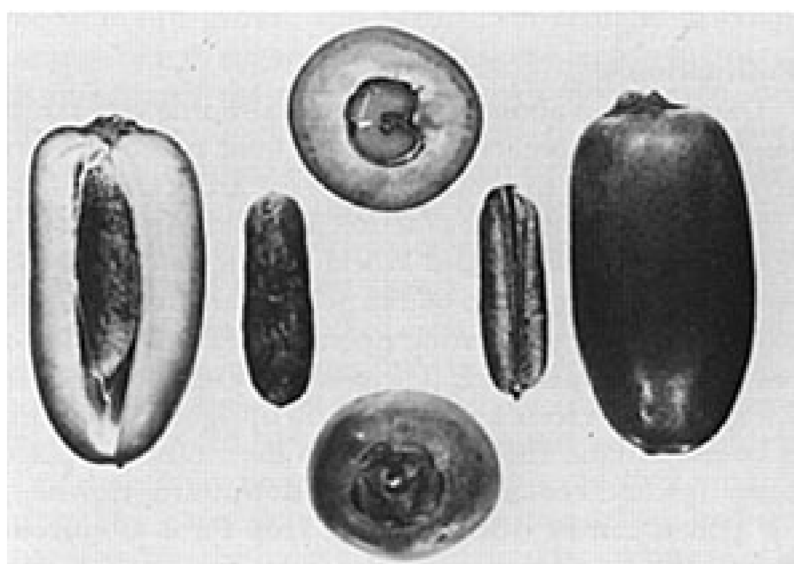
'Saidy' ('Saidi')—highly prized in Libya; soft, very sweet; palm is a heavy bearer; needs a very hot climate.

'Sayer' ('Sayir')—the most widely grown cultivar in the Old World and much exported to Europe and the Orient; dark orange-brown, of medium size, soft, sirupy, and sometimes some of the sirup is drained out and sold separately; not of high quality but the palm is one of the most tolerant of

Fig. 1: An 8-year old-'Deglet Noor' date palm in a private garden near Indio, California Photo'd by Avery Edwin Field, Oct. 1924. In: W.T. Swingle, *Date Growing*: *a new industry for Southwest States* U.S. Dept. of Agriculture Yearbook 1926.

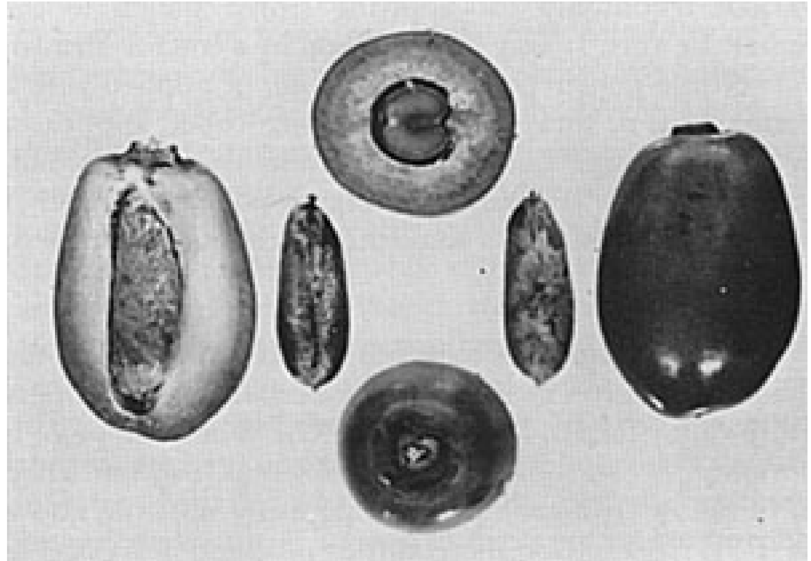


'Deglet Noor'



salt and other adverse factors.

'Halawi'



'Zahdi'

Fig. 2: 'Deglet Noor', (top) a semi soft date. 'Halawi', (center) a leading export date of Iraq. 'Zahdi', (bottom) a small date from northern Iraq. In: D.W. Albert and R H. Hilgeman, Date growing in Arizona. Bull. 149, U. Arizona, Agr. Exper. Sta., Tucson, Ariz. May 1935.

'Thoory'('Thuri')—popular in Algeria; does well in California. Fruit is dry; when cured is brown-red with bluish bloom with very wrinkled skin and the flesh is sometimes hard and brittle but the flavor is good, sweet and nutty. Keeps well; often carried on journeys. The palm is stout with short, stiff leaves; bears heavily, and clusters are very large; somewhat tolerant of humidity.

'Zahdi'('Zahidi')—the oldest-known cultivar, consumed in great quantity in the Middle East; introduced into California about 1900. Of medium size, cylindrical, light golden-brown; semi-dry but harvested and sold in 3 stages: soft, medium-hard, and hard: very sugary; keeps well for months; much used for culinary purposes. The palm is stout, fast growing, heavy bearing; drought resistant; has little tolerance of high humidity.

Among the less well-known cultivars in California are:

'Amir Hajj'—introduced from Mandali Oasis in Iraq in 1929. The fruit is soft, with thin skin and thick flesh; of superior quality but little grown in the United States.

'Iteema'—offshoots from Algeria were introduced into California in 1900. The fruit is large, oblong, light amber, soft, very sweet. Much grown in Algeria but not rain resistant and little grown in California.

'Migraf' ('Mejraf)—a very popular cultivar in Southern Yemen. Fruit is light golden-amber, large; of good quality.

In inland oases of Tunisia, in addition to the 'Deglet Noor', there is **'Ftimi'** ('Alligue') which is equally subject to humidity, less productive and less disease-resistant.

'Manakbir' has a large fruit and ripens earlier but has the disadvantage that the palm produces few offshoots and its multiplication is limited.

In coastal oases, the main cultivars are 'Kenta', Agnioua', 'Bouhatam' and 'Lemsi' which come into season early and ripen before the fall rains. They require less heat than other cultivars. The fruits are more or less dry and the flesh firm.

In all date-growing areas, some confusion is caused if a seed from harvested fruits falls at the base of a select cultivar and the seedling springs up unnoticed among the offshoots. Such seedlings should be watched for and discarded lest they be mistakenly transplanted with the offshoots and later bear fruits of inferior quality.

Pollination

Date pollen is abundant but is not airborne very far. It has become customary to plant one male palm for every 48 or 50 females to provide pollen for artificial pollination which is an ancient practice. In Saudi Arabia and a few other areas of the Old World and in California and Arizona, the long spines on the petioles are first removed to facilitate the pollinating operation. Traditionally, a few strands of open male flowers are put upside-down in a female inflorescence while it is still upright, and a cord is bound around the latter to keep the strands in place when the cluster enlarges and bends downward. However, the pollen can be dried and will keep for 6 months at room temperature. Pollen stored for one year at 8°F (-13.33°C) has given 58%fruit set. Some has been found viable after 7 years of storage, and it is reported that pollen has been kept 14 years in Iran. There are various techniques for applying stored pollen to the female flowers. It may be dusted on by a tractor-drawn, convertible pollen/pesticide machine, or applied with a cotton pad, or sprayed on with a long tubed applicator or other device. Lack of pollination results in small, seedless fruits. In acute shortages, pollen of another species of *Phoenix* or of some other genera may be used.

Climate

The date palm must have full sun. It cannot live in the shade. It will grow in all warm climates where the temper ature rarely falls to 20°F (-6.67°C). When the palm is dormant, it can stand temperatures that low, but when in flower or fruit the mean temperature must be above 64°F (17.78°C). Commercial fruit production is possible only where there is a long, hot growing season with daily maximum temperatures of 90°F (32.22°C) and virtually no rain—less than 1/2 in (1.25 cm) in the ripening season. The date can tolerate long periods of drought though, for heavy bearing, it has a high water requirement. This is best supplied by periodic flooding from the rivers in North Africa and by subsurface water rather than by rain. (See remarks on irrigation under "Culture").

Soil

The date thrives in sand, sandy loam, clay and other heavy soils. It needs good drainage and aeration. It is remarkably tolerant of alkali. A moderate degree of salinity is not harmful but excessive salt will stunt growth and lower the quality of the fruit.

Propagation

Date palms grow readily from seeds if the seeds and seedlings are kept constantly wet. But seedlings are variable and take 6 to 10 years to fruit. Furthermore, 50% of the seedlings may turn out to be males. The best and common means of propagation is by transplanting the suckers, or offshoots when they are 3 to 5 years old and weigh 40 to 75 lbs (18-34 kg). They are usually separated from the parent palm as needed, but in southern Algeria suckers are often put on sale standing in tubs of water. Some offshoots are maintained in nurseries until roots are formed, though most are set directly in the field after a seasoning period of 10 to 15 days just lying on the ground, in order to lose 12 to 15% of their moisture. In parts of Egypt subject to annual flooding, very large offshoots—up to 500lbs (226 kg) are planted to avoid water damage. In general, it is said that at least 2 offshoots can be taken from each palm annually for a period of 10 to 15 years. The potential of tissue culture for multiplication of date palms is being explored in Iraq, Saudi

Arabia and in California.

Culture

In Tunisia, in former times, it was customary to plant 200 date palms per acre (500/ha). Today, optimum density is considered to be 50 per acre (120/ha) and this is about the standard in the Coachella Valley of California, but small-growing palms may be set much closer. The off shoots, trimmed back 1/3 or 1/4, leaving some of the stiff outer leaves to protect the inner ones, are usually planted 30 to 33 ft (9-10 m) apart each way. The holes should be 3 ft (0.9 m) wide and deep, prepared and enriched several months in advance, and may be encircled by a watering ditch. If the soil dries out prior to planting, the holes are filled with water at that time. In Algeria and Oman, the palms may be set much deeper in order to be closer to ground water, but this may result in drowning the palms when irrigating or they may be smothered by sandstorms.

Planting may be done at any time of year, but most often takes place in spring or fall. In Tunisia planting is done in April and May. The base is set vertically in the ground and the curving fronds will gradually assume an upright position, especially if the concave side is set to face south. Most plants will root in 2 months if the soil is kept constantly moist, while some may be delayed for a year or even several years before they show vigorous growth. Some growers expect a loss of 25% of the off shoots. Formerly, the young plants in nursery rows were wrapped nearly to the top with old leaves, paper or burlap sacks for the first year to prevent dehydration by cold, heat or wind. But it is now held that such wrapping interferes with the proper development of the leaves.

The offshoots that survive may begin to bloom in 3 years and fruit a year later but a substantial crop is not possible before the 5th or 6th year. In 8 or 10 years, the date will attain full production and it will keep on for a century though productivity declines after 60 to 80 years and also the flowers will be too high to pollinate and the fruits too high to pick. The palm grows at the rate of 1 to 11/2 ft (30-45 cm) a year and can reach 20 ft in 15 to 20 years depending on the cultivar and soil and water conditions.

In Iraq, date palms are fertilized once a year with manure at the rate of 44 lbs (20 kg) per tree. Commercial fertilizers are utilized in Saudi Arabia and the United States. Of more importance is the supply of water, a large amount being necessary and it is usually supplied by irrigation ditches. In some Old World plantations rising tides cause rivers to flood the ditches twice a day. Where this natural irrigation does not occur, the palms are watered 15 to 40 times a year. Overhead moisture (including rain) during fruit development will cause minute cracks (checking), beginning at the apex of the fruit which ultimately darkens. In California, the fruit clusters are covered with paper bags to shelter them from rain, dust, and predators.

The female inflorescences may be shortened, thinned out, or some removed entirely at pollinating time, or several weeks later when the stalk has drooped lower, in order to conserve the palm's energy for the following season. Some growers advise leaving no more than 12 bunches per palm. Many leave only 30 strands per cluster, each with about 30 fruits. Without thinning, fruits would be borne only every other year. During the pollinating operation, a grower may tie the elongating flower stalk to a palm frond to prevent breaking when later laden with fruit.

The palms are pruned twice a year, dry fronds being removed in the fall and the leaf bases may be taken off in the spring in order that their fiber may be used as a substitute for coir

In Iraq, growth regulators have been experimentally applied to developing dates. In 'Zahdi' and 'Sayer', naphthaleneacetic acid, at 60 ppm, applied 15 to 16 weeks after pollination, improved quality and increased fruit weight by 39%. Moisture content was elevated. Ripening was delayed for 30 days or more.

In the Old World, most date plantations are intercropped with vegetables, cereals or fodder crops in the first few years and subsequently with low growing fruit trees or grapevines. Some authorities hold that this practice distracts the grower from proper care of the dates. In mechanized plantations, intercropping is not possible inasmuch as space must be left for the mobile equipment.

Yield

Ordinarily, in palms 5 to 8 years old, the first crop will be 17.5 to 22 lbs (8-10 kg) per palm; at 13 years, 132 to 176 lbs (60-80 kg). Some improved cultivars, at high densities, have yielded over 220 lbs (100 kg) per year. 'Deglet Noor' in California may yield 4.5 to 7 tons per acre (11-17 tons/ha).

Harvesting and Ripening

Some high-quality dates are picked individually by hand, but most are harvested by cutting off the entire cluster. In North Africa, the harvesters climb the palms, use forked sticks or ropes to lower the fruit clusters, or they may pass the clusters carefully down from hand to hand. Growers in California and Saudi Arabia use various mechanized means to expedite harvesting—saddles, extension ladders, or mobile steel towers with catwalks for pickers. All fruits in a cluster and all clusters on a palm do not ripen at the same time. A number of pickings may have to be made over a period of several weeks. In the Coachella Valley, dates ripen from late September through December and there are 6 to 8 pickings per palm.

Dates go through 4 stages of development: 1) Chimri, or Kimri, stage, the first 17 weeks after pollination: green, hard, bitter, 80% moisture, 50% sugars (glucose and fructose) by dry weight; 2) Khalal stage, the next 6 weeks: become full grown, still hard; color changes to yellow, orange or red, sugars increase, become largely sucrose; 3) Rutab stage, the next 4 weeks: half-ripe; soften, turn light brown; some sucrose reverts to reducing sugar which gains prominence; 4) Tamar stage: ripe; the last 2 weeks; in soft dates, the sugar becomes mostly reducing sugar; semi-dry and dry dates will have nearly 50% each of sucrose and reducing sugars.

Soft dates may be picked early while they are still light colored. Semi dry dates may be picked as soon as they are soft and then ripened artificially at temperatures of 80° to 95°F (26.67°-35°C), depending on the cultivar. Dry dates may be left on the palm until they are fully ripe. Dry dates that have become too dehydrated and hardened on the palm are rehydrated by soaking in cold, tepid or hot water, or by exposure to steam or a humid atmosphere. Extremely dry weather will cause dates to shrivel on the palm. In the Sudan, the fruits are picked when just mature and then are ripened in jars to prevent so much loss of moisture. Rain, high humidity or cool temperatures during the maturing period may cause fruit drop or checking, splitting of the skin, darkening, blacknose, imperfect maturation, and excessive moisture content, or even rotting. Under such adverse weather conditions, as may occur in the Salt River Valley, Arizona, dates must be harvested while still immature and ripened artificially. In the Old World, there are many different methods of doing this: storing in earthen jars, placing the jars in sun hot enough to prevent spoilage, boiling the fruits in water and then sun drying. In Australia, entire clusters are kept under cover with the cut end of the stalk in water until the fruits are fully ripe. In modern packing houses, prematurely harvested dates are ripened in controlled atmospheres, the degrees of temperature and humidity varying with the nature of the cultivar.

Where there is low atmospheric humidity outdoors and adequate sunshine, harvested dates are sun dried whole or cut in half. For fresh shipment in California, the normally ripe, harvested fruits are carried to packing plants, weighed, inspected by agents of the United States Department of Agriculture, fumigated, cleaned, graded, packed, stored under refrigeration, and released to markets according to demand. Saudi Arabia has constructed a number of extra-modern processing plants for fumigation, washing, drying, and packing of dates prior to cold storage.

Keeping Quality

Slightly underripe 'Deglet Noor' dates will keep at 32°F (0°C) up to 10 months; fully mature, for 5 to 6 months. Freezing will extend the storage life for a much longer period. In India, sun-dried dates, buried in sand, have kept well for 1 1/2 years and then have been devoured by worms.

Pests and Diseases

Unripe fruits are attacked by *Coccotrypes daclyliperda* which makes them fall prematurely. Ripe fruits are often infested by nitidulids—*Carpophilus hemipterus*, *C. multilatus* (*C. dimidiatus*), *Urophorus humeralis*, and *Heptoncus luteolus*, which cause decay. Control by insecticides is necessary to avoid serious losses. In Israel, the fruit clusters are covered with netting to protect them from such pests as *Vespa orientalis, Cadra figulilella* and *Arenipes sabella* as well as from depredations by lizards and birds.

In Pakistan, the red weevil, or Indian palm weevil, *Rhynchophorus ferrugineus*, bores into the leaf bases at the top of the trunk, causing the entire crown to wither and die. The rhinocereus beetle, or black palm beetle, *Oryctes rhinocerus*, occasionally attacks the date. Its feeding damage may provide entrance-ways for the weevil. Scale insects may infest the leaves and the trunk. They have been controlled by trimming off the heavily infested leaves, spraying the remaining ones, and treating the fire resistant trunk with a blowtorch. Two of the most destructive scales are the Marlatt scale, *Phoenicoccus marlatti*; which attacks the thick leaf bases, and the Parlatoria scale, *Parlatoria blanchardii*, which is active in summer. The latter was the object of an eradication campaign in California and Arizona in the late 1930's. The date mite scars the fruits while they are still green.

A tineid moth and a beetle, *Lasioderma testacea*, have damaged stored dates in the Punjab. Dates held in storage are subject to invasion by the fig-moth, *Ephestia cautella*, and the Indian meal-moth, *Plodia interpunctella*.

Fusarium albedinis causes the disastrous Bayoud, or Baioudh, disease in Morocco and Algeria. It is evidenced by a progressive fading and wilting of the leaves. Over a 9-year study period of 26 resistant varieties in Morocco, Bayoud disease reduced the planting density from 364 palms per acre (900/ha) to 121 to 142 per acre (300-350/ha). It is because of this disease that 'Medjool' can no longer be grown commercially in Morocco and Algeria.

Decay of the inflorescence is caused by *Manginiella scaeltae* in humid seasons. Several brown stains will be seen on the unopened spathe and the pedicels of the opened cluster will be coated with white "down". Palm leaf pustule, small, dark-brown or black cylindrical eruptions exoding yellow spores, resulting from infestation by the fungus *Graphiola phoenicis*, is widespread but often a serious problem in Egypt. Date palm decline may be physiological or the result of a species of the fungus genus *Omphalia*. Diplodia disease is a fungus manifestation on leafstalks and offshoots and it may kill the latter if not controlled. The fungus caused condition called "black scorch" stunts, distorts and blackens leaves and adjacent inflorescences. Other fungus diseases include pinhead spot (*Diderma effusum*), gray blight *(Pestalotia palmarum*) and spongy white rot (*Polyporus adustus*). The date, as well as its relative, *Phoenix canariensis* Hort. ex Chaub., has shown susceptibility to lethal yellowing in Florida and Texas. No commercial plantings have been affected.

Food Uses

Dry or soft dates are eaten out-of-hand, or may be seeded and stuffed, or chopped and used in a great variety of ways: on cereal, in pudding, bread, cakes, cookies, ice cream, or candy bars. The pitting may be done in factories either by crushing and sieving the fruits or, with more sophistication, by piercing the seed out, leaving the fruit whole. The calyces may be mechanically removed also. Surplus dates are made into cubes, paste, spread, powder (date sugar), jam, jelly, juice, sirup, vinegar or alcohol. Decolored and filtered date juice yields a clear invert sugar solution. Libya is the leading producer of date sirup and alcohol.

Cull fruits are dehydrated, ground and mixed with grain to form a very nutritious stockfeed. Dried dates are fed to camels, horses and dogs in the Sahara desert. In northern Nigeria, dates and peppers added to the native beer are believed to make it less intoxicating. The First International Date Conference was held in Tripoli, Libya in 1959, and led to the development of a special program under the Food and Agriculture Organization of the United Nations to promote the commercial utilizetion of substandard or physically defective dates.

Young leaves are cooked and eaten as a vegetable, as is the terminal bud or heart, though its removal kills the palm. In India, date seeds are roasted, ground, and used to adulterate coffee. The finely ground seeds are mixed with flour to make bread in times of scarcity.

In North Africa, Ghana and the Ivory Coast, date palms are tapped for the sweet sap which is converted into palm sugar, molasses or alcoholic beverages, but each palm should not be tapped more than 2 or 3 times. Tapping the edible date palm interferes with fruit production and it is wiser to tap *P. sylvestris*, which is not valued for its fruit, or some other of the 20 well-known palm species exploited for sugar. When the terminal bud is cut out for eating, the cavity fills with a thick, sweet fluid (called *lagbi* in India) that is drunk for refreshment but is slightly purgative. It ferments in a few hours and is highly intoxicating. Fresh spathes, by distillation, yield an aromatic fluid enjoyed by the Arabian people.

Other Uses

Seeds: Date seeds have been soaked in water until soft and then fed to horses, cattle, camels, sheep and goats. Dried and ground up, they are now included in chicken feed. They contain 7.17-9% moisture, 1.82-5.2% protein. 6.8-9.32% fat, 65.5% carbohydrates, 6.4-13 6% fiber, 0.89-1.57% ash, also sterols and estrone, and an alkali-soluble polysaccharide. The seeds contain 6 to 8% of a yellow-green, non-drying oil suitable for use in soap and cosmetic products. The fatty acids of the oil are: lauric, 8%; myristic, 4%; palmitic, 25%; stearic, 10%, oleic, 45%, linoleic, 10%; plus some caprylic and capric acid. Date seeds may also be processed chemically as a source of oxalic acid, the yield amounting to 65%. In addition, the seeds are burned to make charcoal for silversmiths, and they are often strung in necklaces.

Leaves: In Italy, there are some groves of date palms maintained solely to supply the young leaves for religious use on Palm Sunday. In Spain, only the leaves of male palms are utilized for this purpose. In North Africa, the leaves have been commonly used for making huts. Mature leaves are made into mats, screens, baskets, crates and fans. The processed leaflets, combined with ground up peanut shells and corn cobs, are used for making insulating board. The leaf petioles have been found to be a good source of cellulose pulp. Dried, they are used as walking sticks, brooms, fishing floats, and fuel. The midribs are made into baskets. The leaf sheaths have been prized for their scent. Fiber from the old leaf sheaths is used for various purposes including packsaddles, rope, coarse cloth and large hats. It has been tested as material for filtering drainage pipes in Iraq, as a substitute for imported filters. Analyses of the leaves show: 0.4-0.66% nitrogen; 0.025 0.062% phosphorus; 0.33-0.66% potassium; 10-16.4% ash. There is some coumarin in the leaves and leaf sheaths.

Fruit clusters: The stripped fruit clusters are used as brooms. The fruit stalks contain 0.28-0.42% nitrogen, 0.017-0.04% phosphorus; 3.46-4.94% potassium; 7.7-9.88% ash.

Fruits: In Pakistan, a viscous, thick sirup made from the ripe fruits, is employed as a coating for leather bags and pipes to prevent leaking.

Wood: Posts and rafters for huts are fashioned of the wood from the trunk of the date palm, though this wood is lighter than that of the coconut. It is soft in the center and not very durable. That of male trees and old, un productive females is readily available and used for aqueducts, bridges and various kinds of construction, also parts of dhows. All left over parts of the trunk are burned for fuel.

Medicinal Uses: The fruit, because of its tannin content, is used medicinally as a detersive and astringent in intestinal troubles. In the form of an infusion, decoction, sirup or paste, is administered as a treatment for sore throat, colds, bronchial catarrh. It is taken to relieve fever, cystisis, gonorrhea, edema, liver and abdominal troubles. And it is said to counteract alcohol intoxication.

The seed powder is an ingredient in a paste given to relieve ague.

A gum that exudes from the wounded trunk is employed in India for treating diarrhea and genito-urinary ailments. It is diuretic and demulcent. The roots are used against toothache. The pollen yields an estrogenic principle, estrone, and has a gonadotropic effect on young rats.

Food Value Per 100 g of Edible Portion*

	Fresh, uncooked	*Dried*
Calories	142	274 293
Moisture	31.9 78.5 g	7.0 26.1

Protein	0.9 2.6 g	1.7 3.9 g
Fat	0.6 1.5 g	0.1 1.2 g
Carbohydrates	36.6 g	72.9 77.6 g
Fiber	2.6 4.5 g	2.0 8.5 g
Ash	0.5 2.8 g	0.5 2.7 g
Calcium	34 mg	59 103 mg
Phosphorus	350 mg	63 105 mg
Iron	6.0 mg	3.0 13.7 mg
Potassium	?	648 mg
Vitamin A (ß carotene)	110-175 mcg	15.60 mg
Thiamine	?	0.03 0.09 mg
Riboflavin	?	0.10 0.16 mg
Niacin	4.4-6.9 mg	1.4 2.2 mg
Tryptophan	?	10 17 mg
Ascorbic Acid	30 mg	0

*Based on standard analyses.

Sawaya et al., in their studies of fresh dates in Saudi Arabia, reported ascorbic acid content as 1.8-14.3 mg/100 g in the Khalal stage; 1.1-6.1 in the Tamar state. They found that vitamin A ranged from 20 to 1.416 I.U. in the Khalal stage; from 0-259 l.U. in the Tamar stage. Tannin varied from 1.2 to 6.7% in the Khalal stage. 0.6 to 3.2 % in the Tamar stage.

The sap contains 10% sucrose. Jaggery made from it contains 9.6% moisture, 86.1 % carbohydrates, 1.5% protein, 0.3% fat, 2.6% minerals, 0.36% calcium, 0.06% phosphorus.

Morton, J. 1987. Pejibaye. p. 12–14. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Pejibaye

Bactris gasipaes

Highly regarded today as a source of nutritious food, the pejibaye, *Bactris gasipaes* HBK. (syns. *B. speciosa* Karst.; *Guilielma gasipaes* L.H. Bailey; *G. speciosa* Mart.; *G. utilis* Orst.), family Palmae, is also called peach palm. It is known as *pejivalle* in Costa Rica; peach-nut, *pewa* or *pupunha* in Trinidad; *piva* in Panama; *cachipay, chichagai, chichaguai, contaruro, chonta, choritadura, chenga, jijirre, pijiguay, pipire, pirijao, pupunha*, or *tenga* in Colombia; *bobi, cachipaes, rnacanilla, melocoton, pichiguao, pihiguao, pijiguao, piriguao*, or *pixabay* in Venezuela; *comer, chonta*, and *tempe* in Bolivia; *chonta dura, chonta ruru, pijuanyo, pifuayo, sara-pifuayo, pisho-guayo* in Peru; *amana*, in Surinam; *parepon* in French Guiana; *popunha* in Brazil.

Description

The palm is erect, with a single slender stem or, more often, several stems to 8 in (20 cm) thick, in a cluster; generally armed with stiff, black spines in circular rows from the base to the summit. There are occasional specimens with only a few spines. The pejibaye attains a height of 65 to 100 ft (20 30 m) and usually produces suckers freely. The leaves, with short, spiny petioles, are pinnate, about 8 to 12 ft (2.4-3.6 m) long, with many linear, pointed leaflets to 2 ft (60 cm) long and 1 1/4 in (3.2 cm) wide; dark green above, pale beneath, spiny on the veins. The inflorescence, at first enclosed in a spiny spathe, is composed of slender racemes 8 to 12 in (20-30 cm) long on which the yellowish male and female flowers are mingled except for the terminal few inches where there are only male flowers.

The fruit, hanging in clusters of 50 to 100 or sometimes as many as 300, weighing 25 lbs (11 kg) or more, is yellow to orange or scarlet, yellow-and-red, or brownish at first, turning purple when fully ripe. It is ovoid, oblate, cylindrical or conical, 1 to 2 in (2.5-5 cm) long, cupped at the base by a green, leathery, 3-pointed calyx. A single stem may bear 5 or 6 clusters at a time. The skin is thin, the flesh yellow to light-orange, sweet, occasionally with a trace of bitterness, dry and mealy. Some fruits are seedless. Normally there is a single conical seed 3/4 in (2 cm) long, with a hard, thin shell and a white, oily, coconut-flavored kernel. Rarely one finds 2 fused seeds.

Origin and Distribution

This useful palm is apparently indigenous to Amazonian areas of Colombia, Ecuador, Peru and Brazil, but it has been cultivated and distributed by Indians from ancient times and is so commonly naturalized as an escape that its natural boundaries are obscure. Of prehistoric introduction into Costa Rica, it is plentiful in a seemingly wild state of the Atlantic side of that country and also much cultivated. Every Indian dwelling has a patch of pejibaye palms. The palm has also been planted as partial shade for coffee. It is not as common anywhere else in Central America, though it is fairly abundant in Nicaragua, Honduras and Guatemala, and has long been grown in commercial plots in Panama to furnish fruits for local markets. In Colombia and Peru, great quantities of the fruits appear in the markets and vendors sell them along the streets. There are large stands of this palm in the Orinoco region of Venezuela and equatorial Brazil. The Indians of Colombia and Ecuador hold festivals when the pejibayes are in season, though in the latter country the fruits are valued more as feed for livestock than as food for humans.

The United States Department of Agriculture received seeds from Costa Rica in 1920 (S.P.I. #50679), but those in the first lot had lost viability. The United Fruit Company shipped whole fruits but they fermented en route and were mistakenly thrown overboard at New York, the stevedores not being aware that they were imported only for their seeds. Another shipment was made with adequate instructions and 1,000 seedlings were grown in greenhouses in Maryland and distributed. Today there are scattered specimens in southern Florida, Cuba, Puerto Rico and Trinidad. The palm was introduced into the Philippines in 1924. In the 1970's, the possibility of growing pejibayes in India was inspired by settlers of East Indian lineage in Trinidad and South America who produce and sell the fruits. In 1978, Brazilian horticulturists undertook a study to determine the feasibility of establishing pejibaye plantations in the State of Sao Paulo with a view to exploiting the fruit and the tenninal bud (heart, or *palmito).* There has been much interest generated in recent years in the cultivation of the palm solely for its hearts which are of high quality. Costa Rica is a leader in this enterprise and there the hearts are being canned commercially.

Fig. 3: A single-stemmed pejibave palm *(Bactris gasipaes)*, photo'd by the author at Buenaventura, Colombia, in 1969.

Varieties

There is much variation in form, size, color and quality of the fruits. Some with longitudinal scars *(pejibaye rayodo)* are considered of superior quality. These scars indicate low water content, firmness and a minimum of fiber in the flesh. In Costa Rica there are palms that bear clusters having a majority of seedless fruits. These are called *pejibaye macho* (male pejibaye) and are much prized. It has been found in surveys that only 30 to 60 palms in a seedling planting of 400 will yield highgrade fruit. As many as 100 may yield fruit of such low quality that it is not marketable for human consumption.

In recent years, germplasm collections have been initiated in Costa Rica, Panama, Colombia and Brazil, and there is a great potential for crop improvement and standardization. Spineless forms *(tapire)*, especially, are being sought for breeding purposes.

Plate I: PEJIBAYE, *Bactris gasipaes* (green and ripe)

Climate

The pejibaye requires a tropical climate. It is generally restricted to elevations below 6,000 ft (1,800 m). Fruiting is reduced above 5,000 ft (1,500 m). The ideal average annual temperature ranges between 64.4° and 75.2°F (18°-24°C). At low elevations with excessive rainfall, the palm cannot succeed. Optimum rainfall is 78 to 156 in (200-400 cm), rather evenly distributed the year around.

Plate II: PEJIBAYE, *Bactris gasipaes* (in foreground)

Soil

The palm does well even on poor soils but thrives best on fertile, well drained land. In a favorable producing region of Costa Rica, the soil varies from clay loam to nearly pure clay. However, riparian, alluvial soils are deemed most desirable.

Propagation

The pejibave is grown from seed or from suckers. Seeds can be shade-dried for a few hours, packed in moist sphagnum moss or charcoal and shipped to any part of the world. When planted, they will germinate in 3 months. Young plants must be protected from ants which will destroy the tender shoots.

Culture

The palm grows rapidly and reaches 43 ft (13 m) in 10 to 15 years. At low altitudes, seedlings begin to bear in 6 to 8 years. In cool regions, bearing may not begin until the plant is 10 to 12 years old. Productive life is said to be 50 to 75 years.

In fruit plantations, the palms are set 20 ft (6 m) apart. After a few years the suckers emerge and only 2 to 4 are allowed to remain to maturity. When they are 4 to 6 ft (1.2-1.8 m) high and about 3 in (7.5 cm) thick at the base, excess suckers are taken up, cut back severely, kept in the shade and watered until new roots are formed, and then transplanted to new locations. Weeding is done 2 or 3 times a year.

For the production of palm hearts, the spacing is closer, from 5 to 10 ft (1.5-3 m), as the terminal buds can be harvested in 2 1/2 to 3 years. Researchers have found that an application of flurenol (10 ppm) will induce formation of lateral shoots. At 200 ppm, shoot growth is inhibited.

Season

In Colombia, the fruits of cultivated palms mature in January and February. Wild palms may bear twice a year. There are 2 crops a year in Trinidad, one without seeds, the other with seeds. In Costa Rica, the flowers appear in April, May and June in the lowlands, later in the highlands, and fruits mature from September to April.

Harvesting

Because of the spines on the stems, the fruits are knocked down with long poles or harvested with long poles equipped with cutters, unless ladders are available and the bunches can be cut intact and lowered by rope. If the bunch is dropped down, it is caught in a leaf-lined sack held by 2 men, or may land on a deep pile of banana leaves. When the palm gets too tall, the farmer usually cuts it down to obtain the fruits and the heart. If he is fortunate enough to have a number of nearly spineless palms, the spines can be trimmed off and the palm can be climbed. If all the spines are cut off the spiny trunks, the palm will die, but 5 to 8 ft (1.5 2.5 m) of trunk can be despined safely. Special gear of rope and stirrups has been devised to facilitate climbing. Then, too, if the palms have single trunks and are close enough together, the worker need climb only every other tree, using a specially equipped pole to cut bunches from the neighboring tree. Johannessen (1966) provides details of the modes of handling the crop and the economic role of the pejibaye in the lives of Costa Rican farmers.

In the period 1948 to 1963 in Costa Rica, the harvesting cost was calculated as representing 11.4% of the total cash value of the crop. Hunter (1969) has developed data showing that, efficiently managed, the pejibaye crop, in terms of financial return to the grower, compares favorably with maize (corn).

Yield

A palm with 4 or 5 stems may produce 150 lbs (68 kg) of fruit in a season.

Keeping Quality

Undamaged, raw fruits keep in good condition in a dry atmosphere with good air circulation for a long time, gradually dehydrating. Roughly handled and bruised fruits ferment in only 3 to 4 days. The cooked fruits, as commonly marketed, can be held for 5 or 6 days. In refrigerated storage at 35.6° to 41°F (2°-5°C), uncooked fruits can be kept for 6 weeks with a minimum of dehydration or spoilage.

Pests and Diseases

In Costa Rica, a stem borer, *Metamasius hemipterus*, sometimes penetrates the stalk of the fruit cluster, causing the fruits to rot. There have been no reports of diseases attacking the palm. Fruits injured during harvesting or transport are soon invaded by rot-inducing fungi.

Food Uses

The fruit is caustic in its natural state. It is commonly boiled; in fact, it is customary to boil the fruits for 3 hours in salted water, sometimes with fat pork added, before marketing. Boiling causes the flesh to separate easily from the seed and usually the skin as well, though in some varieties the skin adheres to the flesh even after cooking. It is only necessary to remove the skin from the cooked flesh which can then be eaten out-of-hand. The pre-boiled fruit is sometimes deep-fried or roasted and served as a snack garnished with mayonnaise or a cheese-dip. It is also mixed with cornmeal, eggs and milk and fried, and is often employed as stuffing for roasted fowl. Occasionally it is made into jam. Oven dried fruits have been kept for 6 months and then boiled for half an hour which causes them to regain their characteristic texture and flavor. Peeled, seeded, halved fruits, canned in brine, have been exported to the United States. Dried fruits can be ground into flour for use in various dishes. A strong alcoholic drink is made by allowing the raw, sugared flesh to stand for a few days until it ferments. This is prohibited in some parts of tropical America.

Young flowers may be chopped and added to omelettes. The cooked seeds are eaten like chestnuts but are hard and considered difficult to digest.

The palm heart is excellent raw or cooked. It is served in salads or prepared with eggs and vegetables in a casserole. It is a traditional food of the Indians and its harvesting has greatly reduced the stands of wild palms.

Food Value

One average pejibaye fruit contains 1,096 calories. Analyses made in Honduras and Costa Rica show the following values for 100 g of ripe flesh and skin combined:

Food Value Per 100 g of Edible Portion

Moisture	36.4-60.9 g
Protein	0.340-0.633 g
Fat	3.10-8.17 g
Crude Fiber	0.8-1.4 g

Ash	0.72-1.64 g
Calcium	8.9-40.4 mg
Phosphorus	33.5-55.2 mg
Iron	0.85-2.25 mg
Carotene	0.290-2.760 mg
Thiamine	0.037-0.070 mg
Riboflavin	0.099-0.154 mg
Niacin	0.667-1.945 mg
Ascorbic Acid	14.8-41.4 mg

The protein contains 7 of the 8 essential amino acids: threonine 2.5%/g/N; valine, 2.7%; methionine, 1.3%; isoleucine, 1.7% leucine, 2.6%; phenylalanine, 1.3%; lysine, 4.6%; and 10 others. Tests for tryptophan have given negative results.

The following approximate values are shown for the seed kernels per 100 g: moisture (loss at 212°F [100°C]), 6.9%; protein (N x 6.25), 8.8%; fat, 31.3%; crude fiber, 18.2%; starch (by acid hydrolysis), 20.8%; ash, 1.9%; undetermined material, 12.1%.

Other Uses

Fruit: Excess fruits and peelings are used as feed for poultry and pigs.

Leaves: Leaflets stripped off for better visibility in harvesting are fed to livestock. The leaves have been importent for thatching huts.

Sap: The trunk may be tapped for sap which is fermented into wine.

Bark: The bark is peeled off in one piece, despined and used like canvas to make a substitute for a flat spring in a crude bed or bunk.

Wood: The dark brown wood is very hard but elastic and takes a good polish. It has been used for spears, Indian satires, bows, arrowheads, staffs and walking sticks. More modern uses are siding for houses, veneer and tool handles. Small pieces are fashioned into spindles and other parts used in weaving. Split trunks are used as water troughs.

Morton, J. 1987. Ceriman. p. 15–17. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Ceriman

Monstera deliciosa

Of the many aroids (members of the family of Araceae) that are cultivated as ornamental plants, only this one has been grown as well for its fruit. The ceriman, *Monstera deliciosa* Liebm. (syn. *Philodendron pertusum* Kunth & Bouche), is often called merely monstera and, inappropriately, false breadfruit. Because of the apertures in its leaves, some have called it Swiss-cheese plant, or hurricane plant, suggesting that the holes and slits permit the wind to pass through without damaging the foliage. Generally, in Mexico and other Latin American countries it is known as *pinanona,* or *pina anona,* but in Venezuela it is called *ojul* or *huracan;* in Colombia, *hojadillo;* in Guatemala, *harpon* or *arpon comun.* In Guadeloupe it is *caroal, liane percee,* or *liane franche;* in Martinique, *siguine couleurre;* in French Guiana, *arum du pays* or *arum troud.* In Brazil it is catalogued by a leading nursery as *ananas japonez* (Japanese pineapple).

Description

The plant is a fast-growing, stout, herbaceous vine spreading over the ground and forming extensive mats if unsupported, but climbing trees to a height of 30 ft (9 m) or more. The stems are cylindrical, heavy, 2 1/2 to 3 in (6.25-7.5 cm) thick, rough with leaf scars, and producing numerous, long, tough aerial roots. The leathery leaves, on stiff, erect, flattened petioles to 3 1/2 ft (105 cm) long, are oval, cordate at the base, to 3 ft (90 cm) or more in length and to 2 3/4 ft (82.8 cm) wide; deeply cut into 9-in (22.8 cm) strips around the margins and perforated on each side of the midrib with elliptic or oblong holes of various sizes.

Fig. 4: The ceriman (*Monstera deliciosa*) in flower and fruit at Palm Lodge Tropical Grove, Homestead, Fla. In: J.F. Morton, *Some Useful and Ornamental Plants of the Caribbean Gardens*, 1955.

Several inflorescences arise in a group from the leaf axils on tough, cylindrical stalks. The cream colored spadix, sheltered at first by a waxy, white, calla-lily-like spathe, develops into a green compound fruit 8 to 12 in (20-30 cm) or more in length and 2 to 3 1/2 in (5-8.75 cm) thick, suggesting an ear of corn. The thick, hard rind, made up of hexagonal plates or "scales", covers individual segments of ivory-colored, juicy, fragrant pulp much like diced pineapple. Between the segments there are thin, black particles (floral remnants). Generally there are no seeds, but sometimes, pale-green, hard seeds the size of large peas, may occur in a dozen or so of the segments.

Origin and Distribution

The ceriman is native to wet forests of southern Mexico, Guatemala and parts of Costa Rica and Panama. It was introduced into cultivation in England in 1752; reached Singapore in 1877 and India in 1878. Specimens of the fruit were exhibited by the Massachusetts Horticultural Society in 1874 and 1881. It has become familiar as an ornamental in most of the warm countries of the world and is widely used in warm and temperate regions as a potted plant indoors,—especially in conservatories and greenhouses—though it does not bloom nor fruit in confinement. In Guatemala, it is raised in pots in patios to prevent too rampant growth, as it is apt to become an aggressive nuisance.

The fruits are marketed to some extent in Queensland and, in the past, were sometimes shipped from Florida to gourmet grocers in New York and Philadelphia.

Climate

The ceriman is strictly tropical and cannot tolerate frost. It does best in semi-shade and has a high moisture requirement.

Soil

The plant grows vigorously in almost any soil, including limestone but flourishes best in well drained, rich loam. It is not adapted to saline conditions.

Propagation

In some European nurseries, the ceriman is raised from imported seed. Rapid multiplication has been achieved through tissue culture in Denmark. Generally, propagation is by means of stem cuttings, which may be simply set in beds or pots in the ground where the vine is intended to grow. Suckers or offshoots, with or without roots, can be separated from parent plants and transplanted successfully. Mulching is desirable as well as watering until new roots have become well-established.

Culture

Suckers will fruit in 2 to 4 years; cuttings in 4 to 6 years, depending on the location, soil and attention given. Out-of-doors, the ceriman requires little care. If it is desired to expedite growth and fruiting, a complete fertilizer may be applied 3 or 4 times a year. Indoor plants need frequent repotting to accommodate the root system, and they should be set outside at least once a year in direct light.

Season

Flowering and fruiting overlap because it requires 12 to 14 months from the opening of the inflorescence to the maturity of the fruit. Therefore, there are often unopened inflorescences, immature fruits and ripening fruits together on the same plant. The current year's crop is ripening through summer and fall while the following year's crop is forming beside it.

Harvesting

The rind is always green though it assumes a lighter shade as the fruit matures. The fruit, with at least an inch (2.5 cm) of stem, should be cut from the plant when the tile-like sections of rind separate slightly at the base, making it appear somewhat bulged. At this state, the fruits have been shipped to local or distant markets. If kept at room temperature, the ceriman will ripen progressively toward the apex over a period of 5 or 6 days. The flesh should be eaten only from that portion of the fruit from which the rind segments have so loosened as to be easily flicked off. To ripen the whole fruit at one time, it should be wrapped in paper or plastic, or possibly aluminum foil, as soon as cut from the plant and kept at room temperature until the rind has loosened the entire length of the fruit. At this stage, it will be found that the flesh also falls easily away from the inedible core. Once ripened, the fruit can be kept in the refrigerator in good condition for a week or a little more. Rinsing off the floral remnants improves the appearance of the flesh, but it does cause some loss of juice.

Pests and Diseases

When grown indoors, the plants are subject to infestation by scale insects, mites and mealybugs. Outdoors, they are usually pest-free. However, in dry seasons in Florida, the lubber grasshopper *(Romalea microptera)* has rapidly consumed entire leaves, leaving only the base of the midrib and the petiole. In India, wire cages are placed around developing fruits to protect them from rats, squirrels, monkeys and other creatures.

The following diseases have been recorded in Florida: leaf spot caused by *Leptosphaeria* sp., *Macrophoma philodendri, Phytophthora* sp., and *Pseudomonas cichorri;* anthracnose from *Glomerella cingulata;* bacterial soft rot from infection by *Erwinia carotovora;* and root rot caused by *Pythium splendens* and *Rhizoctonia solani.*

Food Uses

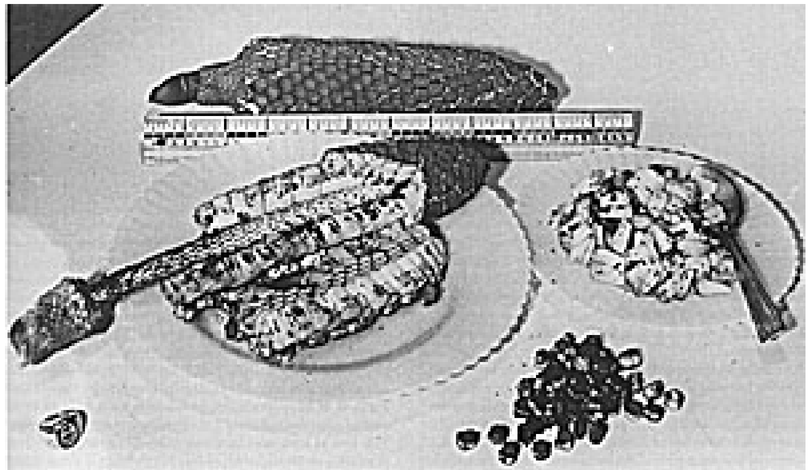


Fig. 5: Compound fruit of the ceriman fully ripe, with loose segments of rind removed and flesh separated for eating. Black specks are floral remnants.

Fully ripe pulp is like a blend of pineapple and banana. It may be served as dessert with a little light cream, or may be added to fruit cups, salads or ice cream. Some people cut cross-sections right through the core, creating wheel like disks that can be held with the thumb and fore finger pinching the "hub" while the edible part is nibbled from the rim. To make a preserve, rinsed segments can be stewed for 10 minutes in a little water, a cup of sugar and a tablespoon of lime juice is then added for each 2 cups of fruit, the mixture is simmered again for 20 minutes and preserved in sterilized jars. Some cooks substitute honey for sugar.

Food Value

Philippine analyses show the following values for the edible portion: calories, 335/lb (737/kg); moisture, 77.88%; protein, 1.81%; fat, 0.2%; sugar, 16.19%; fiber 0.57%; ash, 0.85%.

Toxicity

The oxalic acid, and possibly other unidentified principles, in the unripe fruit, the floral remnants of the ripe fruit, and all parts of the plant, cause oral and skin irritation. Some sensitive individuals claim that even the ripe fruit irritates the throat. It would be well to avoid eating the ceriman in quantity until it is determined that there are no undesirable reactions. Some individuals have experienced urticaria and anaphylaxis after eating ceriman. Some children and adults have reported diarrhea and intestinal gas after consuming the flesh or products made from it.

Other Uses

The aerial roots have been used as ropes in Peru. In Mexico, they are fashioned into coarse, strong baskets.

Medicinal Uses: In Mexico, a leaf or root infusion is taken daily to relieve arthritis. A preparation of the root is employed in Martinique as a remedy for snakebite.

Morton, J. 1987. Pineapple. p. 18–28. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Pineapple

Ananas comosus

The pineapple is the leading edible member of the family Bromeliaceae which embraces about 2,000 species, mostly epiphytic and many strikingly ornamental. Now known botanically as *Ananas comosus* Merr. (syns. *A. sativus* Schult. f., *Ananassa sativa* Lindl., *Bromelia ananas* L., *B. comosa* L.), the fruit has acquired few vernacular names. It is widely called *pina* by Spanish-speaking people, *abacaxi* in the Portuguese tongue, *ananas* by the Dutch and French and the people of former French and Dutch colonies; *nanas* in southern Asia and the East Indes. In China, it is *po-lo-mah;* sometimes in Jamaica, sweet pine; in Guatemala often merely "pine" .

Description

The pineapple plant is a terrestrial herb 2 1/2 to 5 ft (.75-1.5 m) high with a spread of 3 to 4 ft

(.9-1.2 m); a very short, stout stem and a rosette of waxy, straplike leaves, long-pointed, 20 to 72 in (50-180cm) 1ong; usually needle tipped and generally bearing sharp, upcurved spines on the margins. The leaves may be all green or variously striped with red, yellow or ivory down the middle or near the margins. At blooming time, the stem elongates and enlarges near the apex and puts forth a head of small purple or red flowers, each accompanied by a single red, yellowish or green bract. The stem continues to grow and acquires at its apex a compact tuft of stiff, short leaves called the "crown" or "top". Occasionally a plant may bear 2 or 3 heads, or as many as 12 fused together, instead of the normal one.

Fig. 6: A spiny-leaved pineapple in the Supply garden, Homestead, Fla., 1946.

As individual fruits develop from the flowers they join together forming a cone shaped, compound, juicy, fleshy fruit to 12 in (30 cm) or more in height, with the stem serving as the fibrous but fairly succulent core. The tough, waxy rind, made up of hexagonal units, may be dark-green, yellow, orange-yellow or reddish when the fruit is ripe. The flesh ranges from nearly white to yellow. If the flowers are pollinated, small, hard seeds may be present, but generally one finds only traces of undeveloped seeds. Since hummingbirds are the principal pollinators, these birds are prohibited in Hawaii to avoid the development of undesired seeds. Offshoots, called "slips", emerge from the stem around the base of the fruit and shoots grow in the axils of the leaves. Suckers (aerial suckers) are shoots arising from the base of the plant at ground level; those proceeding later from the stolons beneath the soil are called basal suckers or "ratoons".

Origin and Distribution

Native to southern Brazil and Paraguay (perhaps especially the Parana-Paraguay River) area where wild relatives occur, the pineapple was apparently domesticated by the Indians and carried by them up through South and Central America to Mexico and the West Indies long before the arrival of Europeans. Christopher Columbus and his shipmates saw the pineapple for the first time on the island of Guadeloupe in 1493 and then again in Panama in 1502. Caribbean Indians placed pineapples or pineapple crowns outside the entrances to their dwellings as symbols of friendship and hospitality. Europeans adopted the motif and the fruit was represented in carvings over doorways in Spain, England, and later in New England for many years. The plant has become naturalized in Costa Rica, Guatemala, Honduras and Trinidad but the fruits of wild plants are hardly edible.

Spaniards introduced the pineapple into the Philippines and may have taken it to Hawaii and Guam early in the 16th Century. The first sizeable plantation 5 acres (2 ha)—was established in Oahu in 1885. Portuguese traders are said to have taken seeds to India from the Moluccas in 1548, and they also introduced the pineapple to the east and west coasts of Africa. The plant was growing in China in 1594 and in South Africa about 1655. It reached Europe in 1650 and fruits were being produced in Holland in 1686 but trials in England were not success ful until 1712. Greenhouse culture flourished in England and France in the late 1700's. Captain Cook planted pineapples on the Society Islands, Friendly Islands and elsewhere in the South Pacific in 1777. Lutheran missionaries in Brisbane, Australia, imported plants from India in 1838. A commercial industry took form in 1924 and a modern canning plant was erected about 1946. The first plantings in Israel were made in 1938 when 200 plants were brought from South Africa. In 1939, 1350 plants were imported from the East Indies and Australia. but the climate is not a favorable one for this crop.

Over the past 100 years, the pineapple has become one of the leading commercial fruit crops of the tropics. In 1952-53, world production was close to 1,500,000 tons and reportedly nearly doubled during the next decade. Major producing areas are Hawaii, Brazil, Malaysia, Taiwan, Mexico, the Philippines, South Africa and Puerto Rico. By 1968, the total crop had risen to 3,600,000 tons, of which only 100,000 tons were shipped fresh (mainly from Mexico, Brazil and Puerto Rico) and925.000 tons were processed. In the period 1961-66, imports of fresh pineapples into Europe rose by 70%. Soon many new markets were opening. In 1973, the total crop was estimated at 4,000,000 tons with 2.2 million tons processed. The increased worldwide demand for canned fruit has greatly stimulated plantings in Africa and Latin America. For years, Hawaii supplied 70% of the world's canned pineapple and 85% of canned pineapple juice, but labor costs have shifted a large segment of the industry from Hawaii to the Philippines. Because production costs in Hawaii (which are 50% labor) have increased 25% or more, Dole has transferred 75% of its operation to the Philippines, where, in 1983, it employed 10,000 laborers on about 25,000, mostly rented, acres (10,117 ha).

Pineapples were first canned in Malaya by a retired sailor in 1888 and exporting from Singapore soon followed. By 1900, shipments reached a half million cases. The industry alternately grew and declined, and then ceased entirely for 3 1/2 years during World War II. The Malaysian Pineapple Industry Board was established in 1959. Thereafter there has been steady progress. The pineapple, was a very minor crop in Thailand until 1966 when the first large cannery was built. Others followed. Since then processing and exporting have risen rapidly. In 1977-78 many farmers switched from sugarcane to pineapple. Of the annual production of 1 1/2 million tons, 1/8 is canned as fruit or Julce.

South Africa produces 2.7 million cartons of canned pineapple yearly and exports 2.4 million. In addition, 31,000 tons of fresh pineapple are sold on the domestic market and 500,000 cartons exported yearly. As in many areas, pineapple culture existed on a small scale on the Ivory Coast until post WW II when cultural efforts were stepped up. By 1950, annual production amounted to 1800 tons. By 1972, it had risen to 200,000 tons for shipment, fresh or canned, to western Europe. Cameroun's annual production is about 6,000 tons.

In the Azores, pineapples have been grown in green-houses for many years for export mainly to Portugal and Madeira. They are of luxury quality, carefully tended and blemish free, graded for uniform size and well padded in each box for shipment.

As of 1971, the ten leading exporters of fresh pineapples were (in descending order): Taiwan (39,621 tons), Puerto Rico, Hawaii, Ivory Coast, Brazil, Guinea, Mexico, South Africa, Philippines and Martinique (5,000 tons). The ten leading exporters of processed pineapples were (in descending order): Hawaii, Philippines, Taiwan, South Africa, Malaysia (Singapore), Ivory Coast, Australia, Ryukyu, Mexico, Thailand (10,500,000 tons).

In Puerto Rico, the pineapple is the leading fruit crop, 95% produced, processed and marketed by the Puerto Rico Land Authority. The 1980 crop was 42,493 tons having a farm value of 6.8 million dollars.

For 250 years, pineapples have been grown in the Bahama Islands. At one time plantings on Eleuthera, Cat Island and Long Island totaled about 12,000 acres. The pineapple was a pioneer crop along the east coast of Florida and or, the Keys. In 1860 fields were established on Plantation Key and Merritt's Island. And in 1876 planting material from the Keys was set out all along the central Florida east coast. Shipping to the North began in 1879. In 1910 there were 5000 to 10,000 acres stretching as far north as Ft. Pierce. There were more than a dozen families raising pineapples on Elliott's Key where an average crop was 50,000 to 75,000 dozen fruits, mostly sent by schooner to New York. When the industry was flourishing, Florida shipped to New York, Philadelphia and Baltimore one million crates of pineapples a year from the sandy ridge along the Indian River. It was believed in those days that the pineapple benefitted by closeness to salt water.

Wood-lath sheds roofed with palmetto fronds, Spanish moss or tobacco cloth were constructed to provide shade which promoted vigorous plant growth and high fruit quality. Wood-burning ovens were scattered through the sheds for frost protection in winter. Small, open boxcars operating on steam or horsepower ran on wooden rails the length of the shed to transport loads of fruit to the packing station. In open fields, plants were sheltered by palmetto fronds from mid-December to mid-March. 'Smooth Cayenne' had to be grown in sheds. It was not successful in the open. One early planter on Eden Island moved his farm to the mainland because bears ate the ripe fruits. With the coming of the railroad in 1894, pineapple growing expanded. The 1908-09 crop was 1,110,547 crates. Then Cuban competition for U.S. markets caused prices to fall and many Florida growers gave up. The ridge pineapple fields begain to fail as the humus was exhausted by cultivation. Fertilization was steadily raising the pH too high for the pineapple. World War I brought on a shortage of fertilizer, then several freezes in 1917 and 1918 devastated the industry.

In the early 1930's, the United Fruit Company supplied slips for a new field at White City but the pressure of coastal development soon reduced this to a small patch. Shortly after World War II, a plantation of 'Natal Queen' and 'Eleuthera' was established in North Miami but, after a few years, the operation was shifted inland to Sebring, in Highlands County, Central Florida, where it still produces on a small scale.

Varieties

In international trade, the numerous pineapple cultivars are grouped in four main classes: 'Smooth Cayenne', 'Red Spanish', 'Queen', and 'Abacaxi', despite much variation in the types within each class.

'Smooth Cayenne' or 'Cayenne', 'Cayena Lisa' in Spanish (often known in India, Sri Lanka, Malaysia and Thailand as 'Sarawak' or 'Kew') was selected and cultivated by Indians in Venezuela long ago and introduced from Cayenne (French Guyana) in 1820. From there it reached the Royal Botanical Gardens, Kew, England, where it was improved and distributed to Jamaica and Queensland, Australia. Because of the plants near freedom from spines except for the needle at the leaftip and the size-4 to 10 lbs (1.8 4.5 kg)-cylindrical form, shallow eyes, orange rind, yellow flesh, low fiber, juiciness and rich mildly acid flavor, it has become of greatest importance worldwide even though it is subject to disease and does not ship well. Mainly, it is prized for canning, having sufficient fiber for firm slices and cubes as well as excellent flavor.

It was the introduction of this cultivar into the Philippines from Hawaii in 1912 that upgraded the Philippine industry from the casual growing of the semi-wild type which was often seedy. There are several clones of 'Smooth Cayenne' in Hawaii which have been selected for resistance to mealybug wilt. It is the leading cultivar in Taiwan. In 1975, the Queensland Department of Primary Industries, after 20 years of breeding and testing, released a dual purpose cultivar named the 'Queensland Cayenne'. South Africas Pineapple Research Station, East London, after 20 years of selecting and testing of 'Smooth Cayenne' clones, has chosen 4 as superior especially for the canning industry.

'Hilo'is a variant of 'Smooth Cayenne' selected in Hawaii in 1960. The plant is more compact, the fruit is smaller, more cylindrical; produces no slips but numerous suckers It may be the same as the 'Cayenne Lisse' strain grown in Martinique and on the Ivory Coast, the fruit of which weighs from 2 to 2 3/4 lbs (1-1 1/2 kg) and has a very small crown.

'St. Michael', another strain of 'Smooth Cayenne' is the famous product of the Azores. The fruit weighs 5 to 6 lbs (2.25-2.75 kg), has a very small crown, a small core, is sweet with low acidity, and some regard it as insipid when fully ripe.

'Giant Kew', well-known in India, bears a large fruit averaging 6 lbs (2.75 kg), often up to 10 lbs (4.5 kg) and occasionall up to 22 lbs (10 kg). The core is large and its extraction results in too large a hole in canned slices.

'Charlotte Rothschild', second to 'Giant Kew' in size in India, tapers toward the crown, is orange-yellow when ripe, aromatic, very juicy. The crop comes in early. 'Baron Rothschild', a Cayenne strain, grown in Guinea, has a smaller fruit 1 3/4 to 5 lbs (0.8-2 kg) in weight, marketed fresh.

'Perolera' (also celled 'Tachirense', 'Capachera', 'Motilona', and 'Lebrija') is a 'Smooth Cayenne' type ranking second to 'Red Spanish' in importance in Venezuela. It has long been grown in Colombia. The plant is entirely smooth with no spine at the leaftip. The fruit is yellow, large-7 to 9 1bs (3-4 kg) and cylindrical.

'Bumanguesa', of Venezuela and Colombia, is probably a mutation of 'Perolera'. The fruit is red or purple externally, cylindrical with square ends, shallow eyes, deep-yellow flesh, very slender core but has slips around the crown and too many basal slips to suit modern commercial requirements.

'Monte Lirio', of Mexico and Central America, also has smooth leaves with no terminal spine. The fruit is rounded, white-fleshed, with good aroma and flavor. Costa Rica exports fresh to Europe.

Other variants of 'Smooth Cayenne' include the 'Esmeralda' grown in Mexico and formerly in Florida for fresh, local markets; 'Typhone', of Taiwan; 'Cayenne Guadeloupe', of Guadeloupe, which is more disease resistant than 'Smooth Cayenne'; and 'Smooth Guatemalan' end 'Palin' grown in Guatemala; also 'Piamba da Marquita' of Colombia. Some who have made efforts to classify pineapple strains have proposed grouping all smooth-leaved types under the collective name 'Maipure'. In Amazonas, Venezuela, this name is given to a large plant with smooth leaves stained with red. The fruit has 170 to 190 eyes.

Philipps Platts, a leading pineapple authority, experimented with 60 to 70 cultivars in Florida but **'Red Spanish'** proved most dependable. Despite the spininess of the plant, it still is the most popular among growers in the West Indies, Venezuela and Mexico. 'Red Spanish' constitutes 85% of all commercial planting in Puerto Rico and 75% of the production for the fresh fruit market. It is only fair for canning. The fruit is more or less round, orange-red externally, with deep eyes, and ranges from 3 to 6 lbs (1.36-2.7 kg). The flesh is pale-yellow, fibrous, with a large core, aromatic and flavorful. The fruit is hard when mature, breaks off easily and cleanly at the base in harvesting, and stands handling and transport well. It is highly resistant to fruit rot though subject to gummosis.

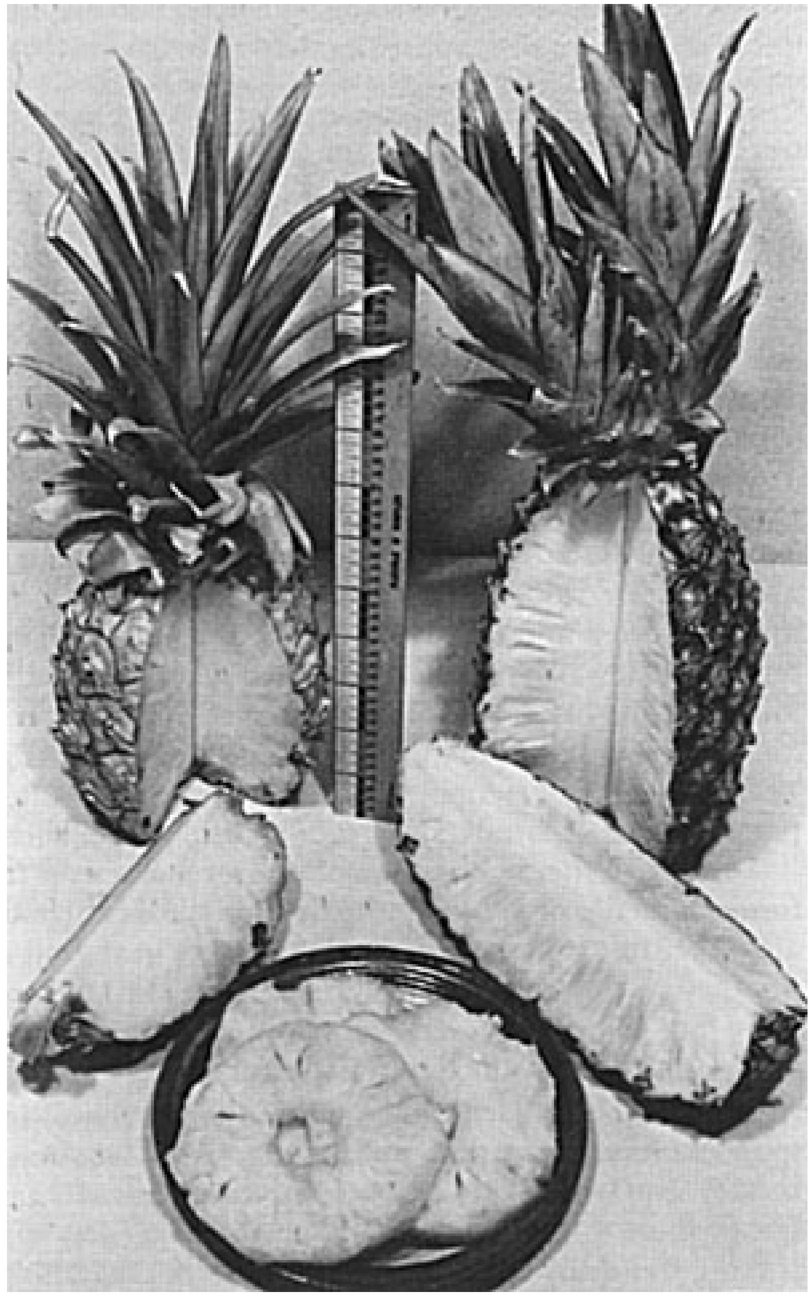


Fig. 7: 'Red Spanish' (left) and 'Abacaxi' (called 'English' in the Bahamas) (right). In: K. and J. Morton, *Fifty Tropical Fruits of Nassau*, 1946.

Two vigorous hybrids of 'Smooth Cayenne' and 'Red Spanish' were developed at the Agricultural Experiment Station of the University of Puerto Rico and released in 1970—'P.R. 1-56' and the slightly larger 'P.R. 1 67', both with good resistance to gummosis and mealybug wilt and of excellent fruit quality. 'P.R. 1 67' averages 5 3/4 lbs (2.5 kg), gives a high yield—32 tons per acre (79 tons/ha). The fruit is sweeter yet with more acidity than 'Red Spanish', less fibrous and good for marketing fresh and for canned juice. It was introduced into Venezuela about 1979 and is grown in the State of Lara.

'Cabezona' ('Bull Head', or 'Pina de ague') is a prominent variant (a natural tetraploid) of 'Red Spanish' long grown in Puerto Rico in the semiarid region of Lajas, to which it is well suited; also in El Salvador. The plant is large, over 3 ft (1 m) high; the leaves are gray-green. The fruit is conical but not as tall as that of 'Valera'; averages 4 to 6 lbs (1.8-2.75 kg) and may reach 18 lbs (8 kg) or more. It is orange-yellow at maturity, has few fibers and sweet-acid flesh. The stem is large and extends up into the base of the fruit and if the fruit is broken off when harvested it leaves a cavity. Consequently, it must be cut with a machete and later trimmed flush with the base in the packing house. It is marketed fresh only. It is resistant to gummosis. Platts reported that it gave a low yield and was disease prone in Florida. There are small plantings in the States of Trujillo and Monagas, Venezuela. It has been cultivated frequently in the Philippines.

'Valera' ('Negrita', or 'Andina'), is an old cultivar originating in Puerto Rico; it is grown in the States of Lara, Merida and Trujillo in Venezuela. It is a small to medium plant with long, narrow, spiny, purple green leaves. The fruit is conical cylindrical, weighing 3 1/2 to 5 1/2 lbs (1.5-2.5 kg); is purple outside with white flesh.

'Valera Amarilla' is a 'Red Spanish' strain grown in the States of Lara and Trujillo in Venezuela. The fruit is broad cylindrical and tall with a large crown; weighs 4 1/2 to 9 lbs (2-4 kg); is yellow externally with very deep eyes, about 72 to 88 in number. The flesh is pale-yellow and very sweet in flavor.

'Valera Roja', grown in Lara, Trujillo and Merida, Venezuela, is a small-to-medium plant with cylindrical fruit 1 1/2 to 2.2 lbs (0.6-1 kg) in weight, reddish externally, with 100 eyes. It has pale-yellow flesh.

'Castilla' is a 'Red Spanish' strain grown in Colombia and El Salvador.

'Cumanesa', supposedly a selection of 'Red Spanish', grown mainly in the State of Sucre, Venezuela, is a medium-sized plant, very spiny, producing an oblong fruit with a large crown. It is orange-yellow externally; weighs 2 to 3 3/4 lbs (0.9-1.70 kg). and has yellowish-white flesh.

'Morada', believed to be a variant of 'Red Spanish', is one of the less important cultivars of Colombia and the State of Monagas, Venezuela. The plant is large, with long, narrow, purple-red leaves. The fruit is broad-cylindrical, purple-red externally, with white flesh.

'Monte Oscuro' ('Pilon'), is a large plant with broad, sawtoothed, spiny-edged leaves. The fruit is barrel-shaped, large, weighing 6.6 lbs (3 kg); has 160-180 medium-deep eyes; is yellow outside with deep-yellow, fibrous flesh. It is ,grown among *Mauritia* palms in the State of Monagas, Venezuela.

'Abacaxi' (also called 'White Abacaxi of Pernambuco', 'Pernambuco', 'Eleuthera', and 'English') is well known in Brazil, the Bahamas and Florida. The plant is spiny and disease-resistant. Leaves are bluish-green with red-purple tinge in the bud. The numerous suckers need thinning out. The fruit weighs 2.2 to ll lbs (1-5 kg), is tall and straight-sided; sunburns even when erect. It is very fragrant. The flesh is white or very pale yellowish, of rich, sweet flavor, succulent and juicy with only a narrow vestige of a core. This is rated by many as the most delicious pineapple. It is too tender for commercial handling, and the yield is low. The fruit can be harvested without a knife; breaks off easily for marketing fresh.

'Sugarloaf' (also called 'Pan de Azucar') is closely related to 'Abacaxi', and much appreciated in Central and South America, Puerto Rico, Cuba and the Philippines. The leaves of the plants and crowns pull out easily and this fact gave rise to the unreliable theory that pineapple ripeness is indicated by the looseness of the leaves. The fruit is more or less conical, sometimes round; not colorful; weighs 1 1/2 to 3 lbs (0.68-1.36 kg). Flesh is white to yellow, very sweet, juicy. This cultivar is too tender for shipping.

Among several strains of 'Sugarloaf' are 'Papelon', and 'Black Jamaica', and probably also 'Montufar' ('Sugar Slice' of Guatemala). The latter fruit is green, conical, weighs 2 to 5 1/2 lbs (0.8 2.5 kg); has yellow, very juicy, flesh, sweet yet a little acid. This pineapple also is too tender to ship.There are a number of tropical American cultivars not categorized as to groups, and among them are:

'Brecheche', grown to a limited extent in southern Venezuela, is a small fruit with small, spineless crown. Average weight is 1 1/2 to 2.2 lbs (0.7-1 kg). The fruit is yellow externally. Flesh is yellow, with little fiber, small core, very fragrant, very juicy.

'Caicara', grown to a small extent in the State of Bolivar, Venezuela, is a large fruit weighing 4 to 5 1/2 lbs (1.8-2.5 kg). with a large, spiny crown. It is cylindrical conical with deep eyes; yellow externally with white flesh, a little fiber, very juicy, with large core.

'Chocona' and 'Sante Clara' are cultivars that have been introduced into Trinidad.

'Congo Red' is a plant with bright-red, long-lasting flowers. The fruit bends over and cracks in hot, dry weather. It weighs up to 5 lbs (2.25 kg), is waxy, with yellow flesh of good flavor.

'Panare', named after the tribe of Indians that has grown it for a long time, is commercially grown to a small extent in the State of Bolivar, Venezuela. The plant is of medium size with long, spiny leaves. The fruit is bottle-shaped, small, 1 to 1 l/2 lbs (0.45-0.70 kg), with small crown; ovate, with deep eyes; orange externally with deep-yellow flesh; slightly fragrant, with little fiber and small core.

'Santa Marta' of Colombia, is subject to cracking of the core in hot, dry weather.

In Peru, farmers still grow the old common 'Criolla' because it can be sold fresh and is not easily damaged in shipment. But modern pineapple production in that country depends on the 'Smooth Cayenne' for canning.

Minor cultivars in Colombia include: 'Amarilla de Cambao', 'Amarilla de Tocaima', 'Blanca Chocoana', 'Blanca del Atrato', 'Blanca de Valle del Cauca', 'Cimarrona', 'Espanola de Santander', 'Hartona', 'Jamaiquena' and 'Manzana'.

'Cacho de Venado' is grown to a small extent in Monagas and Sucre, and 'Injerta' in Trujillo, Venezuela.

'Pearl', 'Itaparica', 'Paulista', and 'Maranhao' (or 'Amarella') are spoken of in Brazil; 'Azucaron' in El Salvador; 'Roja' in Mexico. It remains to be determined if some of these names are merely synonyms for cultivars already referred to.

'Mauritius' (also known as 'European Pine', 'Malacca Queen', 'Red Ceylon' and 'Red Malacca') is one of the 2 leading pineapple cultivars in Malaya; also important in India and Ceylon. The leaves are dark green with broad red central stripe and red spines on the margins. The fruit is small, 3 to 5 lbs (1.36-2.25 kg), yellow externally; has a thin core and very sweet flesh. It is sold fresh and utilized for juice.

'Singapore Red' (Also called 'Red Jamaica', 'Singapore Spanish', 'Singapore Queen', 'Singapore Common') is second to 'Mauritius' in popularity. The leaves are usually all-green but sometimes have a reddish stripe near the margins; they are rarely spiny except at the tips. The fruits, cylindrical, reddish, with deep eyes, are small—3 1/2 to 5 lbs (1.6-2.25 kg)—with slender core, fibrous, golden-yellow flesh; insipid raw but valued for canning. The plant is disease and pest-resistant.

The related 'Green Selangor' (also called 'Selangor Green', 'Green Spanish', and 'Selassie') of Malaysia has all-green leaves prickly only at the tips. The flesh is golden-yellow, often with white dots. This cultivar is grown for canning.

'Queen' (also called 'Common Rough' in Australia) is the leading cultivar in South Africa, Queensland and the Philippines. The plant is dwarf, compact, more cold-resistant and more disease-resistant then 'Smooth Cayenne'. It matures its fruit early but suckers freely and needs thinning, and the yield is low. The fruit is conical, deep-yellow, with deep eyes; weighs 1 to 2 1/2 lbs (0.45-1.13 kg); is less fibrous than 'Smooth Cayenne', but more fragrant; it is juicy, of fine flavor with a small, tender core. It is sold fresh and keeps well. It is only fair for canning because of its shape which makes for much waste.

'Natal Queen' of South Africa, also grown in El Salvador, produces many suckers. The fruit weighs 1 1/2 to 2 lbs (0.75-0.9 kg).

'MacGregor', a variant of 'Nasal Queen' selected in South Africa and grown also in Queensland, is a spreading, more vigorous plant with broad leaves and large suckers produced less freely. The fruit is cylindrical, medium to large, with firm flesh and flavor resembling 'Queen'.

'James Queen' (formerly 'Z') is a mutation of 'Nasal Queen' that originated in South Africa. It has larger fruit with square shoulders.

'Ripley' or 'Ripley Queen', ,grown in Queensland, is a dwarf, compact plant with crimson tinge on leaves; takes 22 weeks from flowering to fruit maturity; is an irregular bearer. The fruit weighs 3 to 6 lbs (1.36-2.7 kg); is pale-copper externally; flesh is pale-yellow, non-fibrous, very sweet and rich. In Florida this cultivar tends to produce suckers without fruiting.

'Alexandria', a selection of 'Ripley Queen' in Queensland, is more vigorous with large suckers and fruit. The fruit is conical, tender, with 'Ripley Queen' flavor.

'Egyptian Queen' was introduced into Florida in 1870. It was popular at first, later abandoned. The fruit weighs 2 to 4 lbs (0 9-1.8 kg).

'Kallara Local' is a little-known cultivar in India. Minor strains in Thailand are 'Pattavia', 'Calcutta', 'Sri Racha', 'Intorachit' and 'Chantabun'.

In the evaluation of pineapples, the crown can be an asset or a liability. Small crowns detract from the decorative appearance of the fruit; large crowns are more attractive but hamper packing and constitute too great a proportion of inedible material from the standpoint of the purchaser.

Climate

The pineapple is a tropical or near tropical plant limited (except in greenhouses) to low elevations between 30°N and 25°S. A temperature range of 65°-95°F (18.33-45°C) is most favorable, though the plant can tolerate cool nights for short periods. Prolonged cold retards growth, delays maturity and causes the fruit to be more acid. Altitude has an important effect on the flavor of the fruit. In Hawaii, the 'Smooth Cayenne' is cultivated from sea level up to 2,000 ft (600 m). At higher elevations the fruit is too acid. In Kenya, pineapples grown at 4500 ft (1371 m) are too sweet for canning; between 4500 and 5700 ft (1371-1738 m) the flavor is most suitable for canning; above 5700 ft (1738 m) the flavor is undesirably acid. Pineapples are grown from sea level to 7545 ft (2300 m) in Ecuador but those in the highlands are not as sweet as those of Guayaquil.

Ideally, rainfall would be about 45 in (1,143 mm), half in the spring and half in the fall; though the pineapple is drought tolerant and will produce fruit under yearly precipitation rates ranging from 25 to 150 in (650-3,800 mm), depending on cultivar and location and degree of atmospheric humidity. The latter should range between 70 and 80 degrees.

Soil

The best soil for pineapple culture is a well-drained, sandy loam with a high content of organic matter and it should be friable for a depth of at least 2 ft (60 cm), and pH should be within a range of 4.5 to 6.5. Soils that are not sufficiently acid are treated with sulfur to achieve the desired level. If excess manganese prevents response to sulfur or iron, as in Hawaii, the plants require regular spraying with very weak sulfate or iron. The plant cannot stand waterlogging and if there is an impervious subsoil, drainage must be improved. Pure sand, red loam, clay loam and gravelly soils usually need organic enrichment. Filter presscake from sugar mills, worked into clay soils in Puerto Rico, greatly enhances plant vigor, fruit yield, number of slips and suckers.

Propagation

Crowns (or "tops"), slips (called nlbs or robbers in New South Wales), suckers and ratoons have all been commonly utilized for vegetative multiplication of the pineapple. To a lesser degree, some growers have used "stumps", that is, mother plant suckers that have already fruited. Seeds are desired only in breeding programs and are usually the result of hand pollination. The seeds are hard and slow to germinate. Treatment with sulfuric acid achieves germination in 10 days, but higher rates of germination (75-90 %) and more vigorous growth of seedlings results from planting untreated seeds under intermittent mist.

The seedlings are planted when 15-18 months old and will bear fruit 16-30 months later. Vegetatively propagated plants fruit in 15-22 months.

In Queensland, tops and slips from the summer crop of 'Smooth Cayenne' are stored upside down, close together, in semi-shade, for planting in the fall. Some producers salvage the crowns from the largest grades of fruits going through the processing factory to be assured of high quality planting material.

South African experiments with 'Smooth Cayenne' have shown medium-size slips to be the best planting material. Next in order of yield were large crowns, medium-size suckers, medium-size crowns and large suckers. Medium and large suckers, however, fruited earlier. Trimming of basal leaves increased yields. Workers in Johore, Malaya, report, without specifying cultivar, that large crowns give highest yield and more slips, followed by small crowns, big slips, small slips, large and small suckers in descending order.

With the 'Red Spanish' in Puerto Rico, the utilization of large slips for planting in the first quarter of the year, medium slips during the next six months, and small slips in the final quarter, provides fruits of the maximum size over an extended period of harvest. Storage of slips until optimum planting time prevents premature bloom and diminished fruit size.

The 'Red Spanish' reaches shipping-green stage (one week before coloring begins) in Puerto Rico 150 days after natural blooming.

In South Africa the 'Queen' is grown mainly from stumps, secondly from suckers. The stumps which have fruited are detached from the mother plant as soon as possible to avoid their developing suckers of their own. In comparison with suckers, the stumps are consistently heavier in yield after the 4th crop. When suckers are used, those of medium size, approximately 18 in (45 cm) long, planted shallow and upright, yield best.

In the past, growers preferred plants that supplied abundant basal slips for planting, not recognizing the fact that such plants gave smaller fruits than those without slips or suckers. Also, breeders aim toward elimination of slips to facilitate harvesting. Because of the increased demand for planting material, a new method of mass propagation received wide attention in 1960. During the harvest, plants that have borne single-crowned, superior fruits without basal slips are selected and marked. Following harvest, these plants are cut close to the ground, the leaves are stripped off and the stems—usually 1 to 2 ft (30-60 cm) long and 3 to 4 in (7.5-10 cm) thick—are sliced lengthwise into 4 triangular strips. The strips are disinfected and placed 4 in (10 cm) apart, with exterior side upward, in beds of sterilized soil, semi-shaded and sprinkler-irrigated. Shoots emerge in 3 to 5 weeks and are large enough to transplant to the nursery in 6 to 8 weeks. 'Smooth Cayenne' yields an average of 3 shoots per slice. 'Red Spanish' and 'Natal Queen', 4 per slice.

This use of the stem is a major improvement over the former practice of allowing it to develop suckers high up after the fruit is harvested. If such suckers bear fruit *in situ* they are not strong enough to support it and collapse. They are better removed for planting, but repeated removal of suckers weakens the mother plant.

In Sri Lanka, the shortage of planting material inspired experiments at first utilizing stem cross-sections 1 in (2.5 cm) thick—15 to 24 from each stem. These sprouted in 4 weeks but plant growth was slow and fruiting was delayed for 30 months. Most of the cuttings developed a single sprout, some as many as 5, others, none at all. Accordingly, this technique was abandoned in favor of a system developed for purposes of reproducing a selected strain in Hawaii. Stems are cut into segments bearing 3 to 5 whorls of leaves. The leaves are trimmed to 4 to 5 in (10-12.5 cm) and the disinfected cuttings set upright in beds until each gives rise to one strong plantlet which is then transferred to the nursery.

The butts, or bases, of mother plants, with leaves intact, are laid end to end in furrows in nurseries and covered with 2 to 3 in (5-7.5 cm) of soil. Sprouting occurs in 6 to 8 weeks. The butts give an average of 6 suckers each, though some have put forth up to 25. A one-acre (0.4 ha) nursery of 25,000 butts, therefore, yields between 100,000 and 200,000 suckers.

The Pineapple Research Institute in Hawaii has also employed axillary buds at the base of crowns. Each crown segment may develop 20 plantlets. This method has been adopted in Sri Lanka for perpetuating superior strains but not for commercial cultivation because the resulting plants require 24 months or more to fruit.

In India, because of low production of slips and suckers in 'Smooth Cayenne', crown cuttings (15-16 per crown) have been adopted for propagation with 95% success, and this method is considered more economical than the utilization of butts.

Vegetative propagation does not assure facsimile reproduction of pineapple cultivars, as many mutations and distinct clones have occurred in spite of it.

Culture

The land should be well prepared at the outset because the pineapple is shallow-rooted and easily damaged by post-planting cultivation. Fumigation of the soil contributes to high quality and high yields.

Planting: In small plots or on very steep slopes, planting is done manually using the traditional short-handled narrow-bladed hoe, the handle of which, 12 in (30 cm) long, is used to measure the distance between plants. Crowns are set firmly at a depth of 2 in (5 cm); slips and suckers at 3 1/2 to 4 in (9 10 cm). Butts, after trimming and drying for several days, are laid end-to-end in furrows and covered with 4 in (10 cm) of soil.

Double-rowing has been standard practice for many years, the plantlets set 10 to 12 in (25 30 cm) apart and staggered, not opposite, in the common rows, and with 2 ft (60 cm) between the two rows. An alley 3, 5 1/2 or 6 ft (.9, 1.6 or 1.8 m) wide is maintained between the pairs, allowing for plant populations of 17,400, 15,800 or 14,500 per acre (42,700, 37,920 or 33,800 per ha) respectively. Close spacing gives highest total crop weight—e.g.. 18,000 plants/acre = 28.8 tons (43,200 plants/ha = 69.12 tons). However, various trials have shown that overcrowding has a negative effect, reducing fruit size and elongating the form undesirably, and it reduces the number of slips and suckers per plant. Density trials with 'P.R. 1-67' in Puerto Rico demonstrated that 21,360 plants per acre (51,265/ha) yielded 35.8 tons/:acre (86 tons/ha) in the main crop and 18.9 tons/acre (45.43 tons/ha) in the ratoon crop, but only one slip per plant for replanting. Excessively wide spacing tends to induce multiple crowns in 'Smooth Cayenne' in Hawaii and in 'Red Spanish' in Puerto Rico.

Some plantings are mulched with bagasse. In large operations, asphalt-treated paper, or black plastic mulch is regarded as essential. It retards weeds, retains warmth in cool seasons, reduces loss of soil moisture, and can be laid by machines during the sterilization and pre-fertilization procedures. Mulch necessitates removal of basal leaves of crowns, slips and suckers and the use of a tool to punch a hole at the pre-marked planting site for the insertion of each plantlet. The mulch is usually rolled onto rounded beds 3 1/4 ft (1 m) wide.

Mechanical planting: Research on the potential of machines to replace the hard labor of planting pineapples was begun in Hawaii in 1945. A homemade device was first employed in Queensland in 1953. Early semi-mechanical planters were self propelled platforms with driver and two men who made the holes in the mulch and set the plants in place. With a 2-row planter, 3 men can set 7,000 plants per hour of operation. Frequent stops are necessary to reload with planting material. With improved equipment, mechanical planting has become standard practice in large plantations everywhere. The most sophisticated machines have attachments which concurrently apply premixed fertilizer and lay a broad center strip of mulch, set the plantlets along each edge, and place a narrow strip along the outer sides. The only manual operation, apart from driving, is feeding of the plantlets to the planting unit. With this system, up to 50,000 plants have been set out per day.

Fertilization: Nitrogen is essential to the increase of fruit size and total yield. Fertilizer trials in Kenya show that a total of 420 lbs N/acre (471.7 kg/ha) in 4 equal applications during the first year is beneficial, whereas no advantage is apparent from added potassium and, phosphorus. Puerto Rican studies have indicated that maximum yields are achieved by urea sprays supplying 147 lbs N/acre (151 kg/ha). In Queensland, total yield of mother plants and ratoons was increased 8% by urea spraying. Normal rate of application is 3 1/2 gals (13.3 liters) per 1,000 plants. On acid Bayamon sandy clay in Puerto Rico, addition of magnesium to the fertilizer mix or applying it as a spray (300 lbs magnesium sulfate per acre—327 kg/ha) increased yield by 3 tons/acre (7 tons/ ha). On sloping, stony clay loam high in potassium, Queensland growers obtained high yields of 'Smooth Cayenne' from side dressings of NPK mixture 5 times a year. On poor soils, nitrogen and potassium levels of the plants may become low toward the end of the crop season. This must be anticipated early and suitable adjustments made in the application of nutrients. Potassium uptake is minimal after soil temperatures drop below 68°F (20°C). On fine sandy loam in Puerto Rico, the cultivar 'P.R. 1-67' performed best with 13-3-12 fertilizer applied at the rate of 1.5 tons/acre (3.74 tons/ha). In this expertmeet, 13,403 plants/acre (32,167/ha) produced 9,882 fruits/acre (23,717/ha), weighing 31.28 tons/acre (75 tons/ha). In Venezuela, 6,250 medium-size fruits per acre (15,000 fruits/ha) is considered a very good crop.

Fruit weight has been considerably increased by the addition of magnesium. In Puerto Rican trials, magnesium treatment resulted in 54% more total weight providing an average of 2.7 more tons/acre (64.8 tons/ha) than in control plots. Fruit size and total yield have been enhanced by applying chelated iron with nitrogen; also, where chlorosis is conspicuous, by accompanying nitrogen with foliar sprays of 0.10% iron and manganese.

Some growers thin out suckers and slips to promote stronger growth of those that remain.

Irrigation: Irrigation is desirable only in dry seasons and should not exceed 1 in (2.5 cm) semi-monthly.

Weed Control: Manual weeding in pineapple fields is difficult and expensive. It requires protective clothing and tends to induce soil erosion. Coir dust has been used as mulch in Sri Lanka to discourage weeds but it has a deleterious effect on the crop, delaying or preventing flowering. The use of paper or plastic mulch and timely application of approved herbicides are the best means of preventing weed competition with the pineapple crop.

Flower Induction: Pineapple flowering may be delayed or uneven, and it is highly desirable to attain uniform maturity and also to control the time of harvest in order to avoid overproduction in the peak periods. In 1874 in the Azores it was accidentally discovered that smoke would bring pineapple plants into bloom in 6 weeks. The realization that ethylene was the active ingredient in the smoke led to the development of other methods.

As far back as 1936, compressed acetylene gas, or a spray of calcium carbide solution (which generates acetylene) were employed to expedite uniform blooming. Some growers have merely deposited calcium carbide in the crown of each plant to be dissolved by rain. A more advanced method is the use of the hormone, *a*-naphthaleneacetic acid (ANA) or *B* naphylacetic acid (BNA) which induce formation of ethylene. In recent years, *B*-hydroxyethyl hydrazine (BOH) came into use. Treatment is given when the plants are 6 months old, 3 months before natural flowering time. The plants should have reached the 30 leaf stage at this age.

Spraying of a water solution of ANA on the developing fruit has increased fruit size in 'Smooth Cayenne' in Hawaii and Queensland. In West Malaysia, spraying 'Singapore Spanish' 6 weeks after flowering with Planofix, an ANA-based trade product, delayed fruit maturity, increased fruit size, weight and acidity. Similar results have been seen after hormone treatment of 'Cayenne Lisse' on the Ivory Coast.

Trials with 'Sugarloaf' in Ghana showed calcium carbide and BOH equally effective on 42-to 46-week-old plants, and Ethrel performed best on 35-to 38-week-old plants. 'Sugarloaf' seems to respond 10 days earlier than 'Red Spanish'.

Ethrel, or the more recently developed Ethephon, applied at the first sign of fruit ripening in a field will cause all the fruit to ripen simultaneously. It brings the ratoons into fruit quickly. There is a great saving in harvesting costs because it reduces the need for successive pickings.

Plants treated with naphthaleneacetic acid produce long, cylindrical, pointed fruits, maturing over an extended period of time, ripening first at the base while the apex is still unripe. Ethylene treatment results in a square shouldered, shorter fruit maturing over a shorter period and ripening more uniformly.

In Puerto Rico, treatment in 'Cabezona' can be done to induce flowering at any time of the year.

Pests

Nematodes *(Rotylenchulus, Meloidogyne, Pratylenchus, Ditylenchus, Helicotylenchus,* and other genera) cause stunting and degeneration in pineapple plants unless soil is fumigated. In Queensland, nematicides have increased yields by 22-40%. Crop rotation has been found effective in Puerto Rico. Turning the field over to Pangola grass *(Digitaria decumbens* Stent.) or green foxtail grass *(Setaria viridis* Beauv.) for 3 years suppresses nematode populations and benefits the soil but may not be practicable unless spare land is available for pineapple culture in the interim.

Mealybugs *(Pseudococcus brevipes* and P. *neobrevipes)* attack leaf bases and cause wilt. The leaves turn orange-brown and wither due to root rot. Prevention requires spraying and dusting to control the fire ants *(Solenopsis* spp.) which carry the mealybugs from diseased to healthy plants. Control is difficult because there are many weeds and other local plants acting.as mealybug hosts. Some success was achieved in Florida in combatting mealybugs with the parasitic wasp, *Hambletonia pseudococciaa* Comp., though the general use of insecticides limits the activity of the wasp.

The pineapple mite, or so-called red spider *(Dolichote-tranychus* (or *Stigmacus) floridanus* (Banks) also attacks leaf bases and is troublesome during prolonged droughts, heavily infesting the slips. The pineapple red scale *(Diaspis bromeliae)* has been a minor pest in Florida. Since 1942 this scale has spread to many pineapple districts in southeastern Queensland, with occasional serious infestations. Natural predators afford about 40% control. The palmetto beetle *(Rhynchophorus cruentatus)*, which feeds on palm logs, enters the bud and lays eggs in young fruits and the fruit stalk.

The sap beetle *(Carpophilus humeralis) is* one of the main enemies of pineapple fruits in Puerto Rico, Hawaii and Malaysia and is especially attracted to fruits affected by gummosis. Populations have been diminished by sanitary procedures and growing of cultivars resistant to gummosis, and chemical control is being evaluated.

In Brazil, larvae of the large moth, *Castnia licus,* and of the butterfly, *Thecla basilides,* damage the fruit. The latter is a problem in other parts of tropical America also and in Trinidad.

Cutworms eat holes in the base of the immature fruit. Fruit fly larvae do not pupate in 'Smooth Cayenne' but new hybrids lack resistance and may require treatment.

In New South Wales, poison baits are employed to combat fruit damage by crows, rats and mice. Rats may eat the base of the stem and destroy ratoons and suckers. Rabbits in winter eat the leaves as high as they can reach.

Diseases

In Queensland, top rot and root rot are caused by the soil fungi *Phytophthora cinnamomi* and P. *nicotianae* var. *parasitica* which are most prevalent in prolonged wet weather in autumn and winter. Improved drainage helps reduce the risk and monthly spraying with fungicide gives good control. P. *cinnamomi* may also cause rot in green fruit on ratoons. These diseases are largely prevented by the use of paper or plastic mulch on raised beds.

Base rot is caused by the fungus *Ceratocystis paradoxa,* especially where drainage is poor. The imperfect form (conidial state) of this fungus, known as *Thielaviopsis paradoxa,* causes butt rot in planting material, also soft rot or breakdown of fruits during shipment and storage. If 1/4-ripe 'Red Spanish' fruits are kept at temperatures between 44.6° and 46.4°F (7°-8°C) while in transit, soft rot will not develop.

Fusarium spp. in the soil are the source of wilt. Black heart is a physiological disorder not visible externally, usually occuring in winter particularly in locations where air flow is inadequate. Highest incidence in West Africa has been reported in midsummer. It begins as "endogenous brown spot" at the base of the fruitless close to the core. Later, affected areas merge. It has been attributed to chilling or low light intensity from dense planting or cloudiness. It can be controlled by one-day heat treatment at 90° to 100°F (32°-38°C) before or after refrigerated storage. In 1974, the microorganism *Erwinia chrysanthemi* was identified in Malaya as the cause of bacterial heart rot and fruit collapse.

Yellow spot virus on leaves is transmitted by *Thrips tabaci* Lind. Black speck and water blister are mentioned among other problems of the pineapple.

A condition called Crookneck is caused by zinc deficiency. It occurs mainly in plants 12-15 months old but is also frequent in suckers. The heart leaves become curled and twisted, waxy, brittle, and light yellowish-green. Sometimes the plant bends over and grows in a nearly horizontal position. Small yellow spots appear near the edges of the leaves and eventually merge and form blisters. Later, these areas become grayish or brownish and sunken. Treatment is usually a 1% solution of zinc sulfate. Many growers use a combined spray of 10% urea. 2% iron sulfate and 1% zinc sulfate. If burning occurs. the proportion of urea should be changed to 5%. Excessive use of urea for this or any other purpose can lead to leaf tip dieback and yellowing of older leaves due to the biuret content in urea.

Copper deficiency is evident in concave leaves with dead tips and waxiness without bloom on the underside.

Sunburn or sunscald develops when fruits fall over and expose one side to the sun, though 'Abacaxi' may sunburn even when erect. Affected fruits soon rot and become infested with pests. They must be cut as soon as noticed and safely disposed of where they will not contaminate other fruits. Dry grass, straw, excelsior or brown paper sleeves may be placed over fruits maturing in the summer to prevent sunburn.

Harvesting

It is difficult to judge when the pineapple is ready to be harvested. The grower must depend a great deal on experience. Size and color change alone are not fully reliable indicators. Conversion of starch into sugars takes place rapidly in just a few days before full maturity. In general, for the fresh fruit market, the summer crop is harvested when the eye shows a light pale green color. At this season, sugar content and volatile flavors develop early and steadily over several weeks. The winter crop is about 30 days slower to mature, and the fruits are picked when there is a slight yellowing around the base. Even then, winter fruit tends to be more acid and have a lower sugar level than summer fruit, and the harvest period is short. Fruits for canning are allowed to attain a more advanced stage. But overripe fruits are deficient in flavor and highly perishable.

Maturity studies conducted with 'Giant Kew' in India showed that highest quality is attained when the fruit is harvested at a specific gravity of 0.98-1.02, total soluble solids of 13.8-17%, or total soluble solids/acid ratio of 20.83-27.24 with development of external yellow color. Some people judge ripeness and quality by snapping a finger against the side of the fruit. A good, ripe fruit has a dull, solid sound; immaturity and poor quality are indicated by a hollow thud.

In manual harvesting, one man cuts off or breaks off the fruits (depending on the cultivar) and tosses them to a truck or passes them to 2 other workers with baskets who convey them to boxes in which they are arranged with the stems upward for the removal of bracts and application of a 3% solution of benzoic acid on the cut stem of all fruits not intended for immediate processing. The harvested fruits must be protected from rain and dew. If moist, they must be dried before packing. All defective fruits are sorted out for use in processing.

If the work is semi-mechanized, the harvesters decrown and trim the fruits and place them on a 30-ft conveyor boom which extends across the rows and carries the fruits to a bin on a forklift which loads it onto a truck or trailer. Some conveyors take the fruits directly into the canning factory from the field. In most regions of the world, pineapples are commonly marketed with crowns intact, but there is a growing practice of removing the crowns for planting. For the fresh fruit market, a short section of stem is customarily left on to protect the base of the fruit from bruising during shipment.

Total mechanical harvesting is achieved by 2 hydraulically operated conveyors with fingers on the top conveyor to snap off the fruit, the lower conveyor carrying it away to the decrowners. After the fruit has been conveyed away, the workers go through the field to collect the crowns (where they have been left on the tops of the plants) and place them on the conveyors for a trip to the bins which are then fork lifted and the crowns dumped into a planting machine.

Life of plantation

In Florida, 'Abakka' fields were maintained for 2, 3, or 4 crops. Some plantings of 'Red Spanish' were prolonged for 25-26 years. In current practice, after the harvesting of the first crop, workers trim off all but 2 ratoons which will bear fruit in 15-18 months. Perhaps there may be a second or third ratoon crop. Then the field is cleared to minimize carryover of pests and diseases. The method will vary with the interest in or practicality of making use of by products. In Malaya, fields have been cleared by cutting the plants, leaving them to dry for 12-16 weeks, then piling and burning. Spraying with kerosene or diesel fuel makes burning possible in 9 weeks. Spraying with Paraquat allows burning in 3 weeks but does not destroy the stumps which take 3-5 months to completely decay while new plants are set out between them.

Field practices will differ if pineapples are interplanted with other crops. In Malaya, pineapples have been extensively grown in young rubber plantations. In India and Sri Lanka the pineapple is often a catchcrop among coconuts. Venezuelan farmers may interplant with citrus trees or avocados.

Storage

Cold storage at a temperature of 40°F (4.44°C) and lower causes chilling injury and breakdown in pineapples. At 44.6-46.4°F (7-8°C) and above, 80-90% relative humidity and adequate air circulation, normal ripening progresses during and after storage. At best, pineapples may be stored for no more than 4-6 weeks. There is a possibility that storage life might be prolonged by dipping the fruits in a wax emulsion containing a suitable fungicide. Irradiation extends the shelf life of half- ripe pineapples by about one week.

Food Uses

In Puerto Rico and elsewhere in the Caribbean, Spaniards found the people soaking pineapple slices in salted water before eating, a practice seldom heard of today.

Field ripe fruits are best for eating fresh, and it is only necessary to remove the crown, rind, eyes and core. In Panama, very small pineapples are cut from the plant with a few inches of stem to serve as a handle, the rind is removed except at the base, and the flesh is eaten out-of-hand like corn on the cob. The flesh of larger fruits is cut up in various ways and eaten fresh, as dessert, in salads, compotes and otherwise, or cooked in pies, cakes, puddings, or as a garnish on ham, or made into sauces or preserves. Malayans utilize the pineapple in curries and various meat dishes. In the Philippines, the fermented pulp is made into a popular sweetmeat called *nata de pina*. The pineapple does not lend itself well to freezing, as it tends to develop off flavors.

Canned pineapple is consumed throughout the world. The highest grade is the skinned, cored fruit sliced crosswise and packed in sirup. Undersize or overripe fruits are cut into "spears", chunks or cubes. Surplus pineapple juice used to be discarded after extraction of bromelain (q.v.). Today there is a growing demand for it as a beverage. Crushed pineapple, juice, nectar, concentrate, marmalade and other preserves are commercially prepared from the flesh remaining attached to the skin after the cutting and trimming of the central cylinder. All residual parts cores, skin and fruit ends are crushed and given a first pressing for juice to be canned as such or prepared as sirup used to fill the cans of fruit, or is utilized in confectionery and beverages, or converted into powdered pineapple extract which has various roles in the food industry. Chlorophyll from the skin and ends imparts a greenish hue that must be eliminated and the juice must be used within 20 hours as it deteriorates quickly. A second pressing yields "skin juice" which can be made into vinegar or mixed with molasses for fermentation and distillation of alcohol.

In Africa, young, tender shoots are eaten in salads. The terminal bud or "cabbage" and the inflorescences are eaten raw or cooked. Young shoots, called *"hijos de pina"* are sold on vegetable markets in Guatemala.

Food Value Per l00 g of Edible Portion*

Moisture	81.3-91.2 g
Ether Extract	0.03 0.29 g
Crude Fiber	0.3-0.6 g
Nitrogen	0.038-0.098 g
Ash	0.21-0.49 g
Calcium	6.2 37.2 mg
Phosphorus	6.6-11.9 mg
Iron	0.27-1.05 mg
Carotene	0.003 0.055 mg
Thiamine	0.048 0.138 mg
Riboflavin	0.011-0.04 mg
Niacin	0.13-0.267 mg
Ascorbic Acid	27.0-165.2 mg

*Analyses of ripe pineapple made in Central America.

Sugar/acid ratio and ascorbic acid content vary considerably with the cultivar. The sugar content may change from 4% to 15% during the final 2 weeks before full ripening.

Toxicity

When unripe, the pineapple is not only inedible but poisonous, irritating the throat and acting as a drastic purgative.

Excessive consumption of pineapple cores has caused the formation of fiber balls (bezoars) in the digestive tract.

Other Uses

Bromelain: The proteolytic enzyme, bromelain, or bromelin, was formerly derived from pineapple juice; now it is gained from the mature plant stems salvaged when fields are being cleared. The yield from 368 lbs (167 kg) of stern juice is 8 lbs (3.6 kg) of bromelain. The enzyme is used like papain from papaya for tenderizing meat and chill proofing beer; is added to gelatin to increase its solubility for drinking; has been used for stabilizing latex paints and in the leather-tanning process. In modern therapy, it is employed as a digestive and for its anti-inflammatory action after surgery, and to reduce swellings in cases of physical injuries; also in the treatment of various other complaints.

Fiber: Pineapple leaves yield a strong, white, silky fiber which was extracted by Filipinos before 1591. Certain cultivars are grown especially for fiber production and their young fruits are removed to give the plant maximum vitality. The 'Perolera' is an ideal cultivar for fiber extraction because its leaves are long, wide and rigid. Chinese people in Kwantgung Province and on the island of Hainan weave the fiber into coarse textiles resembling grass cloth. It was long ago used for thread in Malacca and Borneo. In India the thread is prized by shoemakers and it was formerly used in the Celebes. In West Africa it has been used for stringing jewels and also made into capes and caps worn by tribal chiefs. The people of Guam hand-twist the fiber for making fine casting nets. They also employ the fiber for wrapping or sewing cigars. Pina cloth made on the island of Panay in the Philippines and in Taiwan is highly esteemed. In Taiwan they also make a coarse cloth for farmers' underwear.

The outer, long leaves are preferred. In the manual process, they are first decorticated by beating and rasping and stripping, and then left to ret in water to which chemicals may be added to accelerate the activity of the microorganisms which digest the unwanted tissue and separate the fibers. Retting time has been reduced from 5 days to 26 hours. The rested material is washed clean, dried in the sun and combed. In mechanical processing, the same machine can be used that extracts the fiber from sisal. Estimating 10 leaves to the lb (22 per kg), 22,000 leaves would constitute one ton and would yield 50-60 lbs (22-27 kg) of fiber.

Juice: Pineapple juice has been employed for cleaning machete and knife blades and, with sand, for scrubbing boat decks.

Animal Feed: Pineapple crowns are sometimes fed to horses if not needed for planting. Final pineapple waste from the processing factories may be dehydrated as "bran" and fed to cattle, pigs and chickens. "Bran" is also made from the stumps after bromelain extraction. Expendable plants from old fields can be processed as silage for maintaining cattle when other feed is scarce. The silage is low in protein and high in fiber and is best mixed with urea, molasses and water to improve its nutritional value.

In 1982, public concern in Hawaii was aroused by the detection of heptachlor (a carcinogen) in the milk from cows fed "green chop" leaves from pineapple plants that had been sprayed with the chemical to control the ants that distribute mealybugs. There is supposed to be a one year lapse to allow the heptachlor to become more dilute before sprayed plants are utilized for feed.

Folk Medicine: Pineapple juice is taken as a diuretic and to expedite labor, also as a gargle in cases of sore throat and as an antidote for seasickness. The flesh of very young (toxic) fruits is deliberately ingested to achieve abortion (a little with honey on 3 successive mornings); also to expel intestinal worms; and as a drastic treatment for venereal diseases. In Africa the dried, powdered root is a remedy for edema. The crushed rind is applied on fractures and the rind decoction with rosemary is applied on hemorrhoids. Indians in Panama use the leaf juice as a purgative, emmenagogue and vermifuge.

Ornamental Value

The pineapple fruit with crown intact is often used as a decoration and there are variegated forms of the plant universally grown for their showiness indoors or out. Since 1963, thousands of potted, ethylene treated pineapple plants with fruits have been shipped annually from southern Florida to northern cities as indoor ornamentals.

Morton, J. 1987. Banana. p. 29–46. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Banana

Musa x paridasiaca

The word "banana" is a general term embracing a number of species or hybrids in the genus *Musa* of the family Musaceae. Some species such as *M. Basjoo* Sieb. & Zucc. of Japan and *M. ornata* Roxb., native from Pakistan to Burma, are grown only as ornamental plants or for fiber. *M. textilis* Nee of the Philippines is grown only for its fiber, prized for strong ropes and also for tissue-thin tea bags. The so-called Abyssinian banana, *Ensete ventricosum* Cheesman, formerly *E. edule* Horan, *Musa ensete* Gmel., is cultivated in Ethiopia for fiber and for the staple foods derived from the young shoot, the base of the stem, and the corm.
Most edible-fruited bananas, usually seedless, belong to the species *M. acuminata* Colla (*M. cavendishii* Lamb. ex Paxt., *M. chinensis* Sweet, *M. nana* Auth. NOT Lour., *M. zebrina* Van Houtee ex Planch.), or to the hybrid *M.* X *paradisiaca* L. (*M.* X *sapientum* L.; *M. acumianta* X *M. balbisiana* Colla).

M. balbisiana Colla of southern Asia and the East Indies, bears a seedy fruit but the plant is valued for its disease-resistance and therefore plays an important role as a ";parent"; in the breeding of edible bananas.

M. fehi Bertero ex Vieill. and *M. troglodytarum* L. have been applied to the group of bananas known as fehi or fe'i but taxonomists have yet to make final decisions as to the applicability of these binomials.

To the American consumer, ";banana"; seems a simple name for the yellow fruits so abundantly marketed for consumption raw, and ";plantain"; for the larger, more angular fruits intended for cooking but also edible raw when fully ripe. However, the distinction is not that clear and the terms may even be reversed. The types we call ";banana"; are known by similar or very different names in banana-growing areas. Spanish-speaking people say *banana china* (Paraguay), *banano enano* (Costa Rica), *cambur* or *camburi* (Colombia, Venezuela), *cachaco, colicero, cuatrofilos* (Colombia); *carapi* (Paraguay), *curro* (Panama), guineo (Costa Rico, Puerto Rico, E1 Salvador); *murrapo* (Colombia); *mampurro* (Dominican Republic); *patriota* (Panama); *platano* (Mexico); *platano de seda* (Peru); *platano enano* (Cuba); *suspiro* (Dominican Republic); *zambo* (Honduras). Portuguese names in Brazil are: *banana maca*, *banana de Sao Tome'*, *banana da Prata*. In French islands or areas, the terms may be *bananier nain, bananier de Chine* (Guadaloupe), *figue*, *figue banane, figue naine* (Haiti). Where German is spoken, they say: *echte banane*, *feige*, or *feigenbaum*. In the Sudan, *baranda*.

The types Americans call ";plantain";, Plate IV, may be known as *banaan* (Surinam); *banano macho* (Panama); *banane* or *bananier* (Haiti, Guadeloupe, Martinique); *banane misquette* or *banane musquee*, or *pie banane* (Haiti); *bananeira de terra* (Brazil); *banano indio* (Costa Rica); *barbaro* (Mexico); *butuco* (Honduras); *parichao* (Venezuela); plantain (Guyana, Jamaica, Trinidad); *platano* (Cuba, Puerto Rico, Dominican Republic); *platano burro, platano hembra* (Cuba); *platano macho* (Cuba, Panama); *platano de la isla* (Peru); *topocho* or *yapuru* (Venezuela); *zapolote* (Mexico). Numerous other vernacular names, according to geographical region, are provided by N.W. Simmonds in his textbook, *Bananas*.

In India, there is no distinction between bananas and plantains. All cultivars are merely rated as to whether they are best for dessert or for cooking.

Description

The banana plant, often erroneously referred to as a "tree", is a large herb, with succulent, very juicy stem (properly "pseudostem") which is a cylinder of leaf-petiole sheaths, reaching a height of 20 to 25 ft (6-7.5 m) and arising from a fleshy rhizome or corm. Suckers spring up around the main plant forming a clump or "stool", the eldest sucker replacing the main plant when it fruits and dies, and this process of succession continues indefinitely. Tender, smooth, oblong or elliptic, fleshy-stalked leaves, numbering 4 or 5 to 15, are arranged spirally. They unfurl, as the plant grows, at the rate of one per week in warm weather, and extend upward and outward, becoming as much as 9 ft (2.75 m) long and 2 ft (60 cm) wide. They may be entirely green, green with maroon splotches, or green on the upperside and red purple beneath. The inflorescence, a transformed growing point, is a terminal spike shooting out from the heart in the tip of the stem. At first, it is a large, long-oval, tapering, purple-clad bud. As it opens, it is seen that the slim, nectar-rich, tubular, toothed, white flowers are clustered in whorled double rows along the floral stalk, each cluster covered by a thick, waxy, hoodlike bract, purple outside, deep-red within. Normally, the bract will lift from the first hand in 3 to 10 days. If the plant is weak, opening may not occur until 10 or 15 days. Female flowers occupy the lower 5 to 15 rows; above them may be some rows of hermaphrodite or neuter flowers; male flowers are borne in the upper rows. In some types the inflorescence remains erect but generally, shortly after opening, it begins to bend downward. In about one day after the opening of the flower clusters, the male flowers and their bracts are shed, leaving most of the upper stalk naked except at the very tip where there usually remains an unopened bud containing the last-formed of the male flowers. However, there are some mutants such as 'Dwarf Cavendish' with persistent male flowers and bracts which wither and remain, filling the space between the fruits and the terminal bud.

As the young fruits develop from the female flowers, they look like slender green fingers. The bracts are soon shed and the fully grown fruits in each cluster become a "hand" of bananas, and the stalk droops with the weight until the bunch is upside down. The number of "hands" varies with the species and variety.

The fruit (technically a "berry") turns from deep-green to yellow or red, or, in some forms, green-and white-striped, and may range from 2 1/2 to 12 in (6.4-30 cm) in length and 3/4 to 2 in (1.9-5 cm) in width, and from oblong, cylindrical and blunt to pronouncedly 3-angled, somewhat curved and hornlike. The flesh, ivory-white to yellow or salmon-yellow, may be firm, astringent, even gummy with latex, when unripe, turning tender and slippery, or soft and mellow or rather dry and mealy or starchy when ripe. The flavor may be mild and sweet or subacid with a distinct apple tone. Wild types may be nearly filled with black, hard, rounded or angled seeds 1/8 to 5/8 in (3-16 mm) wide and have scant flesh. The common cultivated types are generally seedless with just minute vestiges of ovules visible as brown specks in the slightly hollow or faintly pithy center, especially when the fruit is overripe. Occasionally, cross-pollination by wild types will result in a number of seeds in a normally seedless variety such as 'Gros Michel', but never in the Cavendish type.

Origin and Distribution

Edible bananas originated in the Indo-Malaysian region reaching to northern Australia. They were known only by hearsay in the Mediterranean region in the 3rd Century B.C., and are believed to have been first carried to Europe in the 10th Century A.D. Early in the 16th Century, Portuguese mariners transported the plant from the West African coast to South America. The types found in cultivation in the Pacific have been traced to eastern Indonesia from where they spread to the Marquesas and by stages to Hawaii.

Bananas and plantains are today grown in every humid tropical region and constitute the 4th largest fruit crop of the world, following the grape, citrus fruits and the apple. World production is estimated to be 28 million tons—65% from Latin America, 27 % from Southeast Asia, and 7 % from Africa. One-fifth of the crop is exported to Europe, Canada, the United States and Japan as fresh fruit. India is the leading banana producer in Asia. The crop from 400,000 acres (161,878 ha) is entirely for domestic consumption. Indonesia produces over 2 million tons annually, the Philippines about 1/2 million tons, exporting mostly to Japan. Taiwan raises over 1/2 million tons for export. Tropical Africa (principally the Ivory Coast and Somalia) grows nearly 9 million tons of bananas each year and exports large quantities to Europe.

Brazil is the leading banana grower in South America—about 3 million tons per year, mostly locally consumed, while Colombia and Ecuador are the leading exporters. Venezuela's crop in 1980 reached 983,000 tons. Large scale commercial production for export to North America is concentrated in Honduras (where banana fields may cover 60 sq mi) and Panama, and, to a lesser extent, Costa Rica. In the West Indies, the Windward Islands of Martinique and Guadeloupe are the main growers and for many years have regularly exported to Europe. Green bananas are the basic food of the people of Western Samoa and large quantities are exported.

In Ghana, the plantain is a staple food but up to the late 1960's the crop was grown only in home gardens or as a shade for cacao. When the cacao trees declined, solid plantings of plantain were established in their place and in newly cleared forest land where the richness of organic matter greatly promotes growth. By 1977, Ghana was harvesting 2,204,000 tons (2,000,000 MT) annually.

The plantain is the most important starchy food of Puerto Rico and is third in monetary value among agricultural crops, being valued at $30,000,000 annually. While improved methods of culture have been adopted in recent years and production has been increased by 15% in 1980, it was still necessary to import 1,328 tons (1,207 MT) to meet local demand. Annual per capita consumption is said to be 65 lbs (29.5 kg). In the past, most of the plantains in Puerto Rico were grown on humid mountainsides. High prices have induced some farmers to develop plantations on level irrigated land formerly devoted to sugarcane.

In tropical zones of Colombia, plantains are not only an important part of the human diet but the fruits and the plants furnish indispensable feed for domestic animals as well. The total plantain area is about 1,037,820 acres (420,000 ha) with a yield of 5,500 lbs per acre (5,500) kg/ha). Mexico grows about 1/6 as much, 35% under irrigation, and the crop is valued at $1,335 US per acre ($3,300 US/ha). Venezuela has somewhat less of a crop 517,000 tons from 146,000 acres (59,000 ha) in 1980—and the Dominican Republic is fourth in order with about 114,600 acres (46,200 ha). Bananas and plantains are casually grown in some home gardens in southern Florida. There are a few small commercial plantations furnishing local markets.

Varieties

Edible bananas are classified into several main groups and subgroups. Simmonds placed first the diploid *M. acuminata* group **'Sucrier'**, represented in Malaya, Indonesia, the Philippines, southern India, East Africa, Burma, Thailand, the West Indies, Colombia and Brazil. The sheaths are dark-brown, the leaves yellowish and nearly free of wax. The bunches are small and the fruits small, thin-skinned and sweet. Cultivars of this group are more important in New Guinea than elsewhere.

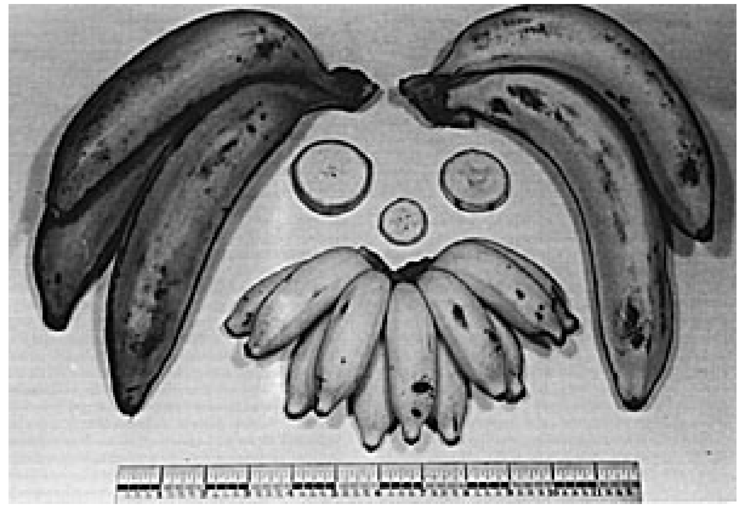


Fig. 8: Green plantains (left), 'Gros Michel' bananas(right) and 'Lady Finger' (center). In: K. and J. Morton, *Fifty Tropical Fruits of Nassau*, 1946.

Here belongs one of the smallest of the well-known bananas, the **'Lady Finger'**, also known as'Date'or'Fig', and, in Spanish, as 'Dedo de Dama', 'Datil', 'Nino', Bocadillo', 'Manices', 'Guineo Blanco', or 'Cambur Titiaro'. The plant reaches 25 ft (7.5 m) in height, has a slender trunk but a heavy root system that fortifies the plant against strong winds. The outer sheaths have streaks or patches of reddish brown. The bunch consists of 10 to 14 hands each of 12 to 20 fingers. The fruit is 4 to 5 in (10-12.5 cm) long, with thin, light-yellow skin and sweet flesh. This cultivar is resistant to drought, Panama disease and the black weevil but subject to Sigatoka (leaf spot). It is common in Latin America and commercial in Queensland and New South Wales.

In second place, there is the group represented by the prominent and widely cultivated **'Gros Michel'** originally from Burma, Thailand, Malaya, Indonesia and Ceylon. It was introduced into Martinique early in the 19th Century by a French naval officer and, a few years later, was taken to Jamaica; from there it was carried to Fiji, Nicaragua, Hawaii and Australia, in that sequence. It is a large, tall plant bearing long bunches of large, yellow fruits, and it was formerly the leading commercial cultivar in Central Africa, Latin America and the Caribbean, but has been phased out because of its great susceptibility to Panama disease. It has given rise to several named sports or mutants.

The Cavendish subgroup includes several important bananas:

a) The **'Dwarf Cavendish'**, Plate III, first known from China and widely cultivated, especially in the Canary Islands, East Africa and South Africa. The plant is from 4 to 7 ft (1.2-2.1 m) tall, with broad leaves on short petioles. It is hardy and wind resistant. The fruit is of medium size, of good quality, but thin-skinned and must be handled and shipped with care. This cultivar is easily recognized because the male bracts and flowers are not shed.

b) The **'Giant Cavendish'**, also known as 'Mons Mari, 'Williams', 'Williams Hybrid', or 'Grand Naine', is of uncertain origin, closely resembles the 'Gros Michel', and has replaced the 'Dwarf' in Colombia, Australia, Martinique, in many Hawaiian plantations, and to some extent in Ecuador. It is the commercial banana of

Taiwan. The plant reaches 10 to 16 ft (2.7-4.9 m). The pseudostem is splashed with darkbrown, the bunch is long and cylindrical, and the fruits are larger than those of the 'Dwarf' and not as delicate. Male bracts and flowers are shed, leaving a space between the fruits and the terminal bud.


Plate III: DWARF CAVENDISH BANANA, *Musa acuminata*

c) **'Pisang masak hijau'**, or 'Bungulan', the triploid Cavendish clone of the Philippines, Indonesia and Malaya, is erroneously called 'Lacatan' in Jamaica where it replaced 'Gros Michel' because of its immunity to Panama disease, though it is subject to Sigatoka (leaf spot). The plant is tall and slender and prone to wind injury. Its fruits ripen unevenly in winter, bruise easily and are inclined to spoil in storage. It is no longer grown commercially in Jamaica and the Windward Islands. The fruits are commonly used as cooking bananas in Jamaican households. Simmonds declares this cultivar is not the true 'Lacatan' of the Philippines. He suggested that 'Pisang masak hijau' may have been the primary source of all the members of the Cavendish group.

d) **'Robusta'**, very similar to the so-called 'Lacatan', has largely replaced that cultivar in Jamaica and the Windward Islands and the 'Gros Michel' in Central America because it is shorter, thick-stemmed, less subject to wind. It is being grown commercially also in Brazil, eastern Australia, Samoa and Fiji. It is resistant to Panama disease but prone to Sigatoka.

e) **'Valery'**, also a triploid Cavendish clone, closely resembles 'Robusta' and some believe it may be the same. However, it is being grown as a successor to 'Robusta'. It is already more widely cultivated than 'Lacatan' for export. As compared with other clones in cooking trials, it has low ratings because cooking hardens the flesh and gives it a waxy texture.

The Banana Breeding Research Scheme in Jamaica has developed a number of tetraploid banana clones with superior disease-resistance and some are equal in dessert quality to the so-called 'Lacatan' and 'Valery'.

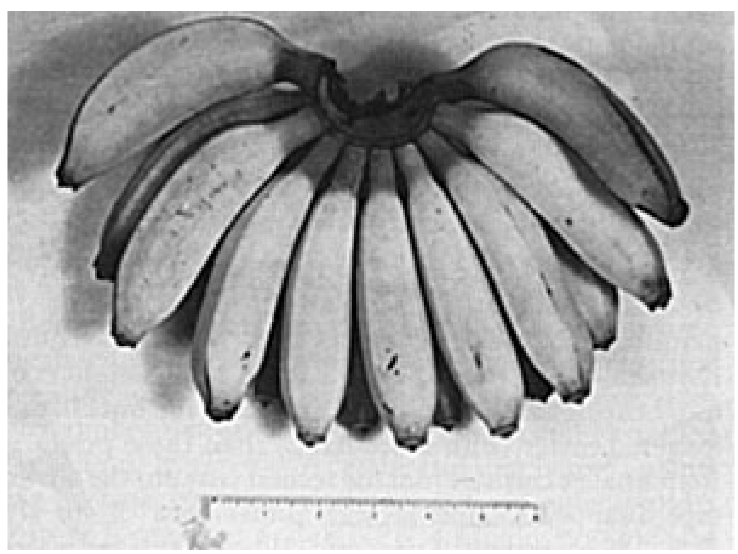


Fig. 9: 'Radja' banana, introduced into Florida by Dr. J.J. Ochse about 1957.

'Bluggoe' (with many other local names) is a cooking banana especially resistant to Panama disease and Sigatoka. It bears a few distinctly separated hands of large, almost straight, starchy fruits, and is of great importance in Burma, Thailand, southern India, East Africa, the Philippines, Samoa, and Grenada.

'Ice Cream' banana of Hawaii ('Cenizo' of Central America and the West Indies; 'Krie' of the Philippines), is a relative of 'Bluggoe'. The plant grows to 10 or 15 ft (3-4.5 m), the leaf midrib is light pink, the flower stalk may be several feet long, but the bunch has only 7 to 9 hands. The fruit is 7 to 9 in (17.5 22.8 cm) long, up to 2 1/2 in (6.25 cm) thick, 4-to 5-angled, bluish with a silvery bloom when young, pale yellow when ripe, The flesh is white, sweetish, and is eaten raw or cooked.

'Mysore', also known as 'Fillbasket' and 'Poovan', is the most important banana type of India, constituting 70% of the total crop. It is sparingly grown in Malaya, Thailand, Ceylon and Burma. It is thought to have been introduced into Dominice in 1900 but the only place where it is of any importance in the New World is Trinidad where it is cultivated as shade for cacao. The plant is large and vigorous, immune to Panama disease and nearly so to Sigatoka; very hardy and drought tolerant. It bears large, compact bunches of medium sized, plump, thin skinned, attractive, bright yellow fruits of subacid flavor.

Other prominent commercial cultivars are **'Salembale'** and **'Rasabale'**, not suitable for canning because of starchy taste and weak flavor. **'Pachabale'** and **'Chandrabale'** are important local varieties preferred for canning. K.C. Naik described 34 cultivars as the more important among the many grown in South India.

'Silk', 'Silk Fig', or 'Apple' ('Manzana' in Spanish), is the most popular dessert banana of the tropics. It is widely distributed around the tropics and subtropics but never grown on a large scale. The plant is 10 to 12 ft (3-3.6m) tall, only medium in vigor, very resistant to Sigatoka but prone to Panama disease. There are only 6 to 12 hands in the bunch, each with 16 to 18 fruits. The plump bananas are 4 to 6 in (10-15 cm) long, slightly curved; astringent when unripe but pleasantly subacid when fully ripe; and apple scented. If left on the bunch until fully developed, the thin skin splits lengthwise and breaks at the stem end causing the fruit to fall, but it is firm and keeps well on hand in the home.

The **'Red'**, 'Red Spanish', 'Red Cuban', 'Colorado', or'Lal Kela' banana may have originated in India, where it is frequently grown, and it has been introduced into all banana growing regions. The plant is large, takes 18 months from planting to harvest. It is highly resistant to disease. The pseudostem, petiole, midrib and fruit peel are all purplish red, but the latter turns to orange yellow when the fruit is fully ripe. The bunch is compact, may contain over 100 fruits of medium size, with thick peel, and flesh of strong flavor. In the mutant called 'Green Red', the plant is variegated green and red, becomes 28 ft (8.5 m) tall with pseudostem to 18 in (45 cm) thick at the base. The bunch bears 4 to 7 hands, the fruits are thick, 5 to 7 in (12.5 17.5 cm) long. The purplish-red peel changes to orange-yellow and the flesh is firm, cream-colored and of good quality.

The **'Fehi'** or 'Fe'i' group, of Polynesia, is distinguished by the erect bunches and the purplish-red or reddish-yellow sap of the plants which has been used as ink and for dyeing. The plants may reach 36 ft (10.9 m) and the leaves are 20 to 30 in (50-75 cm) wide. The bunches have about 6 hands of orange or copper-colored, thick skinned fruits which are starchy, sometimes seedy, of good flavor when boiled or roasted. These plants are often grown as ornamentals in Hawaii.

As a separate group, Simmonds places the 'I.C. 2', or **'Golden Beauty'** banana especially bred at the Imperial College of Tropical Agriculture in Trinidad in 1928 by crossing the 'Gros Michel' with a wild *Musa acuminata*. It is resistant to Panama disease and very resistant to Sigatoka. Though the bunches are small and the fruits short, they ship and ripen well and this cultivar is grown for export in Honduras and has been planted in Hawaii, Samoa and Fiji.

'Orinoco', 'Horse', 'Hog', or 'Burro', banana, a medium tall, sturdy plant, is particularly hardy. The bunch consists of only a few hands of very thick, 3 angled fruits about 6 in (15 cm) long. The flesh has a salmon tint, is firm, edible raw when fully ripe but much better cooked fried, baked or otherwise, as are plantains.

Trials of 5 clones of 'Giant Cavendish' and 9 other cultivars ('Robusta A', 'Robusta B', 'Cocos A', 'Cocos B', 'Golden Beauty', 'Enano Nautia', 'Enano Gigante', 'Enano' and 'Valery') were made between 1976 and 1979 at the Campo Agricola Experimental at Tecoman, Mexico. 'Enano Gigante' is the most widely grown cultivar in that region but the tests showed that 'Enano Nautia' and 'Golden Beauty' bore heavier bunches of better quality fruit, even though 'Enano Gigante' had a greater number of bunches and highest yield per ground area. 'Giant Cavendish' clones 1, 2, 3 and 4, and 'Cocos B' grew very tall, gave low yields and the fruit was of poor quality.

Among the plantains, there are many forms, some with pink, red or dark-brown leaf sheaths, some having also colored midribs or splotches on leaves or fruits. The plants are usually large, vigorous and resistant to Panama disease and Sigatoka but attacked by borers. Major subgroups are known as 'French plantain' and 'Horn plantain', the former with persistent male flowers. The usually large, angled fruits are borne in few hands. All are important sources of food in southern India, East Africa, tropical America and the West Indies. The tall **'Maricongo'** and the **'Common Dwarf'** are leading commercial cultivars. A dwarf mutant is the 'Plantano enano of Puerto Rico (*'banane cochon'* of Haiti). Ordinary plantains are called *'cuadrado'*, *'chato'*, and *'topocho'* in Mexico. The leading commercial cultivars are 'Pelipita' and 'Saba' which are resistant to Black Sigatoka but they do not have the high culinary quality of 'Harton', 'Dominico-Harton', 'Currare', and 'Horn'. 'Laknau' is a fertile plantain that resembles 'Horn' but is of inferior quality. It has opened up possibilities for hybridizing and is being crossed with 'Pelipita' and 'Saba'.

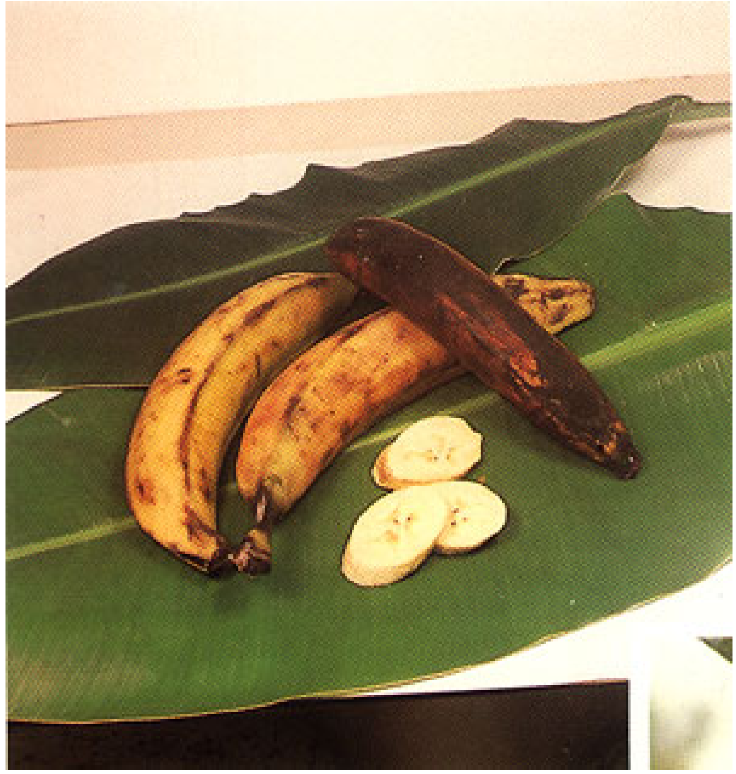


Plate IV: PLANTAIN, *Musa* × *paradisiaca*

Banana and plantain cultivars most often grown in Florida are the 'Dwarf Cavendish', 'Apple', and 'Orinoco' bananas and the 'Macho' plantain. The 'Red' and 'Lady Finger' bananas are very occasionally grown in sheltered locations.

There are five major collections of banana and plantain clones in the world. United Brands maintains a collection of 470 cultivars and 100 species at La Lima, Honduras.

Climate

The edible bananas are restricted to tropical or neartropical regions, roughly the area between latitudes 30°N and 30°S. Within this band, there are varied climates with different lengths of dry season and different degrees and patterns of precipitation. A suitable banana climate is a mean temperature of 80°F (26.67°C) and mean rainfall of 4 in (10 cm) per month. There should not be more than 3 months of dry season.

Cool weather and prolonged drought retard growth. Banana plants produce only one leaf per month in winter, 4 per month in summer. If low temperatures occur just at flowering time, the bud may not be able to emerge from the stem. If fruits have already formed, maturity may be delayed several months or completely suspended. If only the leaves are destroyed, the fruits will be exposed to sunburn. Smudging, by burning dry trash covered with green clippings to create smoke, can raise the temperature 2 to 4 degrees. Flooding the field in advance of a cold snap will keep the ground warm if the chill weather is brief. In Australia, bananas are planted on sunny hill sides at elevations of 200 to 1,000 ft (60 to 300 m) to avoid the cold air that settles at lower levels. Brief frosts kill the plants to the ground but do not destroy the corm. 'Dwarf Cavendish' and the 'Red' banana are particularly sensitive to cold, whereas the dwarf cultivar 'Walha', or 'Kullen', of India is successful up to 4,000 ft (1,220 m) in the outer range of the Western Ghats. 'Vella vazhai' is extensively cultivated in the Lower Pulneys between 3,200 and 5,500 ft (975 and 1,616 m). A cooking banana, 'Plankel', survives winters in home gardens in northern India. In South Africa, the main banana-producing area is along the southeast coast at 3,000 ft (915 m) above sea level with summer rainfall of 35 to 45 in (90-115 cm). The major part of the crop in East Africa is grown between 4,000 and 5,000 ft (1,220 and 1,524 m) and the total range extends from sea-level to 7,500 ft (2,286 m).

Wind is detrimental to banana plants. Light winds shred the leaves, interfering with metabolism; stronger winds may twist and distort the crown. Winds to 30 mph break the petioles; winds to 40 mph will topple a pseudostem that is supporting the weight of a heavy bunch unless the stem is propped, and may cause root damage in non fruiting plants that are not blown down; winds of 60 mph or over will uproot entire plantations, especially when the soil is saturated by rain. Windbreaks are often planted around banana fields to provide some protection from cold and wind. Cyclones and hurricanes are devastating and the latter were the main reason for the shift of large scale banana production from the West Indies to Central America, Colombia and Ecuador. Hail results from powerful convection currents in the tropics, especially in the spring, and does much damage to bananas.

Soil

The banana plant will grow and fruit under very poor conditions but will not flourish and be economically productive without deep, well-drained soil—loam, rocky sand, marl, red laterite, volcanic ash, sandy clay, even heavy clay—but not fine sand which holds water. Over head irrigation is said to improve the filth of heavy clay and has made possible the use of clay soils that would never have been considered for banana culture in the past. Alluvial soils of river valleys are ideal for banana growing. Bananas prefer an acid soil but if the pH is below 5.0 lime should be applied the second year. Low pH makes bananas more susceptible to Panama disease. Where waterlogging is likely, bananas and plantains are grown on raised beds. Low, perennially wet soils require draining and dry soils require irrigation.

Propagation

Banana seeds are employed for propagation only in breeding programs. Corms are customarily used for planting and Mexican studies with 'Giant Cavendish' have shown that those over 17.5 lbs (8 kg) in weight come into bearing early and, in the first year, the bunches are longer, heavier, with more hands than those produced from smaller corms. From the second year on, the advantage disappears. Most growers prefer "bits" 2- to 4-lb (0.9-1.8 kg) sections of the corm. When corms are scarce, smaller sections—1 to 2 lbs (454-908 g) have been utilized and early fertilization applied to compensate for the smaller size. But in Queensland it is specified that "bits" of 'Dwarf Cavendish' shall not be less than 4 x 3 x 3 in (10 x 7.5 x 7.5 cm) and "bits" of 'Lady Finger' and other tall cultivars shall be not less than 5 x 5 x 3 1/2 in (12.5 x 12.5 x 9 cm). The corm has a number of buds, or "eyes", which develop into new shoots. The two upper buds are the youngest and have a pinkish tint. These develop rapidly and become vigorous plants. To obtain the "bits", a selected, healthy banana plant, at least 7 months old but prior to fruiting, is uprooted and cut off about 4 to 5 in (10-12.5 cm) above the corm. The outer layer of leaf bases is peeled off to expose the buds, leaving just a little to protect the buds during handling and transport. The corm is split between the 2 upper buds and trimmed with square sides, removing the lower, inferior buds and any parts affected by pests or disease, usually indicated by discoloration. Then the "bits" are fumigated by immersing for 20 minutes in hot water at about 130°F (54.44°C) or in a commercial nematicide solution. Sometimes it is advisable to apply a fungicide to prevent spoilage. They should then be placed in a sanitary place (away from all diseased trash) in the shade for 48 hrs before planting.

Inasmuch as "bits" are not often available in quantity, the second choice is transplantation of suckers. These should not be too young nor too old.

The sucker first emerges as a conical shoot which opens and releases leaves that are mostly midribs with only vestiges of blade. These juvenile leaves are called "sword", "spear", or "arrow", leaves. Just before the sucker produces wide leaves resembling those of the mature plant but smaller, it has sufficient corm development to be transplanted. Sometimes suckers from old, deteriorating corms have broad leaves from the outset. These are called "water" suckers, are insubstantial, with very little vigor, and are not desirable propagating material. "Maiden" suckers that have passed the "sword"-leaved stage and have developed broad leaves must be large to be acceptably productive. In banana trials at West Bengal, India, suckers 3 to 4 months old with well-developed rhizomes proved to be the best yielders. In comparison, small, medium, or large "sword" suckers develop thicker stems, and give much higher yields of marketable fruits per land parcel. "Bits' grow slowly at first, but in 2 years' time they catch up to plants grown from suckers or "butts" and are much more economical. "Butts" (entire corms, or rhizomes, of mature plants), called "bull heads" in the Windward Islands, are best used to fill in vacancies in a plantation. For quick production, some farmers will use "butts" with several "sword" suckers attached. Very young suckers, called "peepers", are utilized only for establishing nurseries.

Instead of waiting for normal sucker development, multiplication has been artificially stimulated in the field by removing the soil and outer leaf sheaths covering the upper buds of the corm, packing soil around them and harvesting them when they have reached the "sword' sucker stage. A greenhouse technique involves cleaning and injuring a corm to induce callus formation from which many new plants will develop. As many as 180 plantlets have been derived from one corm in this manner.

Diseases are often spread by vegetative propagation of bananas, and this fact has stimulated efforts to create disease-free planting material on a large scale by means of tissue culture. Some commercial banana cultivars have been cultured in Hawaii. A million 'Giant Cavendish' banana plants were produced by meristem culture in Taiwan in 1983. In the field, these laboratory plantlets showed 95% survival, grew faster than suckers in the first 5 months, had bigger stems and more healthy leaves.

Rapid multiplication of 'Philippine Lacatan' and 'Grand Naine' bananas, and the Sigatoka-resistant 'Saba' and 'Pelipita' plantains by shoot-tip culture has been achieved by workers at State University of New York.

Culture

On level land where the soil is compact, deep ploughing is needed to improve aeration and water filtration, whereas on a sloping terrain minimum tillage is advised as well as contouring of rows to minimize erosion. Planting is best done at the end of the dry season and beginning of the wet season for adequate initial moisture and to avoid waterlogging of the young plants. Puerto Rico, because of its favorable climate, is able to make monthly plantings of plantains the year around in order to produce a continuous supply for processing factories. However, some consideration has been given to manipulation of planting dates to avoid a summer surplus (June-September) caused by March and May plantings and to take advantage of higher prices in winter and spring (February to April). To achieve this, it is suggested that plantings be made only in the first or second weeks of January, July, September, November and December. Generally, the banana requires 10 to 12 months from planting to harvest. Summer plantings of plantains in Puerto Rico take 14 to 16 months; winter plantings 17 to 19. In regions where there may be periods of low temperatures in winter, planting time is chosen to allow flowering and fruiting before predictable cold periods.

Spacing varies with the ultimate size of the cultivar, the fertility of the soil, and other factors. Close planting protects plantations exposed to high winds, but results in fewer suckers, hinders disease control, and has been found to be profitable for only the first year. In subsequent years, fruits are shorter, the flesh is softer and bunches ripen prematurely. The standard practice in Puerto Rico is 500 plants of 'Maricongo' plantain per acre (1,235 plants/ha). Increasing to 800 plants/acre (1,976/ha) has increased yield by 4 tons, but elevating density to 1,300 plants/acre (3,212 plants/ha) has not shown any further increase. In Surinam, most of the plantains are grown at a density of 809 to 1,012 plants per acre (2,000-2,500/ha), but density may range from 243 to 1,780 plants per acre (600-4,400/ha).

The higher the number of plants in the field, the larger the volume of fertilizer that must be applied. The crop suffers severely from root competition, for the roots of a fully grown banana plant may extend outward 18 ft (5.5 m). The higher the altitude, the lower the density must be because solar radiation is reduced. Too much space between plants allows excessive evaporation from uncovered soil and increases the weed problem. Growers must determine the most economical balance between sufficient light for good yields and efficient land managemeet. Spacing distances for 'Dwarf Cavendish' range from 10 x 6 ft (3 x 1.8 m) to 15 x 12 ft (4.5 x 3.6 m). A spacing of 12 ft (3.6 m) between rows and 8 ft (2.4 m) between plants allows 450 plants per acre

(1,112 plants/ha). Studies conducted with the so called 'Lacatan' ('Pisang masak hijau') over a 3-year period in Jamaica, demonstrated the optimum density to be 680 plants per acre (2,680/ha). At closer spacings, yield increased but profits declined. Hexagonal spacing gives the maximum number of plants per area. Double- and triple-row plantings provide alleys for mechanical operations and harvesting.

Planting holes should be at least 18 in (45 cm) wide and 15 in (38 cm) deep, but may be as much as 3 ft (0.91 m) wide and 2 ft (0.6 m) deep for extra wind resistance. They should be enriched in advance of planting. On hillsides, suckers are set with the cut surface facing downhill; the bud or "eye" of a "bit" must point uphill; so that the "follower" sucker will emerge on the uphill side where the soil is deepest. A surface cover of about 4 in (10 cm) of soil is trampled down firmly.

Weed control is essential. Geese have been installed as weeders because they do not eat the banana plants. However, they consume mostly grass and fail to eliminate certain broad-leaved weeds which still require cleaning out. Certain herbicides, including Diuron and Ametryne, have been approved for banana fields. They are applied immediately after planting but great care must be taken to minimize adverse effects on the crop. Ametryne has been shown to be relatively safe for the plants and it has a short life in the soil. The most persistent weed is *Cyperus rotundus* L. (nutgrass, yellow nutgrass, purple nutsedge, coqui or coyolillo) which decreases yields and competes with the crop for nitrogen.

In some plantations, a mulch of dry banana leaves is maintained to discourage weeds. Some growers resort to live groundcovers such as *Glycine javanica* L. (Rhodesian kodzu), *Commelina* spp., or *Zebrina pendula* Schnizl. or other creepers, but these tend to climb the banana stems and become a nuisance. Sometimes short-term crops are interplanted in young banana fields, for example, maize, eggplant, peppers, tomatoes, okra, sweetpotato, pineapple or upland rice. A space of at least 3 ft (0.91 m) must be kept clear around each banana plant. However, there are banana authorities who are opposed to interplanting.

Bananas and plantains are heavy feeders. It has been calculated that a harvest of 5 tons of fruit from an acre leaves the soil depleted by 22 lbs (10 kg) nitrogen, 4 lbs (1.8 kg) phosphorus, 55 lbs (25 kg) potash and 11 oz (312 kg) calcium. In general, it can be said that banana plants have high nitrogen and phosphorus requirements and a fertilizer formula of 8:10:8 NPK is usually suitable and normally 1 to 1 1/2 tons/acre (1 1 1/2 MT/ha) may be adequate. One-third of the fertilizer is worked into each planting site when most of the plants appear above ground, one third in a circle about 1 ft (30 cm) out from each plant 2 months later, and one-third at double the distance 2 months after that. Supplementary feedings will depend on signs of deficiencies (often determined by leaf analyses) as the plantation develops. Fertilization needs vary with the soil. In Puerto Rico, most plantains are grown on humid Oxisols and Ultisols in the interior. These soils are well drained but relatively infertile and highly acid, the pH being about 4.8. On such soils, potassium uptake may be too high and N and Mg deficiencies occur. But experts have shown that these soils respond to good fertilization practices and can be very productive. As an example, 224 lbs N per acre (224 kg/ha) applied in circular bands 1.5 ft (0.46 m) from the base of the pseudostem gives a significantly higher yield than broadcast N, and there is good response to Mg applied at time of planting and again 7 months later.

In the humid mountain regions of Puerto Rico, 250 to 325 lbs N per acre (250 325 kg/ha), 125 to 163 lbs phosphorus per acre (125 163 kg/ha), and 500 to 650 lbs potassium per acre (500 650 kg/ha) are recommended for plantains. On lowland sandy clay, phosphorus and magnesium applications appear ineffective. Applications of N at the rate of 168 to 282 lbs/acre (168-282 kg/ha) increase size and number of fruits harvested, but higher rates of N decrease yield because of the number of plants that bend over halfway or are stunted or fail to flower. Applications of 1,121 1bs N per acre (1,121 kg/ha) reduce production by 46%. Potassium at the rate of 405 to 420 lbs/acre (405 420 kg/ha) has the effect of increasing weight and number of fruits. However, there appear to be factors, possibly soil magnesium and calcium, which inhibit the uptake of potassium. One study showed that it took one year for heavy applications of K to reach down to a depth of 8 in (20 cm) where most of the roots were found in a banana plantation on clay loam. One benefit of added potassium is that it makes bananas more buoyant. In cool, dry seasons in Honduras, the fruit tissue is abnormally dense and there is a high rate of "sinkers" when hands are floated through a washing tank. Such fruits have been found deficient in potassium and increased potassium in the fertilizer has reduced the problem. Irrigation by costly overhead sprinkler systems is standard practice in large scale banana culture in Central America. Without such equipment, irrigation basins may be necessary throughout the field and they should be able to hold at least 3 in (7.5 cm) of water. During the first 2 months, the plants should be irrigated every 7 to 10 days; older plants need irrigation only every 3 to 4 weeks in dry seasons. On heavy soils, too frequent irrigations decrease yields. For maximum root development, the water table must be between 14 and 19 in (36 48 cm) below ground level.

To preserve the original density, the plants are pruned; that is, only the most deep seated sucker and one or more of its offshoots ("peepers") are permitted to exist beside each parent plant to serve as replacements and maintain a steady succession. All other suckers are killed to prevent competition with the pseudostem and its "followers", and a bunch of fruits will be ready for harvest every 6 to 8 months. Various methods of de-suckering have been employed: 1) wrenching by hand; 2) cutting at soil level with a banana knife; 3) cutting at soil level and filling the base with kerosene; 4) cutting at soil level and killing the under ground terminal bud by thrusting in and twisting a gouging tool.

As the older leaves wither and droop, they must be removed because they interfere with spraying, they shade the suckers, cause blemishes on the fruits, harbor disease, insects and other creatures, and constitute a fire hazard.

Bearing bananas require propping. This has been done with simple wooden or bamboo poles, forked poles, or two stakes fastened together to form an "X" at the top, a system much less harmful to the pseudostem. Or the plant may be tied back to pickets driven into the ground, to prevent falling with the weight of the bunch.

Various types of covering—dry banana leaves, canvas, drill cloth, sisal sacks, or burlap or so-called "Hessian' bags (made of jute), have been put over banana bunches intended for export, especially to enhance fruit development in winter and avoid blemishes. In 1955, Queensland led the trend toward adoption of tubular poly vinylchloride (PVC), then the cheaper blue polyethylene covers after trials produced record bunches. At first, the transparent covering caused sunburn on the first two hands and it was found necessary to protect these with newspaper before pulling on the plastic sleeve. The use of plastic covers became standard practice not only in Australia but in Africa, India and the American tropics. In 1963, Queensland growers were turning to covers made of High Wet Strength (formaldehyde-treated) kraft paper which was already in use for garbage bags. These bags were easily stapled at the top, prevented sunburn, resisted adverse weather, and were reusable for at least another season. Some growers still prefer the burlap. It is cautioned that the cover should not be put on until the bracts have lifted from the fruits (about 21 days after "shooting") so that the young fingers will be firm enough to resist the friction of the cover.

If bunches are composed of more than 7 hands, debudding, or "de-belling" that is, removal of the

Fig. 10: Immature banana bunch ("stem") in protective plastic cover; Hacienda Secadal, Ecuador.

terminal male bud (which keeps on extending and growing) will result in somewhat fuller bananas, thus increasing bunch weight. The cut should be made several inches below the last hand so that the rotting tip of the severed stalk will not affect the fruits.

Harvesting

Banana bunches are harvested with a curved knife when the fruits are fully developed, that is, 75% mature, the angles are becoming less prominent and the fruits on the upper hands are changing to light green; and the flower remnants (styles) are easily rubbed off the tips. Generally, this stage is reached 75 to 80 days after the opening of the first hand. Cutters must leave attached to the bunch about 6 to 9 in (15-18 cm) of stalk to serve as a handle for carrying. With tall cultivars, the pseudostem must be slashed partway through to cause it to bend and harvesters pull on the leaves to bring the bunch within reach. They must work in pairs to hold and remove the bunch without damaging it. In the early 1960's a "banana bender" was invented in Queensland—an 8-ft pole with a steel rod mounted at the top and shaped with a downward pointing upper hook and an upward-pointing lower hook, the first to pull the pseudostem down after nicking and the second to support the bent pseudostem so that the bunch can be cut at a height of about 4 1/2 ft (1.35 m).

Fig. 11: Mature, newly harvested, banana bunches at Hacienda Secadal, Ecuador.

Formerly, entire bunches were transported to shipping points and exported with considerable loss from inevitable damage. Improved handling methods have greatly reduced bunch injuries. In modern plantations, the bunches are first rested on the padded shoulder of a harvester and then are hung on special racks or on cables operated by pulleys by means of which they can be easily conveyed to roads and by vehicle to nearby packing sheds. Where fields have been located in remote areas lacking adequate highways, transport out has been accomplished by hovercraft flying along riverbeds. In Costa Rica, when rains have prevented truck transport to railway terminals, bananas have been successfully carried in slings suspended from helicopters. Exposure to even moderate light after harvest initiates the ripening process. Therefore the fruits should be protected from light as much as possible until they reach the packing shed.

In India, studies have been made to determine the most feasible disposition of a plant from which a bunch has been harvested. It is normal for it to die and it may be left standing for 3 to 4 months to dehydrate before removal, or the top half may be removed right after harest by means of a tool called a "mattock" (a combined axe and hoe); or the pseudostem may be cut at ground level, split open, and the tender core taken away for culinary purposes. Results indicated that the first two practices have equal effect on production, but the complete felling and removal of the pseudostem lowered the yield of the "follower" significantly. In Jamaica and elsewhere it is considered best to chop and spread as organic matter the felled pseudostem and other plant residue. This returns to the soil 404 lbs N, 101 lbs P and 1, 513 lbs K from an acre of bananas (404 kg, 101 kg and 1,513 kg, respectively, from a hectare). The stump should be covered with hard-packed soil to discourage entrance of pests.

Banana plantations, if managed manually, may survive for 25 years or far longer. The commercial life of a banana "stool" is about 5 or 6 years. From the 4th year on, productivity declines and the field becomes too irregular for mechanical operations. Sanitary regulations require that the old plantings be eradicated. In the past, this has been done by digging out the plants with the mattock, or bringing in cattle to graze on them. In recent years, the old plants and the suckers that arise from the old corms are injected with herbicide until all are thoroughly killed and the field is then cleared. Where bananas or plantains are raised on cleared forest land without sophisticated maintenance practices, they become thoroughly infested with nematodes by the end of the third year and the regrowth of underbrush has begun to take over the field, so it is simply abandoned.

Yield

It is clear that many factors determine the annual yield from a banana or plantain plantation: soil and agronomic practices, the cultivar planted, spacing, the type of propagating material and the management of sucker succession. The 'Gros Michel' banana has yielded 3 to 7 tons per acre (3 to 7 MT/ha) in Central America. A 'Giant Cavendish' bunch may weigh 110 lbs (50 kg) and have a total of 363 marketable fruits. A well-filled bunch of ''Dwarf Cavendish' will have no more than 150 to 200 fruits. Sword suckers of plantains have yielded 54,984 fruits per acre (135,866 fruits /ha); water suckers, 49,021 fruits per acre (121,132 fruits/ha).

With heavy fertilization, the 'Maricongo' plantain in Puerto Rico, planted at the rate of 725 per acre has produced 21,950 fruits per acre (54,238 fruits/ha); at the rate of 1,450 per acre has produced 39,080 fruits per acre (96,369 fruits/ha); in a single year.

In 1981, investigators of the earnings of plantain producers in Puerto Rico found that traditional farmers had costs of $1,568.00 per acre ($3,874.59/ha); gross income of $2,436.90 per acre ($6,021.58/ha); and net profit of $868.88 per acre ($2,146.99/ha). Those farmers who had adopted improved techniques for preparing the field, weeding and control of pests and diseases had a cost of $2,132.14 per acre ($5,268.52/ha); gross income of $4,253.26 per acre ($10,509.81/ha); and net profit of $2,121.12 per acre ($5,241.29/ha).

'Maricongo' plantains spaced at 5 x 5 ft (1.5 x 1.5 m), 1,742 plants/acre (4,303 plants/ha), have produced 33.4 tons per acre (73.5 tons/ha) over a period of 30 months.

Handling and Packing

Banana bunches were formerly padded with leaf trash which absorbed much of the sap and latex from the hervesting operation and the sites of broken off styles, each of which can leak at least 6 drops, especially if bunches are cut early in the morning. In the 1960's, when whole bunches were being exported from the Windward Islands and Jamaica to England, they were wrapped in wadding (paperbacked layers of paper tissue) to absorb the latex, and then encased in plastic sleeves for shipment. Nowadays plastic sleeves left on the bunches help protect them during transport from the field to distant packing sheds and a cushion of banana trash on the floor and against the sides of the truck does much to reduce injury. But the plastic bags increase the problem of staining by the sap/latex which mingles with the condensation inside the bag, becomes more fluid, runs down the inside and stains the peel. When hands are cut off, additional sap/latex mixture oozes from the severed crown. Banana growers and handlers know that this substance oxidizes and makes an indelible dark-brown stain on clothing. It similarly blemishes the fruits. At packing stations, the hands are floated through water tanks to wash it off. (Sodium hydrochlorate is an effective solvent.) Some people maintain that the fruit should remain in the tank for 30 minutes until all oozing of latex ceases. At certain times of the year, up to 5% of the hands may sink to the bottom of the tank, become superficially scarred and no longer exportable. As mentioned earlier, increased potassium in fertilizer mixtures renders the bananas more buoyant and fewer hands sink. In rainy seasons, it may be necessary to apply fungicide on the cut crown surface to avoid rotting, though experiments have shown that some fungicides give an off-flavor to the fruit.

Boxing was experimented with in the late 1920's but abandoned because of various types of spoilage. Modern means of combatting the organisms that cause such problems, as well as better systems of handling and transport, quality control, and good container design, have made carton packing not only feasible but necessary. First, the hands are graded for size and quality and then packed in layers in special ventilated cartons with plastic padding to minimize bruising.

In the past, bananas for export from Fiji to New Zealand were detached individually from the hands and packed tightly in 72-lb (33 kg) wooden boxes, with much bruising of the upper layer and of the fruits in contact with the sides. Reduction of fruit quality was found to offset the economic advantage of filling all the shipping space with fruits. Wooden boxes were abandoned and suppliers were converted to the packing of hands with cushioning material.

Controlled Ripening and Storage

At times, markets may not be able to absorb all the bananas or plantains ready for harvest. Experiments have been conducted to determine the effect of applying gibberellin, either by spraying or in the form of a lanolin paste, on the stalk just above the first hands, or by injection of a solution, powder or tablet into the stalk. In Israel, gibberellin $A_{4}A_{7}$, applied by any of these methods about 2 months before time of normal ripening, had the effect of delaying ripening from 10 to 19 days. If applied too early, the gibberellin treatment has no effect.

Harvested bananas allowed to ripen naturally at room temperature do not become as sweet and flavorful as those ripened artificially. Post harvest ripening is expedited undesirably if bunches or hands are stored in unventilated polyethylene bags. As a substitute for expensive controlled-temperature storage rooms, researchers in Thailand have found that hands treated with fungicide can be stored or shipped over a period of 4 weeks in polyethylene bags if ethylene absorbing vermiculite blocks (treated with a fresh solution of potassium permanganate) are included in the sack. The permanganate solution will be ineffective if exposed to light and oxygen. The blocks must be encased in small polyethylene bags perforated only on one side to avoid staining the fruits.

Bananas are generally ripened in storage rooms with 90 to 95% relative humidity at the outset, later reduced to 85% by ventilation: and at temperatures ranging from 58° to 75°F (14.4°-23.9°C), with 2 to 3 exposures to ethylene gas at 1: 1000, or 6 hourly applications for 1 to 4 days, depending on the speed of ripening desired. The fruit must be kept cool at 56° 60°F (13.3°-15.6°C) and 80 to 85% relative humidity after removal from storage and during delivery to markets to avoid rapid spoilage. Post-ripening storage at 70°F (21°C) in air containing 10 to 100 ppm ethylene accelerates softening but the fruits will remain clear yellow and attractive with few or no superficial brown specks.

Plantains for processing in the ripe stage or marketing fresh must be stored under conditions that will provide the best quality of finished product. Puerto Rican studies have shown that uniform ripening is achieved in 4 to 5 days by storage at 56° to 72°F (13.3°-22.2°C), 95 to 100% relative humidity, and with a single exposure to ethylene gas. The initial 4% starch content is reduced to 1 to 1.74% and sugars increase by about 2%. The ripe fruit can be held another 6 days at 56°F (13.3°C) and still be acceptable for processing.

The manufacture of products from the green, still starchy, plantain is a major industry in Puerto Rico. If held at room temperature, the fruits begin to ripen 7 days after harvest and become fully ripe at the end of 2 more days. Chemically disinfected fruits stored in polyethylene bags with an ethylene absorbent (Purefil wrapped in porous paper) keep 25 days at room temperature of 85°F (29.44°C), and for 55 days under refrigeration at 55°F (12.78°C). Products of such fruits have been found to be as good as or better than those made from freshly harvested green plantains.

The potential benefits of waxing have been considered by various investigators. While it is true that waxing of pre-disinfected fruits prolongs storage life by 60% at room temperature, 78°-92°F (25.56°-33.33°C), and by 28% at 52° to 55°F (11.11°-12.78°C), there is no advantage in waxing if the fruits can be held in gas storage, a combination of waxing and gassing being no better than gassing alone. In fact, waxing may result in uneven ripening after storage.

In the mid 1960's, fumigation by ethylene dibromide (EDB) against fruit fly infestation was authorized to permit export of Hawaiian bananas to the mainland USA. The treatment accelerated ripening and it could not be applied to 'Dwarf Cavendish' without covering the bunch with opaque or semi-opaque material for at least 2 months prior to harvest. EDB is no longer approved for use on food products for marketing within the United States.

Pests

Wherever bananas and plantains are grown, nematodes are a major problem. In Queensland, bananas are attacked by various nematodes that cause rotting of the corms: spiral nematodes—*Scutellonema brachyurum*, *Helicotylenchus multicinctus* and *H. nannus*; banana root-lesion nematode, *Pratylenchus coffaea*, syn. *P. musicola*; and the burrowing nematode, *Radopholus similis* less than 1 mm long, which enters roots and corms, causing red, purple and reddish-black discoloration and providing entry for the fungus *Fusarium oxysporum*. And also prevalent is the root-knot nematode, *Meliodogyne javanica*.

Plantains in Puerto Rico are attacked by 22 species of nematodes. The most injurious is the burrowing nematode and it is the cause of the common black headtoppling disease on land where plantains have been cultivated for a long time. Wherever coffee has been grown, *Pratylenchus coffaea* is the principal nematode, and where plantains have been installed on former sugar cane land, *Meliodogyne incognita* is dominant. These last two are among the three most troublesome nematodes of Surinam, the third being *Helicotylenchus* spp., especially *H. multicinctus*.

Nematicides, properly applied, will protect the crop. Otherwise, the soil must be cleared, plowed and exposed to the sun for a time before planting. Sun destroys nematodes at least in the upper several inches of earth. Some fields may be left fallow for as long as 3 years. Rotating plantains with Pangola grass (*Digitaria decumbens*) controls most of the most important species of nematodes except *Pratylenchus coffaea*. All planting material must be disinfected—corms, or parts of corms, or the bases of suckers. There are various means of accomplishing this. In Hawaii, corms are immersed in water at 122°F (50°C) for 15 minutes and soaked for 5 minutes in 1% sodium hypochlorite. In Puerto Rico, nematodes are combatted by immersing plantain corms in a solution of Nemagon for 5 minutes about 24 hours before planting and, when planting, mixing the soil in the hole with granular Dasanit (Fensulfothion) and every 6 months applying Dasanit in a ring around the pseudostem.

In Queensland, corms are immersed in hot water-131°F (55°C)—for 20 minutes or solutions of nonvolatile Nemacur or Mocap. Hot water and Nemacur are equally effective but hot water has less adverse effects on plant vigor. The Australians believe that nematicidal treatment of corms must be preceded by peeling off 3/8 in (1 cm) of the outer layer (usually discolored) even though this diminishes the vigor of the planting material. However, tests with 'Maricongo' plantain corms in Puerto Rico indicate that immersing for 10 minutes in aqueous solutions of Carbofuran, Dasanit, Ethoprop, or Phenamiphos without the time consuming and possibly detrimental peeling reduces the initial nematode populations by about 95 % and all the nematicides except Carbofuran give adequate post-planting control. Carbofuran apparently does not penetrate deeply enough. The Florida spiral nematode is the most damaging nematode in Brazil and Florida, especially during hot, rainy summers. Ethoprop is the only nematicide registered for use on bananas in Florida but it is not effective against this pest. The hot water treatment must be employed.

The black weevil, *Cosmopolites sordidus*, also called banana stalk borer, banana weevil borer, or corm weevil, is the second most destructive pest of bananas and plantains. It attacks the base of the pseudostem and tunnels upward. A jelly like sap oozes from the point of entry. It was formerly controlled by Aldrin, which is now banned. In Surinam it has been combatted by injecting pesticide into the pseudostem, or spraying the pseudostem with Monocrotophos. In Ghana, they dip planting material in a solution of Monocrotophos and apply dust of Dieldrin or Heptachlor around the base of the pseudostem. Puerto Rican tests of several pesticides have shown that Aldicarb 10G, a nematicide insecticide, applied at the base of plantain plants at the rate of 1 to 1 1/2 oz (30-45 g) every 4 months, or 1 oz (30 g) every 6 months, controls both the burrowing nematode and the black weevil. Biological control of black weevil utilizing a weevil predator, *Piaesius* *javanus*, has not been successful.

The banana rust thrips, *Chaetanophothrips orchidii*; syn. *C. signipennis*, stains the peel, causes it to split and expose the flesh which quickly discolors. The pest is usually partially controlled by the spraying of Dieldrin around the base of the pseudostem to combat the banana weevil borer, because it pupates in the soil. Another measure has been to treat the inside of polyethylene bunch covers with insecticidal dust, especially Diazinon, before slipping them over the bunches. It is recognized that this procedure constitutes a health hazard to the workers. A great improvement is the introduction of polyethylene bags impregnated with 1% of the insecticide Dursban, eliminating the need for dusting. Bunches enclosed in these bags have been found 85.% free of attack by the banana rust thrips. The bags retain their potency for at least a year in storage. Impregnated with 1 to 2% Dursban, they are equal to Diazinon in preventing banana injury by the banana fruit scarring beetle, *Colaspis hypochlora*, also called coquito. This pest invades the bunches when the fruits are very young. It has been very troublesome in Venezuela, and at times from Guyana to Mexico. The banana scab moth, *Nacoleia octasema*, infests the inflorescence from emergence to the time half the bracts have lifted. It is a major pest in North Queensland, Malaysia and the southwest Pacific. Control may be by injection or dusting with pesticide, sometimes with lifting or removal of bracts. Corky scab of bananas in southern Queensland is caused by the banana flowers thrips, *Thrips florum*, especially in hot, dry weather. The infestation is lessened by removal of the terminal male bud which tends to harbor the pest.

Among minor enemies in Queensland is the banana spider mite, *Tetranychus lambi* which moves from beneath the leaves to the fruits in warm weather and creates dull brown specks which may become so numerous as to completely cover the peel, causing it to dehydrate and crack irregularly. The leaves of the plant will wilt. Bi-weekly sprayings of pesticide get rid of the mites.

The banana silvering thrips, *Hercinothrips bicintus*, causes silvery patches on the peel and dots them with shiny black specks of excrement. The rind-chewing caterpillar, *Barnardiella sciaphila*, usually does little damage. Two species of fruit fly—*Strumeta tryoni* and *S. musae* —occasionally attack bananas in North Queensland.

Diseases

The subject of diseases is authoritatively presented by C.W. Wardlaw in the second edition of his textbook, *Banana Diseases, including plantains and abaca*, 1972; 878 pages.

It is appropriate here only to mention the main details of those maladies which are of the greatest concern to banana and plantain growers. Sigatoka, or leaf spot, caused by the fungus *Mycosphaerella musicola* (of which the conidial stage *is Cercospora musae*) was first reported in Java in 1902, next in Fiji in 1913 where it was named after the Sigatoka Valley. It appeared in Queensland 10 years later, and in another 10 years made its appearance in the West Indies and soon spread throughout tropical America. The disease was noticed in East and West Tropical Africa in 1939 and 1940. It was discovered in Ghana in 1954 and ravaged a state farm in 1965. It is most prevalent on shallow, poorly drained soil and in areas where there is heavy dew. The first signs on the leaves are small, pale spots which enlarge to 1/2 in (1.25 cm), become dark purplish black and have gray centers. When the entire plant is affected, it appears as though burned, the bunches will be of poor quality and will not mature uniformly. The fruits will be acid, the plant roots small. Control is achieved by spraying with orchard mineral oil, usuall every 3 weeks, a total of 12 applications of 1 1/2 gals per acre (14.84 liters/ha); or by systemic fungicides applied to the soil or by aerial spraying.

A much more virulent malady, Black Sigatoka, or Black Leaf Streak, caused by *Mycosphaerella fifiensis* var. *difformis*, attacked bananas in Honduras in 1969 and spread to banana plantations in Guatemala and Belize. It appeared in plantations in Honduras in 1972 where there had not been any need to spray against ordinary Sigatoka. It made headway rapidly through plantain fields in Central America to Mexico and about 10 years later was found in the Uruba region of Colombia. The disease struck Fiji in 1963 and became an epidemic. It began spreading in 1973, largely replacing ordinar Sigatoka. Surveys have revealed this previously unrecognized disease on several other South Pacific islands, in Hawaii, the Philippines, Malaysia and Taiwan. It is spread mostly by wind; kills the leaves and exposes the bunches to the sun. Cultivars which are resistant to Sigatoka have shown no resistance to Black Sigatoka. There are vigorous efforts to control the disease by fungicides or intense oil spraying. But it is not completely controlled even by spraying every 10 to 12 days a total of 40 sprayings. The cost of control with fungicides is 3 to 4 times that of controlling ordinary Sigatoka because of the need for more frequent aerial sprayings. It is very difficult to treat properly on islands where bananas are grown mostly in scattered plantings. In Mexico where plantains are extremely important in the diet, and 65% of the production is on non-irrigated land, control efforts have elevated costs of plantain production by 145 to 168%. In the Sula Valley of Honduras, Black Sigatoka has caused annual losses of 3,000,000 boxes of bananas. The great need is for resistant cultivars of high quality.

Panama Disease or Banana Wilt, which arises from infection by the fungus, *Fusarium oxysporum* f. sp. *cubense* originates in the soil, travels to the secondary roots, enters the corm only through fresh injuries, passes into the pseudostem; then, beginning with the oldest leaves, turns them yellow first at the base, secondly along the margins, and lastly in the center. The interior leaves turn bronze and droop. The pseudostem turns brown inside. This plague has seriously affected banana production in Central America, Colombia and the Canary Islands. It started spreading in southern Taiwan in 1967 and has become the leading local banana disease. The 'Cavendish' types have been considered highly resistant but they succumb if planted on land previously occupied by 'Gros Michel'. The disease is transmitted by soil, moving agricultural vehicles or other machinery, flowing water, or by wind. It is combatted by flooding the field for 6 months. Or, if it is not too serious, by planting a cover crop. There are reportedly two races: Race #1 affects 'Gros Michel', 'Manzano', 'Sugar' and 'Lady Finger'; Race #2 attacks 'Bluggoe'. Resistant cultivars are the Jamaican 'Lacatan', 'Monte Cristo', and 'Datil'or'Nino'. Resistant plantains are 'Maricongo', 'Enano' end 'Pelipita'.

Moko Disease, or Moko de Guineo, or Marchites bacteriana, is caused by the bacterium, *Pseudomonas solanacearum*, resulting in internal decay. It has become one of the chief diseases of banana and plantain in the western hemisphere and has seriously reduced production in the leading areas of Colombia. It attacks *Heliconia* species as well. It is transmitted by insects, machetes and other tools, plant residues, soil, and root contact with the roots of sick plants. There are said to be 4 different types transmitted by different means. Efforts at control include covering the male bud with plastic to prevent insects from visiting its mucilaginous excretion; debudding, disinfecting of cutting tools with formaldehyde in water 1: 3; disinfection of planting material; disposal of infected fruits and plant parts; injection of herbicide into infected plants to hasten dehydration, and also seemingly healthy neighboring plants. If the organism is variant SFR, all adjacent plants within a radius of 16.5 ft (5 m) must be destroyed and the area not replanted for 10 to 12 months, for this variant persists in the soil that long. If it is variant B, the plants within 32.8 ft (10 m) must be injected and the area not replanted for 18 months. In either case, the soil must be kept clear of broad leaved weeds that may serve as hosts. In Colombia, there are 12 species of weeds that serve as hosts or "carriers" but only 4 of these are themselves susceptible to the disease. Crop rotation is sometimes resorted to. The only sure defense is to plant resistant cultivars, such as the 'Pelipita' plantain.

Black-end arises from infection by the fungus *Gloeosporium musarum*, of which *Glomerella cingulata* is the perfect form. It causes anthracnose on the plant and attacks the stalk and stalk-end of the fruits forming dark, sunken lesions on the peel, soon penetrating the flesh and developing dark, watery, soft areas. In severe cases, the entire skin turns black and the flesh rots. Very young fruits shrivel and mummify. This fungus is often responsible for the rotting of bananas in storage. Immersing the green fruits in hot water, 131°F (55°C) for 2 minutes before ripening greatly reduces spoilage.

Cigar-tip rot, or Cigar-end disease, *Stachylidium* (*Verticillium*) *theobromae* begins in the flowers and extends to the tips of the fruits and turns them dark, the peel darkens, the flesh becomes fibrous. One remedy is to cut off withered flowers as soon as the fruits are formed and apply copper fungicides to the cut surfaces.

In Surinam, cucumber mosaic virus attacks plantains especially when cocumber is interplanted in the fields.

Also, Chinese cabbage, Cayenne pepper and "bitter greens" (*Cestrum latifolium* Lam.) are hosts for the disease.

Cordana leaf spot (*Cordana musae*), causes oval lesions 3 in (7.5 cm) or more in length, brown with a bright-yellow border. There is progressive dying of the leaves beginning with the oldest, as in Sigatoka, with consequent undersized fruits ripening prematurely. It formerly occurred mainly in sheltered, humid regions of Queensland. Now it is seen mostly as an invader of areas affected by Sigatoka, in various geographical locations.

Bunchy top, an aphid-transmitted virus disease of banana, was unknown in Queensland until about 1913 when it was accidentally introduced in suckers brought in from abroad. In the next 10 years it spread swiftly and threatened to wipe out the banana industry. Drastic measures were taken to destroy affected plants and to protect uninvaded plantations. The disease was found in Western Samoa in 1955 and it eliminated the susceptible 'Dwarf Cavendisht' from commercial plantings. A vigorous eradication and quarantine program was undertaken in 1956 and carried on to 1960. Thereafter, strict inspection and control measures continued. Other crops were provided to farmers in heavily infested areas. Leaves formed after infection are narrow, short, with upturned margins and become stiff and brittle; the leafstalks are short and unbending and remain erect, giving a "rosetted" appearance. The leaves of suckers and the 3 youngest leaves of the mother plant show yellowing and waviness of margins, and the youngest leaves will have very narrow, dark-green, usually interrupted ("dot-and dash") lines on the underside.

Because of the seriousness of Panama disease and Bunchy Top in southern Queensland, the prospective banana planter must obtain a permit from the Queensland Department of Primary Industries. In the Southern Quarantine Area, any plant showing Bunchy Top, as well as its suckers and all plants within a 15 ft (4.6 m) radius must be killed by injecting herbicide or must be dug out completely and cut into pieces no bigger than 2 in (5 cm) wide. In restricted areas, only the immune 'Lady Finger' may be grown. In the Northern Quarantine Area, no plants may be brought in from another area and all plants within a radius of 120 ft (36.5 m) from a diseased plant must be eradicated.

Swelling and splitting of the corm and the base of the pseudostem is caused by saline irrigation water and by overfertilization during periods of drought which builds up soluble salts in the soil.

Food Uses

The ripe banana is utilized in a multitude of ways in the human diet—from simply being peeled and eaten out of-hand to being sliced and served in fruit cups and salads, sandwiches, custards and gelatins; being mashed and incorporated into ice cream, bread, muffins, and cream pies. Ripe bananas are often sliced lengthwise, baked or broiled, and served (perhaps with a garnish of brown sugar or chopped peanuts) as an accompaniment for ham or other meats. Ripe bananas may be thinly sliced and cooked with lemon juice and sugar to make jam or sauce, stirring frequently during 20 or 30 minutes until the mixture jells. Whole, peeled bananas can be spiced by adding them to a mixture of vinegar, sugar, cloves and cinnamon which has boiled long enough to become thick, and then letting them cook for 2 minutes.

In the islands of the South Pacific, unpeeled or peeled, unripe bananas are baked whole on hot stones, or the peeled fruit may be grated or sliced, wrapped, with or without the addition of coconut cream, in banana leaves, and baked in ovens. Ripe bananas are mashed, mixed with coconut cream, scented with *Citrus* leaves, and served as a thick, fragrant beverage.

Banana puree is important as infant food and can be successfully canned by the addition of ascorbic acid to prevent discoloration. The puree is produced on a commercial scale in factories close to banana fields and packed in plastic-lined #10 cans and 55-gallon metal drums for use in baby foods, cake, pie, ice cream, cheesecake, doughnuts, milk shakes and many other products. It is also used for canning half-and-half with applesauce, and is combined with peanut butter as a spread. Banana nectar is prepared from banana puree in which a cellulose gum stabilizer is added. It is homogenized, pasteurized and canned, with or without enrichment with ascorbic acid.

Sliced ripe bananas, canned in sirup, were introduced to the food trade for commercial use in frozen tarts, pies, gelatins and other products. In 1966, the United Fruit Company built a processing plant at La Lima, Honduras, for producing canned and frozen banana puree and canned banana slices. Because of seasonal gluts and perishability and the tonnages of bananas and plantains that are not suitable for marketing or export because of overripeness or stained peel or other defects, there is tremendous interest in the development of modes of processing and preserving these fruits.

In Polynesia, there is a traditional method of preserving large quantities of bananas for years as emergency fare in case of famine. A pit is dug in the ground and lined with banana and *Heliconza* leaves. The peeled bananas are wrapped in *Heliconza* leaves, arranged in layer after layer, then banana leaves are placed on top and soil and rocks heaped over all. The pits remain unopened until the fermented food, called "masi", is needed.

In Costa Rica, ripe bananas from an entire bunch are peeled and boiled slowly for hours to make a thick sirup which is called "honey".

Green bananas, boiled in the skin, are very popular in Cuba, Puerto Rico and other Caribbean islands. In Puerto Rico, the cooked bananas are recooked briefly in a marinating sauce containing black pepper, vinegar, garlic, onions, bay leaves, olive oil and salt and left standing at room temperature for 24 hours before being eaten. Peeled, sliced green bananas are quick-frozen in Puerto Rico for later cooking. If steam treated to facilitate peeling, the enzymes are inactivated only on the surface of the flesh and the interior, when exposed, will turn brown unless sulfited. It is more satisfactory to immerse the whole bananas in water at 200°F (93°C) for 30 minutes which wholly inactivates the enzymes. No sulfite is then needed and no browning occurs.

Much research has been conducted by food technologists at the University of Puerto Rico to determine the best procedures for canning sliced green bananas and plantains to make them readily available for cooking. Enzyme inactivation is necessary and the hot water treatment facilitates the peeling. If peeled raw, green bananas and plantains exude gummy white latex which stains materials. When canning, citric acid in a 2% brine is added, but this method of preservation has not yet met with success because of rapid detinning of the inside of the cans. The problem is not solved by using enamellined cans because the fruit darkens quickly after the cans are opened. Glass jars may prove to be the only suitable containers.

Through experimental work with a view to freezing peeled, blanched, sliced green bananas, it has been found that, with a pulp-to-peel ratio of less than 1:3 the fruits turn gray on exposure to air after processing and this discoloration is believed to be caused by the high iron content (4.28 p/m) of the surface layer of the flesh and its reaction to the tannin normally present in green bananas and plantains. At pulp to peel ratio of 1:0, the tannin level in green bananas is 241.4 mg; at l:3, 151.0 mg, and at 1:5, 112.6 mg, per 100 g. Therefore, it is recommended that for freezing green bananas be harvested at a stage of maturity evidenced by 1:5 pulp-to-peel ratio. Such fruits have a slightly yellowish flesh, higher carotene content, and are free of off-flavors. The slices are cooked by the consumer without thawing.

Completely green plantains are 50% flesh and 50% peel. Plantains for freezing should have a pulp content of at least 60% for maximum quality in the ultimate food product, but a range of 55 to 65% is considered commercially acceptable.

Ripe plantains, held until the skin has turned mostly or wholly black, are commonly peeled, sliced diagonally and fried in olive oil, accompany the main meal daily in the majority of homes in tropical Latin America. In the Dominican Republic, a main dish is made of boiled, mashed ripe plantains mixed with beaten eggs, flour, butter, milk and cloves, and layered in a casserole with ground beef fried with Picalilli and raisins, lastly topped with grated cheese and baked until golden brown. In Guatemala, boiled plantains are usually served with honey.

Green plantains are popular sliced crosswise, fried until partially cooked, pressed into a thickness of 1/2 in (1.25 cm), and fried in deep fat till crisp. The product is called 'tostones" and somewhat resembles French-fried potatoes. Puerto Rican "mofongo" is a ball of fried green plantain mashed with fried pork rind, seasoned with thickened stock, garlic and other condiments. It must be eaten hot before it hardens. "Mofongo" has been successfully frozen in boilable pouches. Slices of nearly ripe plantain (5% starch content) are cooked in sirup and frozen in boilable pouches. Puerto Rican plantains, shipped green to Florida, have been ripened, peeled, quartered, infused with orange juice, frozen and provided to schools for serving as luncheon dessert.

In Ghana, plantains are consumed at 5 different stages of ripeness. Fully ripe plantains are often deep fried or cooked in various dishes. A Ghanian pancake called "fatale" is made of nearly full ripe plantains and fermented whole meal dough of maize, seasoned with onions, ginger, pepper and salt, and fried in palm oil. "Kaklo" is the same mix but thicker and rolled into balls which are deep-fried. Because home preparation is laborious, a commercial dehydrated mix has been developed. In Ghana, green plantains are boiled and eaten in stew or mashed, together with boiled cassava, into a popular plastic product called "fufu" which is eaten with soup. Because of the great surplus of plantains in summer, technologists have developed methods for drying and storing of strips and cubes of plantain for house use in making "fufu" out of season. The cubes can also be ground into plantain flour. Use of infrared, microwave, and extrusion systems has resulted in high-quality finished products. Processing has the added advantage of keeping the peels at factories where they may be converted into useful by-products instead of their adding to the bulk of household garbage.

Banana or plantain flour, or powder, is made domestically by sun-drying slices of unripe fruits and pulverizing. Commercially, it is produced by spray-drying, or drum-drying, the mashed fruits. The flour can be mixed 50-50 with wheat flour for making cupcakes. Two popular Puerto Rican foods are "pasteles" and "alcapurias"; both are pastry stuffed with meat; the first is wrapped in plantain leaves and boiled; the latter is fried. The pastry is made of plantain flour or a mixture of plantain with cassava (*Manihot esculenta* Crantz.) or cocoyam (tanier), *Xanthosoma* spp. The plantain cultivars 'Saba', 'Tundoc' and 'Latundan' are very suitable for making flour.

Commercial production and marketing of fried green plantain and banana chips has been increasing in various parts of the world over the past 25 years and these products are commonly found in retail groceries alongside potato chips and other snack foods. 'Carinosa' and 'Bungulan' bananas are favored for chip-making. In Puerto Rico, the plantain cultivars 'Guayamero Alto' and 'Congo Enano' are chosen for this purpose.

Dried bananas, or so-called "banana figs" are peeled firm-ripe bananas split lengthwise, sulphured, and ovendried to a moisture content of 18 to 20%. Wrapped individually in plastic and then packed by the dozen in polyethylene bags, and encased in cartons, they can be stored for a year at room temperature—75.2° to 86°F (24°-30°C) and they are commonly exported. The product can be eaten as a snack or minced and used together with candied lemon peel in fruit cake and other bakery products. In India the 'Dwarf Cavendish' is preferred for drying; in the Philippines, the true 'Lacatan' or the 'Higo'.

Canadian researchers have developed a system of osmotic dehydration for sliced firm ripe bananas and plantains, especially designed for developing countries with plentiful sugar for the solutions required.

Since the early 1960's, Brazil has produced dehydrated banana flakes for local markets and export to the USA and elsewhere in vacuum sealed cans. The flakes are used on cereal, in baked goods, canapes, meat loaf and curries, desserts, sauces, and other products. In Israel, banana flakes have been made by steam blanching 'Dwarf Cavendish' bananas and drum drying to 2.6% moisture. The flakes, packed in vacuum sealed cans, keep for a year at 75.2° to 86°F (24° 30°C). At temperatures to 95°F (35°C), the flakes darken somewhat and tend to stick together. Israel has also introduced a formula for high-protein flakes made of 70% banana and 30% soybean protein and this development has been adopted in Brazil. The flakes are used by Brazilian food manufacturers in ice cream, and as fillings for cakes and other bakery products. South Africa has produced flakes of 2/3 banana and 1/3 maize meal.

In Africa, ripe bananas are made into beer and wine. The Tropical Products Institute in London has established a simple procedure for preparing an acceptable vinegar from fermented banana rejects.

The terminal male bud of the wild banana, *M. balbisiana*, is marketed in Southeast Asia. It is often boiled whole after soaking an hour in salt water, or with several changes of water to reduce astringency, and eaten as a vegetable. The male bud of cultivated bananas is considered too astringent but it is, nevertheless, sometimes similarly consumed. The flowers may be removed from the bud and prepared separately. They are used in curries in Malaya and eaten with palm oil in West Tropical Africa.

The new shoots of young plants may be cooked as greens. Banana pseudostem core constitutes about 10 to 15% of the whole and contains 1% starch, 0.68% crude fiber and 1% total ash. It is often cooked and eaten as a vegetable in India and is canned with potatoes and tomatoes in a curry sauce. Circular slices about 1/2 in (1.25 cm) thick are treated with citric acid and potassium metabisulphite and candied.

In India, a solution of the ash from burned leaves and pseudostems is used as salt in seasoning vegetable curries. The ash contains roughly (per 100 g): potassium, 255 mg; magnesium, 27 mg; phosphorus, 33 mg; calcium, 6.6 mg; sodium, 51 mg.

Dried green plantains, ground fine and roasted, have been used as a substitute for coffee.

Animal Feed

Reject ripe bananas, supplemented with protein, vitamins and minerals, are commonly fed to swine. Green bananas are also used for fattening hogs but, because of the dryness and astringency and bitter taste due to the tannin content, these animals do not care for them unless they are cooked, which makes the feeding costs too high for most growers. Therefore, dehydrated green banana meal has been developed and, though not equal to grain, can constitute up to 75% of the normal hog diet, 40% of the diet of gestating sows. It is not recommended for lactating sows, nor are ripe bananas, even with a 40% protein supplement.

Beef cattle are very fond of green bananas whether they are whole, chopped or sliced. Because of the fruit's deficiency in protein, urea is added at the rate of 8.8 lbs (4 kg) per ton, with a little molasses mixed in to mask the flavor. But transportation is expensive unless the cattle ranch is located near the banana fields. A minor disadvantage is that the bananas are somewhat laxative and the cattle need to be washed down daily. With dairy cattle, it is recommended that bananas constitute no more than 20% of the feed.

In the Philippines, it has been found that meal made from dehydrated reject bananas can form 14% of total broiler rations without adverse effects. Meal made from green and ripe plantain peels has been experimentally fed to chicks in Nigeria. A flour from unpeeled plantains, developed for human consumption, was fed to chicks in a mixture of 2/3 flour and 1/3 commercial chickfeed and the birds were maintained until they reached the size of fryers. They were found thinner and lighter than those on 100% chickfeed and the gizzard lining peeled in shreds. It was assumed that these effects were the result of protein deficiency in the plantains, but they were more likely the result of the tannin content of the flour which interferes with the utilization of protein.

Leaves, pseudostems, fruit stalks and peels, after chopping, fermentation, and drying, yield a meal somewhat more nutritious than alfalfa presscake. This waste material has been considered for use as organic fertilizer in Somalia. In Malaya, pigs fed the pseudostems are less prone to liver and kidney parasites than those on other diets.

Banana peel contains beta sitosterol, stigmasterol, campesterol, cycloeucalenol, cycloartanol, and 24-methylene cycloartanol. The major constituents are 24-methylene cycloartanol palmitate and an unidentified triterpene ketone.

Food Value Per 100 g of Edible Portion*

Banana	Plantain							
	Ripe	Green	Dried	Flour (green)	Ripe	Ripe (cooked)	Green	Dried (green)
Calories	65.5-111	108	298	340	110.7-156.3	77	90.5-145.9	359
Moisture	68.6-78.1g	72.4g	19.5-27.7g	11.2-13.5g	52.9-77.6g	79.8g	58.7-74.1g	9.0g
Protein	1.1-1.87g	1.1g	2.8-3.5g	3.8-4.1g	0.8-1.6g	1.3g	1.16-1.47g	3.3g
Fat	.016-0.4g	0.3g	0.8-1.1g	0.9-1.0g	0.1-0.78g	0.10g	0.10-0.12g	1.4g
Carbohydrates	19.33-25.8g	25.3g	69.9g	79.6g	25.50-36.81g	18.1g	23.4-37.61g	83.9g
Fiber	0.33-1.07g	1.0g	2.1-3.0g	3.2-4.5g	0.30-0.42g	0.2g	0.40-0.48g	1.0g
Ash	0.60-1.48g	0.9g	2.1-2.8g	3.1g	0.63-1.40g	0.7g	0.63-0.83g	2.4g
Calcium	3.2-13.8mg	11mg		30-39mg	5.0-14.2mg		10.01-12.2mg	50mg
Phosphorus	16.3-50.4mg	28mg		93-94mg	21.0-51.4mg		32.5-43.2mg	65mg
Iron	0.4-1.50mg	0.9mg		2.6-2.7mg	0.40-0.11mg		0.56-0.87mg	1.1mg
B-Carotene	0.006-0.151mg				0.11-1.32mg		0.06-1.38mg	45mg
Thiamine	0.04-0.54mg				0.04-0.11mg		0.06-0.09mg	0.10mg
Riboflavin	0.05-0.067mg				0.04-0.05mg		0.04-0.05mg	0.16mg
Niacin	0.60-1.05mg				0.48-0.70mg		0.32-0.55mg	1.9mg
Ascorbic Acid	5.60-36.4mg				18-31.2mg		22.2-33.8mg	1mg
Tryptophan	17-19mg				8-15mg		7-10mg	14mg
Methionine	7-10mg				4-8mg		3-8mg	
Lysine	58-76mg				34-60mg		37-56mg	

*Derived from various analyses made in Cuba, Central America and Africa.

Other Uses

Banana leaves are widely used as plates and for lining cooking pits and for wrapping food for cooking or storage. A section of leaf often serves as an eye-shade. In Latin America, it is a common practice during rains to hold a banana leaf by the petiole, upside-down, over one's back as an "umbrella" or "raincoat". The leaves of the 'Fehi' banana are used for thatching, packing, and cigarette wrappers. The pseudostems have been fastened together as rafts.

Split lengthwise, they serve as padding on banana inspection turntables and as cushioning to protect the bunches ("stems") during transport in railway cars and trucks. Seat pads for benches are made of strips of dried banana pseudostems in Ecuador. In West Africa, fiber from the pseudostem is valued for fishing lines. In the Philippines, it is woven into a thin, transparent fabric called "agna" which is the principal material in some regions for women's blouses and men's shirts. It is also used for making handkerchiefs. In Ceylon, it is fashioned into soles for inexpensive shoes and used for floor coverings.

Plantain fiber is said to be superior to that from bananas. In the mid-19th Century, there was quite an active banana fiber industry in Jamaica. Improved processes have made it possible to utilize banana fiber for many purposes such as rope, table mats and handbags. In Kerala, India, a kraft type paper of good strength has been made from crushed, washed and dried banana pseudostems which yield 48 to 51% of unbleached pulp. A good quality paper is made by combining banana fiber with that of the betel nut husk (*Areca catechu* L.). But Australian investigators hold that the yield of banana fiber is too low for extraction to be economical. Only 1 to 4 oz (28-113 g) can be obtained from 40 to 80 lbs (18-36 kg) of green pseudostems; 132 tons of green pseudostems would yield only 1 ton of paper. Their conclusion is that the pseudostem has much greater value as organic matter chopped and left in the field.


Fig. 12 Banana pseudostem pad on inspection-turntable, Hacienda Secadal, Ecuador.

Dried banana peel, because of its 30 to 40% tannin content, is used to blacken leather. The ash from the dried peel of bananas and plantains is rich in potash and used for making soap. That of the burned peel of unripe fruits of certain varieties is used for dyeing.

In the Philippines, the Pinatubo Negritos cut off a banana plant close to the ground, make a hollow in the top of the stump, which then fills with watery sap drunk as an emergency thirst quencher. Central Americans obtain the sap of the red banana in the same manner and take it as an aphrodisiac.

Medicinal Uses: All parts of the banana plant have medicinal applications: the flowers in bronchitis and dysentery and on ulcers; cooked flowers are given to diabetics; the astringent plant sap in cases of hysteria, epilepsy, leprosy, fevers, hemorrhages, acute dysentery and diarrhea, and it is applied on hemorrhoids, insect and other stings and bites; young leaves are placed as poultices on burns and other skin afflictions; the astringent ashes of the unripe peel and of the leaves are taken in dysentery and diarrhea and used for treating malignant ulcers; the roots are administered in digestive disorders, dysentery and other ailments; banana seed mucilage is given in cases of catarrh and diarrhea in India.

Antifungal and antibiotic principles are found in the peel and pulp of fully ripe bananas. The antibiotic acts against *Mycobacteria*. A fungicide in the peel and pulp of green fruits is active against a fungus disease of tomato plants. Norepinephrine, dopamine, and serotonin are also present in the ripe peel and pulp. The first two elevate blood pressure; serotonin inhibits gastric secretion and stimulates the smooth muscle of the intestines.

Alleged hallucinogenic effects of the smoke of burning banana peel have been investigated scientifically and have not been confirmed.

Folklore

The banana plant because of its continuous reproduction is regarded by Hindus as a symbol of fertility and prosperity, and the leaves and fruits are deposited on doorsteps of houses where marriages are taking place. A banana plant is often installed in the corner of a rice field as a protective charm. Malay women bathe with a decoction of banana leaves for 15 days after childbirth. Early Hawaiians used a young plant as a truce flag in wars.

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Morton, J. 1987. Fig. p. 47–50. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Fig

Ficus carica

While the ancient history of the fig centers around the Mediterranean region, and it is most commonly cultivated in mild-temperate climates, it nevertheless has its place in tropical and subtropical horticulture. Botanically identified as *Ficus carica* L. (family Moraceae), it is unique in a genus embracing perhaps over 1,000 species, mostly giant "rubber trees", and mostly tropical. It is almost universally known simply as fig, common fig, or edible fig. The name is very similar in French (*figue*), German (*feige*), Italian and Portuguese (*figo*). In Spanish it is *higo* or *brevo*. Haitians give it the name, *figue France*, to distinguish it from the small, dried bananas called "figs".

Description

The fig is a tree of small dimensions, 10 to 30 ft (3-9 m) high, with numerous spreading branches and a trunk rarely more than 7 in (17.5 cm) in diameter. It contains copious milky latex. The root system is typically shallow and spreading, sometimes covering 50 ft (15 m) of ground, but in

Plate V: FIG, *Ficus carica*

permeable soil some of the roots may descend to 20 ft (6 m). The deciduous leaves are palmate, deeply divided into 3 to 7 main lobes, these more shallowly lobed and irregularly toothed on the margins. The blade is up to 10 in (25 cm) in length and width, fairly thick, rough on the upper surface, softly hairy on the underside. What is commonly accepted as a "fruit" is technically a synconium, that is, a fleshy, hollow receptacle with a small opening at the apex partly closed by small scales. It may be obovoid, turbinate, or pear-shaped, 1 to 4 in (2.5-10 cm) long, and varies in color from yellowish-green to coppery, bronze, or dark-purple. Tiny flowers are massed on the inside wall. In the case of the common fig discussed here, the flowers are all female and need no pollination. There are 3 other types, the "Caprifig" which has male and female flowers requiring visits by a tiny wasp, *Blastophaga grossorum*; the "Smyrna" fig, needing crosspollination by Caprifigs in order to develop normally; and the "San Pedro" fig which is intermediate, its first crop independent like the common fig, its second crop dependent on pollination. The skin of the fig is thin and tender, the fleshy wall is whitish, pale-yellow, or amber, or more or less pink, rose, red or purple; juicy and sweet when ripe, gummy with latex when unripe. Seeds may be large, medium, small or minute and range in number from 30 to 1,600 per fruit.

Origin and Distribution

The fig is believed to be indigenous to Western Asia and to have been distributed by man throughout the Mediterranean area. It has been cultivated for thousands of years, remnants of figs having been found in excavations of Neolithic sites traced to at least 5,000 B.C. As time went on, the fig-growing territory stretched from Afghanistan to southern Germany and the Canary Islands. Pliny was aware of 29 types. Figs were introduced into England some time between 1525 and 1548. It is not clear when the common fig entered China but by 1550 it was reliably reported to be in Chinese gardens. European types were taken to China, Japan, India, South Africa and Australia.

The first figs in the New World were planted in Mexico in 1560. Figs were introduced into California when the San Diego Mission was established in 1769. Later, many special varieties were received from Europe and the eastern United States where the fig reached Virginia in 1669. The Smyrna fig was brought to California in 1881-82 but it was not until 1900 that the wasp was introduced to serve as the pollinating agent and make commercial fig culture possible. From Virginia, fig culture spread to the Carolinas, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas. The tree was planted in Bermuda in early times and was common around Bahamian plantations in Colonial days. It became a familiar dooryard plant in the West Indies, and at medium and low altitudes in Central America and northern South America. There are fair-sized plantations on mountainsides of Honduras and at low elevations on the Pacific side of Costa Rica. From Florida to northern South America and in India only the common fig is grown. Chile and Argentina grow the types suited to cooler zones.

In Venezuela, the fig is one of the fruits in greatest demand by fruit processors. Because of the inadequate supply, a program was launched in 1960 to encourage commercial plantings. In 1976, fresh figs were regarded as highly desirable luxuries and were selling for $6.35 to $7.25 per lb ($14-$16/kg) in Colombia. The Instituto Colombiano Agropecuario had realized some years earlier that fig growing should be encouraged and had established an experimental plantation in 1973. The results were so favorable that they circulated an advisory bulletin to farmers in 1977, including improved methods of cultivation, costs of production and potential revenue.

Varieties

There are many cultivated varieties in each class of figs. In fact, over 700 varietal names are in use but many are synonyms. Here we need only present those that are suited to warm areas and do not require pollination. Most popular among these are 'Celeste' and 'Brown Turkey', followed by 'Brunswick' and 'Marseilles', described as follows:

'Celeste'—pear-shaped, ribbed, sometimes with a short neck and slender stalk to 3/4 in (2 cm) long; the eye (opening at apex) is closed; the fruit is small to medium; the skin purplish-brown or bronze tinged with purple and covered with bloom; the pulp whitish or pinkish amber, of rich flavor and good quality; almost seedless. Main crop is heavy but of short duration. There is rarely an early, "breba", crop.

'Brown Turkey'—broad-pyriform, usually without neck; medium to large; copper-colored; pulp is whitish shading to pink or light red; of good to very good quality; with few seeds. The tree is prolific. The main crop, beginning in mid-July, is large; the early, breba, crop is small. This cultivar is well adapted to warm climates. It is grown on all the islands of Hawaii.

'Brunswick' ('Magnolia')—leaves narrow-lobed; fruits of main crop are oblique-turbinate, mostly without neck; fruit stalk thick, often swollen; fruit of medium size; bronze or purple-brown; pulp whitish near skin, shading to pink or amber; hollow in center; of fair to good quality; nearly seedless. Ripens over a long season. Breba crop poor; large, bronze-skinned; flesh light-red; coarse.

'Marseilles' ('White Marseilles', or 'Lemon')—fruits of main crop round to oblate without neck; on slender stalks to 1/4 in (6 mm) long; of medium size. Those of breba crop, turbinate with short, thick neck and short stalk; yellow-green with small green flecks; pulp white, sweet; seeds large, conspicuous. Of fair quality.

In Queensland, 'Brown Turkey', 'Adriatic', 'Genoa' and 'Purple Genoa' perform very well.

'Adriatic' ('White Adriatic', or 'Grosse Verte')—turbinate with short, thick neck and short stalk; above medium size; green to yellowish-green with red pulp; of distinctive flavor and very good quality. In early, minor, breba crop the fruits are oblique-pyriform, large, green, often tinged with purplish-red with dark-red pulp and strong flavor.

'Genoa' ('White Genoa')—pyriform or turbinate, very faintly ribbed; neck thick and short, or absent; above medium in size; skin downy, greenish-yellow; pulp greenish-white near skin, mostly amber tinged with red; hollow; of fair quality. Fruits of breba crop oblique-obovate with thick neck and short stalk; yellowish-green externally; pulp light-red; of fair to good quality.

'Purple Genca' ('Black Genoa'; 'Black Spanish') oblong, broad at apex, narrow at base; large; very dark-purple with thick blue bloom; pulp yellowish becoming reddish to red at the center; juicy, with sweet, rich flavor.

At Saharanpur, India, 'Brown Turkey', 'Bangalore', 'Black Ischia' and 'Lucknow' are successfully grown. Around Bombay, there is only one variety, 'Poona'.

'Black Ischia' ('Blue Ischia')—an Italian variety; main crop is elongated pear shaped with many noticeable rlbs; short neck and short to medium stalk; large, 2 1/2 in (6.35 cm) long and 1 1/2 in (3.8 cm) wide; dark purple-black except at the apex where it is lighter and greenish; there are many golden flecks; skin is wholly coated with thin, dark-blue bloom; eye open, with red-violet scales; pulp is violet-red, of good quality. In the breba crop, there are few rlbs and mostly indistinct; the fruit is small, about 1 1/2 in (3.8 cm) long and of the same width at the apex; the pulp is red to greenish-amber; of poor flavor. The tree is particularly ornamental and the leaves are glossy, only shallowly 3 lobed. A heavy bearer.

'Poona'-bell-shaped, of medium size, weighing about 1 1/2 oz (42 g); thin-skinned; light-purple with red flesh, of sweet, good flavor.

We have no descriptions of 'Bangalore' and 'Lucknow'.

Climate

In southern India, 'Marseilles' flourishes on hills above 5,000 ft (1,525 m). In tropical areas generally, figs thrive between 2,600 and 5,900 ft (800-1,800 m). The tree can tolerate 10° to 20° of frost in favorable sites. It should have a dry climate with light early spring rains if it is intended for the production of fresh fruit. Rains during fruit development and ripening are detrimental to the crop, causing the fruits to split. The semi arid tropical and subtropical regions of the world are ideal for fig-growing if means of irrigation are available. But very hot, dry spells will cause fruit-drop even if the trees are irrigated.

Soil

The fig can be grown on a wide range of soils; light sand, rich loam, heavy clay or limestone, providing there is sufficient depth and food drainage. Sandy soil that is medium-dry and contains a good deal of lime is preferred when the crop is intended for drying. Highly acid soils are unsuitable. The pH should be between 6.0 and 6.5. The tree is fairly tolerant of moderate salinity.

Propagation

Fig trees have been raised from seed, even seed extracted from commercial dried fruits. Ground- or air-layering can be done satisfactorily, and rapid mass multiplication by tissue culture has been achieved in Greece, but the tree is commonly propagated by cuttings of mature wood 2 to 3 years of age, 1/2 to 3/4 in (1.25-2 cm) thick and 8 to 12 in (20-30 cm) long. Planting must be done within 24 hours but, first, the upper, slanting end of the cutting should be treated with a sealant to protect it from disease, and the lower, flat, end with a root-promoting hormone. Trees of unsatisfactory varieties can be topworked by shield- or patch-budding, or cleft- or bark-grafting.

Culture

Cuttings are raised in nursery beds and are set out in the field after 12 or 15 months. They may be spaced from 6 to 25 ft (1.8-7.5 m) apart depending on the cultivar and the fertility of the soil. A spacing of 13 x 13 ft (4x4 m) allows 260 trees/acre (625 trees/ha). In Colombia, growers are advised to set the trees at 10 x 10 ft (3x3 m) on level land, 10 x 13 ft (3x4 m) on slopes. Fruiting will commence in less than a year from planting out. Young plants will benefit from shading with palm fronds or other material until they are well established. A fertilizer formula of 10-30-10 or 10-20-20 NPK is recommended 2 oz (about 60 g) each for young plants and 1/5 lb (100 g) each for adults, plus minor elements at the rate of 1 oz (30 g) per tree every 6 months.

Fig trees are cut back severely in fall or winter, depending on whether the crop is desired the following summer or fall. Branches are often notched to induce lateral branching and increase the yield. If there are heavy rains, drainage ditches should be dug to prevent water-logging. Fig trees remain productive up to 12 or 15 years of age and thereafter the crop declines though the trees may live to a very advanced age.

Season

Fig trees usually bear 2 crops a year, the early season ("breba") fruits being inferior and frequently too acid, and only those of the second, or main, crop of actual value.

In Colombia and Venezuela, some fruits are borne throughout the year but there are 2 principal crops, one in May and June and the other in December and January.

Large-scale fig producers in California spray ethephon to speed up ripening and then wind-machines are drawn past the trees or helicopter overflights are made to hasten fruit drop, thus shortening the harvest period by as much as 10 days in order to avoid impending rain and insect attack. Proper timing of the growth regulator is crucial to fruit quality.

Harvesting and Yield

The fruits may be picked from the tree or gathered normally or by mechanical sweepers after they fall to the ground. 'Brunswick' is so tender it must be picked when slightly unripe in order to be firm enough for processing. Workers must wear gloves and protective clothing because of the latex. Harvested fruits are spread out in the shade for a day so that the latex will dry a little. Then they are transported to processing plants in wooden boxes holding 22 to 33 lbs (10-15 kg). In India, a fig tree bears 180 to 360 fruits per year. Venezuelan growers expect 132 to 176 lbs (6-8 kg) per tree.

Keeping Quality

Fresh figs are very perishable. At 40° to 43°F (4.44°-6.11°C) and 75% relative humidity, figs remain in good condition for 8 days but have a shelf life of only 1 to 2 days when removed from storage. At 50°F (10°C) and relative humidity of 85%, figs can be kept no longer than 21 days. They remain in good condition for 30 days when stored at 32° to 35° F (0°-1.67° C). If frozen whole, they can be maintained for several months.

Pests and Diseases

Fig trees are prone to attack by nematodes (especially *Meloidogyne* spp.) and, in the tropics, have been traditionally planted close to a wall or building so that the roots can go underneath and escape damage. A heavy mulch will serve equally well. Today, control is possible with proper application of nematicides.

In India, a stem-borer, *Batocera rufomaculata*, feeds on the branches and may kill the tree. Lepidopterous pests in Venezuela include the fig borer, *Azochis gripusalis*, the larvae of which feed on the new growth, tunnel down through the trees to the roots and kill the tree. Another, called *cachudo de la higuera*, has prominently horned larvae up to 3 1/8 in (8 cm) long that can destroy a fig tree in a few days. There are also coleopterous insects of the genera *Epitrix* and *Colaspis* that perforate and severely damage the leaves and shoots. Scale insects include *Asterolecanium* sp. which attacks the bark of trees weakened by excessive humidity or prolonged drought, and the lesser enemy, *Saissetia haemispherica.*

A common and widespread problem is leaf rust caused by *Cerotelium fici*; bringing about premature leaf fall and reducing yields. It is most prevalent in rainy seasons. Leaf spot results from infection by *Cylindrocladium scoparium* or *Cercospora fici*. Fig mosaic is caused by a virus and is incurable. Affected trees must be destroyed.

The dried fruit beetle, or sour bug, *Carpophilus* spp., enters the fruit through the eye and leads to souring and smut caused by *Aspergillus niger*. This fungus may attack ripening fruits.

Food Uses

Some people peel the skin back from the stem end to expose the flesh for eating out of-hand. The more fastidious eater holds the fruit by the stem end, cuts the fruit into quarters from the apex, spreads the sections apart and lifts the flesh from the skin with a knife blade, discarding the stem and skin. Commercially, figs are peeled by immersion for 1 minute in boiling lye water or a boiling solution of sodium bicarbonate. In warm, humid climates, figs are generally eaten fresh and raw without peeling, and they are often served with cream and sugar. Peeled or unpeeled, the fruits may be merely stewed or cooked in various ways, as in pies, puddings, cakes, bread or other bakery products, or added to ice cream mix. Home owners preserve the whole fruits in sugar sirup or prepare them as jam, marmalade, or paste. Fig paste (with added wheat and corn flour, whey, sirup, oils and other ingredients) forms the filling for the well known bakery product, "Fig Newton". The fruits are sometimes candied whole commercially. In Europe; western Asia, northern Africa and California, commercial canning and drying of figs are industries of great importance.

Some drying is done in Poona, India, and there is currently interest in solar-drying in Guatemala. Usually, the fruits are allowed to fully ripen and partially dehydrate on the tree, then are exposed to sulphur fumes for about a half hour, placed out in the sun and turned daily to achieve uniform drying, and pressed flat during the 5- to 7-day process. 'Black Mission' and 'Kadota' figs are suitable for freezing whole in sirup, or sliced and layered with sugar.

Dried cull figs have been roasted and ground as a coffee substitute. In Mediterranean countries, low-grade figs are converted into alcohol. An alcoholic extract of dried figs has been used as a flavoring for liqueurs and tobacco.

Toxicity

The latex of the unripe fruits and of any part of the tree may be severely irritating to the skin if not removed promptly. It is an occupational hazard not only to fig harvesters and packers but also to workers in food industries, and to those who employ the latex to treat skin diseases.

Other Uses

Seed oil: Dried seeds contain 30% of a fixed oil containing the fatty acids: oleic, 18.99%; linoleic, 33.72%; linolenic, 32.95%; palmitic, 5.23%; stearic, 2.1 8%; arachidic, 1.05%. It is an edible oil and can be used as a lubricant.

Leaves: Fig leaves are used for fodder in India. They are plucked after the fruit harvest. Analyses show: moisture, 67.6%; protein, 4.3%; fat, 1.7%; crude fiber, 4.7%; ash, 5.3%; N-free extract, 16.4%; pentosans, 3.6%; carotene on a dry weight basis, 0.002%. Also present are bergaptene, stigmasterol, sitosterol, and tyrosine.

In southern France, there is some use of fig leaves as a source of perfume material called "fig-leaf absolute"—a dark-green to brownish-green, semi-solid mass or thick liquid of herbaceous-woody-mossy odor, employed in creating woodland scents.

Latex: The latex contains caoutchouc (2.4%), resin, albumin, cerin, sugar and malic acid, rennin, proteolytic enzymes, diastase, esterase, lipase, catalase, and peroxidase. It is collected at its peak of activity in early morning, dried and powdered for use in coagulating milk to make cheese and junket. From it can be isolated the protein-digesting enzyme *ficin* which is used for tenderizing meat, rendering fat, and clarifying beverages.

In tropical America, the latex is often used for washing dishes, pots and pans. It was an ingredient in some of the early commercial detergents for household use but was abandoned after many reports of irritated or inflamed hands in housewives.

Medicinal Uses: The latex is widely applied on warts, skin ulcers and sores, and taken as a purgative and vermifuge, but with considerable risk. In Latin America, figs are much employed as folk remedies. A decoction of the fruits is gargled to relieve sore throat; figs boiled in milk are repeatedly packed against swollen gums; the fruits are much used as poultices on tumors and other abnormal growths. The leaf decoction is taken as a remedy for diabetes and calcifications in the kidneys and liver. Fresh and dried figs have long been appreciated for their laxative action.

Food Value Per 100 g of Edible Portion*

	Fresh	*Dried*
Calories	80	274
Moisture	77.5-86.8g	23.0g
Protein	1.2-1.3g	4.3g
Fat	0.14-0.30g	1.3g
Carbohydrates	17.1-20.3g	69.1g
Fiber	1.2-2.2 g	5.6 g

Ash	0.48 0.85 g	2.3 g
Calcium	35-78.2 mg	126 mg
Phosphorus	22-32.9 mg	77 mg
Iron	0.6-4.09 mg	3.0 mg
Sodium	2.0 mg	34 mg
Potassium	194 mg	640 mg
Carotene	0.013-0.195 mg	—
as Vitamin A	20-270 I.U.	80 I.U.
Thiamine	0.034-0.06 mg	0.10 mg
Riboflavin	0.053-0.079 mg	0.10 mg
Niacin	0.32-0.412 mg	0.7 mg
Ascorbic Acid	12.2-17.6 mg	0 mg
Citric Acid	0.10-0.44 mg	

Note: There are small amounts of malic, boric and oxalic acids.

*According to analyses made in India, Hawaii, Central America, and by the U.S. Department of Agriculture in Washington, D.C

Morton, J. 1987. Breadfruit. p. 50–58. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Breadfruit

Artocarpus altilis

One of the great food producers in its realm and widely known, at least by name, through its romanticized and dramatized history, the breadfruit, *Artocarpus altilis* Fosb. (syns. *A. communis* J.R. and G. Forst.; *A. incisus* L.f.) belongs to the mulberry family, Moraceae. The common name is almost universal, in English, or tanslated into Spanish as *fruta de pan* (fruit), or *arbor de pan*, *arbor del pan* (tree), or *pan de pobre*; into French, as *fruit a pain* (seedless), *chataignier* (withseeds), *arbre a pain* (tree); Portuguese, *fruta pao*, or *pao de massa*; Dutch, *broodvrucht* (fruit), *broodboom* (tree). InVenezuela it may be called *pan de ano*, *pan de todo el ano*, *pan de palo*, *pan de name*, *topan*, or *tupan*; in Guatemale and Honduras, *mazapan* (seedless), *castana* (with seeds); in Peru, *marure*; in Yucatan, *castano de Malabar* (with seeds); in Puerto Rico, *panapen* (seedless), *pana de pepitas* (with seeds). In Malaya and Java, it is *suku* or *sukun* (seedless); *kulur*, *kelur*, or *kulor* (with seeds); in Thailand, *sa-ke*, in the Philippines, *rimas* (seedless); in Hawaii, *ulu*. The type with seeds is sometimes called "breadnut", a name better limited to *Brosimum alicastrum* Swartz, an edible-seeded tree of Yucatan, Central America and nearby areas. Its Spanish name is *ramon* and the seeds, leaves and twigs are prized as stock feed.

Description

Fig. 13: Ripe breadfruit (*Artocarpus altilis*). In: K. & J. Morton, *Fifty Tropical Fruits of Nassau*, 1946.

The breadfruit tree is handsome and fast growing, reaching 85 ft (26 m) in height, often with a clear trunk to 20 ft (6 m) becoming 2 to 6 ft (0.6-1.8 m) in width and often buttressed at the base, though some varieties may never exceed 1/4 or 1/2 of these dimensions. There are many spreading branches, some thick with lateral foliage-bearing branchlets, others long and slender with foliage clustered only at their tips. The leaves, evergreen or deciduous depending on climatic conditions, on thick, yellow petioles to 1 1/2 in (3.8 cm) long, are ovate, 9 to 36 in (22.8-90 cm) long, 8 to 20 in (20-50 cm) wide, entire at the base, then more or less deeply cut into 5 to 11 pointed lobes. They are bright-green and glossy on the upper surface, with conspicuous yellow veins; dull, yellowish and coated with minute, stiff hairs on the underside.

The tree bears a multitude of tiny flowers, the male densely set on a drooping, cylindrical or club-shaped spike 5 to 12 in (12.5-30 cm) long and 1 to 1 1/2 in (2.5-3.75 cm) thick, yellowish at first and becoming brown. The female are massed in a somewhat rounded or elliptic, green, prickly head, 2 1/2 in (6.35 cm) long and 1 1/2 in (3.8 cm) across, which develops into the compound fruit (or syncarp), oblong, cylindrical, ovoid, rounded or pearshaped, 3 1/2 to 18 in (9-45 cm) in length and 2 to 12 in (5-30 cm) in diameter. The thin rind is patterned with irregular, 4- to 6-sided faces, in some "smooth" fruits level with the surface, in others conical; in some, there may rise from the center of each face a sharp, black point, or a green, pliable spine to 1/8 in (3 mm) long or longer. Some fruits may have a harsh, sandpaper-like rind. Generally the rind is green at first, turning yellowish-green, yellow or yellow-brown when ripe, though one variety is lavender.

In the green stage, the fruit is hard and the interior is white, starchy and somewhat fibrous. When fully ripe, the fruit is somewhat soft, the interior is cream colored or yellow and pasty, also sweetly fragrant. The seeds are irregularly oval, rounded at one end, pointed at the other, about 3/4 in (2 cm) long, dull-brown with darker stripes. In the center of seedless fruits there is a cylindrical or oblong core, in some types covered with hairs bearing flat, brown, abortive seeds about 1/8 in (3 mm) long. The fruit is borne singly or in clusters of 2 or 3 at the branch tips. The fruit stalk (pedicel) varies from 1 to 5 in (2.5-12.5 cm) long.

All parts of the tree, including the unripe fruit, are rich in milky, gummy latex. There are two main types: the normal, "wild" type (cultivated in some areas) with seeds and little pulp, and the "cultivated" (more widely grown) seedless type, but occasionally a few fully developed seeds are found in usually seedless cultivars. Some forms with entire leaves and with both seeds and edible pulp have been classified by Dr. F.R. Fosberg as belonging to a separate species, *A. mariannensis* Trecul. but these commonly integrate with *A. altilis* and some other botanists regard them as included in that highly variable species.

Fig. 14 Breadfruit is borne singly or in 2's or 3's at the branch tips of this handsome, large-leaved tree.

Origin and Distribution

The breadfruit is believed to be native to a vast area extending from New Guinea through the Indo-Malayan Archipelago to Western Micronesia. It is said to have been widely spread in the Pacific area by migrating Polynesians, and Hawaiians believed that it was brought from the Samoan island of Upalu to Oahu in the 12th Century A.D. It is said to have been first seen by Europeans in the Marquesas in 1595, then in Tahiti in 1606. At the beginning of the 18th Century, the early English explorers were loud in its praises, and its fame, together with several periods of famine in Jamaica between 1780 and 1786, inspired plantation owners in the British West Indies to petition King George III to import seedless breadfruit trees to provide food for their slaves.

There is good evidence that the French navigator Sonnerat in 1772 obtained the seeded breadfruit in the Philippines and brought it to the French West Indies. It seems also that some seedless and seeded breadfruit plants reached Jamaica from a French ship bound for Martinique but captured by the British in 1782. There were at least two plants of the seeded breadfruit in Jamaica in 1784 and distributions were quickly made to the other islands. There is a record of a plant having been sent from Martinique to the St. Vincent Botanical Garden before 1793. The story of Captain Thigh's first voyage to Tahiti, in 1787, and the loss of his cargo of 1,015 potted breadfruit plants on his disastrous return voyage is well known. He set out again in 1791 and delivered 5 different kinds totalling 2,126 plants to Jamaica in February 1793. On that island, the seedless breadfruit flourished and it came to be commonly planted in other islands of the West Indies, in the lowlands of Central America and northern South America. In some areas, only the seedless type is grown, in others, particularly Haiti, the seeded is more common. Jamaica is by far the leading producer of the seedless type, followed by St. Lucia. In New Guinea, only the seeded type is grown for food.

It has been suggested that the seeded breadfruit was carried by Spaniards from the Philippines to Mexico and Central America long before any reached the West Indies. On the Pacific coast of Central America, the seeded type is common and standard fare for domestic swine. On the Atlantic Coast, seedless varieties are much consumed by people of African origin. The breadfruit tree is much grown for shade in Yucatan. It is very common in the lowlands of Colombia, a popular food in the Cauca Valley, the Choco, and the San Andres Islands; mostly fed to live stock in other areas. In Guyana, in 1978, about 1,000 new breadfruit trees were being produced each year but not nearly enough to fill requests for plants. There and in Trinidad, because of many Asians in the population, both seeded and seedless breadfruits are much appreciated as a regular article of the diet; in some other areas of the Caribbean, breadfruit is regarded merely as a food for the poor for use only in emergencies. Nowadays, it is attracting the attention of gourmets and some islands are making small shipments to the United States, Canada and Europe for specialized ethnic markets. In the Palau Islands of the South Pacific, breadfruit is being outclassed by cassava and imported flour and rice. For some time breadfruit was losing ground to taro (*Colocasia esculenta* Schott.) in Hawaii, but now land for taro is limited and its culture is static.

The United States Department of Agriculture brought in breadfruit plants from the Canal Zone, Panama, in 1906 (S.P.I. #19228). For many years there have been a number of seedless breadfruit trees in Key West, Florida, and there is now at least one on Vaca Key about 50 miles to the northeast. On the mainland of Florida, the tree can be maintained outdoors for a few years with mild winters but, unless protected with plastic covering to prevent dehydration, it ultimately succumbs. A few have been kept alive in greenhouses or conservatories such as the Rare Plant House of Fairchild Tropical Garden, and the indoor garden of the Jamaica Inn on Key Biscayne.

Varieties

An unpublished report of 1921 covered 200 cultivars of breadfruit in the Marquesas. The South Pacific Commission published the results of a breadfruit survey in 1966. In it, there were described 166 named sorts from Tonga, Niue, Western and American Samoa, Papua and New Guinea, New Hebrides and Rotuma. There are 70 named varieties of seeded and seedless breadfruits in Fiji. They are locally separated into 8 classes by leaf form. The following, briefly presented, are those that are recorded as "very good". It will be noted that some varietal names are reported under more than one class.

Class I: Leaf entire, or with one or two, occasionally, three lobes.

'Koqo'— round; 4 in (10 cm) wide; seedless; does not deteriorate quickly.

'Tamaikora'—gourd shaped (constricted around middle); to 4 1/2 in (11.5 cm) long, 3 in (7.5 cm) wide; with many seeds. Can be eaten raw when ripe. Highly perishable. Tree to 40 or 45 ft (12-13.5 m).

Class II: Leaf dissected at apex.

'Temaipo'—round; 3 1/2 in (9 cm) long; seedless. Can be eaten raw when ripe. There is also an oblong form with many seeds.

Class III: Leaf moderately deeply dissected at apex.

'Uto Kuro'—round; 5 in (12.5 cm) long; does not deteriorate quickly.

Class IV: Leaf moderately deeply dissected on upper half.

'Samoa'—('Kasa Balavu') round; 4 to 6 in (10-15 cm) long; seeds sparse to many.

'Uto Yalewa'—oblong; to 8 in (20 cm) long and 6 in (15 cm) wide; seedless.

'Kulu Dina'—oblong; to 16 in (40 cm) long and 13 in (33 cm) wide; seedless. Need not be peeled after cooking. Tree bears all year.

'Sogasoga'—oblong; to 9 in (23 cm) long and 6 1/2 in (16.5 cm) wide; seedless.

'Uto Dina'—oblong; to 6 in (15 cm) long and 3 to 3 1/2 in (7.5-9 cm) wide; seedless; need not be peeled after cooking. Tree 60 to 70 ft (18-21 m) high.

'Buco Ni Viti'—oblong; 11 to 14 in (28-35.5 cm) long, 6 to 7 in (15-18 cm) wide; seedless; one of the best cultivars.

'Tamaikora'—oblong; 7 to 9 in (18-23 cm) long, 5 to 6 1/2 in (12.5-16.5 cm) wide; seeds sparse; pulp eaten raw when ripe. Tree to 75 or 85 ft (23-26 m) high; bears 2 crops per year.

'Kulu Mabomabo'—oval; 6 to 8 in (15-20 cm) long, 4 to 5 1/2 in (10-14 cm) wide; seedless.

Class V: Leaf moderately deeply dissected; shape of leaf base variable.

'Uto Dina'—round; 4 1/2 to 5 in (11.5-12.5 cm) wide; seed less. Highly recommended. Tree is 25-30 ft (7.5-9 m) tall.

'Balekana Ni Samoa'—round; 4 to 5 in (10-12.5 cm) long; seeds sparse. Best of all Samoan varieties. There is an oval form by the same name; seedless; deteriorates very quickly.

'Balekana Ni Vita'—round; 3 1/2 to 4 in (9-10 cm) long; seedless. Does not deteriorate quickly.

'Balekana Dina'—oval; 6 to 8 in (15-20 cm) long, 3 to 5 in (7.5-12.5 cm) wide; seeds sparse. One of the best, especially when boiled.

'Tabukiraro'—round; 8 in (20 cm) long; seedless; skin sometimes eaten after cooking.

'Sici Ni Samoa'—oval; 5 to 6 in (12.5-15 cm) long, 3 to 3 1/2 in (7.5-9 cm) wide; seedless. One of the highly recommended Samoan varieties.

'Uto Me'—oval; 5 to 6 3/4 in (12.5-17 cm) long, 4 1/2 to 5 in (11.5 cm) wide; with many seeds; does not deteriorate quickly.

'Uto Wa'—oval; 6 to 7 1/2 in (15-19 cm) long, 5 to 5 1/2 in (12.5-14 cm) wide. The variety most recommended.

'Kulu Vawiri'—oval; 9 to 12 in (22-30 cm) long, 8 to 9 in (20-22 cm) wide; especially good when boiled.

Class VI: Leaf deeply dissected.

'Kulu Dina'—round; 3 to 4 in (7.5-10 cm) long; seedless. Need not be peeled after boiling. Highly recommended.

'Balekana'—oval; 4 in (10 cm) long, 3 in (7.5 cm) wide; of the best quality. Tree 70 to 80 ft (21-24 m) high.

'Balekana Ni Samoa'—round; 3 in (7.5 cm) long; seeds sparse. Best of all Samoan varieties.

'Balekana Ni Viti'—oblong; 5 to 6 in (12.5-15 cm) long, 3 to 4 in (7.5-10 cm) wide; seedless. The best native-type variety.

'Uto Dina'—('Kasa Leka') round; 4 in (10 cm) long; seedless.

'Uto Matala'—round; 3 to 4 in (7.5-10 cm) long. Especially fine when boiled. Tree bears 3 times a year.

Class VII: Leaf deeply dissected; apex pointed.

'Balekana Ni Samoa'—round; 5 to 5 1/2 in (12.5-14 cm) long; seeds sparse. Best of all Samoan varieties.

'Kulu Dina'—('Kasa Balavu') oval; 6 to 7 in (15-18 cm) long, 4 to 5 in (10-12.5 cm) wide; seedless.

'Uto Dina'—(Large) oval; 8 to 9 in (20-22 cm) long, 4 to 7 in (10-18 cm) wide; seedless. Also, by the same name, a form with only moderately dissected leaves.

'Bokasi'—round; 4 in (10 cm) long, 3 in (7.5 cm) wide.

Class VIII: Leaf deeply dissected, wide spaces between lobes.

'Savisavi Ni Samoa'—oval; 4 to 5 in (10-12.5 cm) long, 3 to 3 1/2 in (7.5-9 cm) wide. Ranks with best Samoan varieties.

'Savisavi Ni Viti'—oblong; 6 to 8 in(16-20 cm) long, 4 to 6 in (10-15 cm) wide; seedless; especially good when boiled.

'Savisavi'—round; 3 to 3 1/2 in (7.5-9 cm) wide; especially good when boiled.

'Balawa Ni Viti'—oval; 6 to 7 in (15-18 cm) long, 3 1/2 to 4 in (9-10 cm) wide; seedless.

'Uto Kasekasei'—round; 4 to 5 in (10-12.5 cm) long; seeds sparse.

'Via Loa'—oblong; 6 to 7 in (15-18 cm) long, 4 to 5 in (10-12.5 cm) wide; seedless; does not deteriorate quickly.

Koroieveibau provides a key to the 8 classes illustrated by leaf and fruit outline sketches.

P.J. Wester, in 1928, published descriptions of 52 breadfruit cultivars of the Pacific Islands. In the book, *The Breadfruit of Tahiti*; by G.P. Wilder, there are detailed descriptions and close-up, black-and-white photographic illustrations of the foliage and fruit of 30 named varieties, and of the foliage only of one which did not have mature fruit at the time of writing. One 'Aata', an oblong fruit, is described as of poor quality and eaten by humans only when better breadfruits are scarce, but it is important as feed for pigs and horses. The tree bears heavily. Among the best are:

'Aravei'—fruit ellipsoidal; large, 8 to 12 in (10-30 cm) long, 6 to 9 in (15-22 cm) wide; rind yellowish-green with brown spots on the sunny side; rough, with sharp points which are shed on maturity. Pulp is light-yellow, dry or flaky and of delicious flavor after cooking which takes very little time. Core long, slim, with many abortive seeds.

'Havana'—fruit oval-round; the rind yellowish-green, spiny; pulp golden-yellow, moist, pasty, separates into loose flakes when cooked; very sweet with excellent flavor; core oval, large, with a row of abortive seeds. Very perishable; must be used within 2 days; cooks quickly over fire. Fruit borne in 2's and 3's. Popularly claimed to be one of the best breadfruits.

'Maohi'—fruit round; 6 in (15 cm) wide; rind bright yellow-green with patches of red-brown; rough, with spines, and often bears much exuded latex. Pulp cream-colored and smooth when cooked; of very good flavor; slow cooking, needs even heat. Core is large. Fruit is borne in 2's and 3's. Tree a heavy bearer. This is the most common breadfruit of Tahiti.

'Paea'—ellipsoidal; very large, to 11 in (28 cm) long and 9 in (22.8 cm) wide; rind yellowish-green, spiny; core oblong, thick, with a row of brown, abortive seeds; pulp bright-yellow, moist, slightly pasty, separating into flakes when cooked; agreeable but only one of its forms, 'Paea Maaroaro', is really sweet. Formerly, 'Paea' was reserved for chiefs only. Needs one hour to roast on open fire. The tree is tall, especially well formed and elegant.

'Pei'—broad-ellipsoidal; large; rind light-green, relatively smooth; pulp light-yellow and flaky when cooked, aromatic, of sweet, delicious "fruity" flavor; cooks quickly. Ripens earlier than others. When the breadfruit crop is scant, the fruits of this cultivar are stored by burying in the ground until needed, even for a year, then taken up, wrapped in *Cordyline* leaves and boiled.

'Pucro'—fruit spherical or elongated; large; rind yellow-green with small brown spots, very rough, spiny, thin; pulp light-yellow and smooth, of excellent flavor. Cooks quickly. Highly esteemed, ranked with the very best breadfruits. There are two oblong forms, one with a large, hairy core.

'Rare'—fruit broad-ovoid; to 7 in (17.5 cm) long, rind bright-green, rough, spiny; pulp of deep-cream tone, fine-grained, smooth, flaky when cooked; of very sweet, excellent flavor. Core is small with a great many small abortive seeds. Must be cooked for about one hour. There are 3 forms that are well recognized. Fruits are borne singly on a tall, open, short branched tree.

'Rare Aumee'—fruit round; 6 1/2 in (16.5 cm) across; rind bright-green with red-brown splotches, fairly smooth at the base but rough at the apex; pulp deep-ivory, firm, smooth when cooked; not very sweet but of excellent flavor. Cooks quickly. Highly prized; in scarce supply because the tall, few branched tree bears scantily.

'Rare Autia'—fruit round; 6 in (15 cm) across; rind dull-green with red-brown markings. Pulp light-yellow when cooked and separates into chunks; has excellent flavor. Core is large with small abortive seeds all around. This cultivar is so superior it was restricted to royalty and high chiefs in olden times.

'Tatara'—fruit broad-ellipsoid; verylarge, up to 10 lbs(4.5 kg) in weight; rind has prominent faces with long green spines; pulp light-yellow, smooth when cooked and of pleasant flavor. Core is oblong. This variety is greatly esteemed. The tree is found only in a small coastal valley where there is heavy rainfall. It is of large dimensions and high-branching and it is difficult to harvest the fruits.

'Vai Paere'—fruit is obovoid; 10 to 12 in (25-30 cm) long, 7 to 8 in (17.5-20 cm) wide; rind is yellow-green with red-brown splotches and there is a short raised point at the center of each face; pulp light-yellow, firm, smooth, a little dryish when cooked, with a slightly acid, but excellent flavor. Core is oblong, large, with a few abortive seeds attached. Fruit cooks easily. Tree is very tall, bears fruit in clusters. Grows at sea level in fairly dry locations.

There are at least 50 cultivars on Ponape and about the same number on Truk. In Samoa, a variety known as **'Maopo'**, with leaves that are almost entire or sometimes very shallowly lobed, is very common and considered one of the best.

'Puou' is another choice and much planted variety since early times. It has deeply cut leaves and nearly round fruits 6 in (15 cm) long. 'Ulu Ea', with leaves even more deeply lobed, has oblong fruits to 6 1/8 in (15.5 cm) long and 5 in (12.5 cm) wide; is a longtime favorite.

In the past three decades there has been an awakening to the possibilities of increasing the food supply of tropical countries by more plantings of selected varieties of seedless breadfruit. In 1958, many appealing varieties (some early, some late in season) were collected around the South Pacific region and transferred to Western Samoa, Tahiti and Fiji for comparative trials. Two years later, plans were made to introduce Polynesian varieties into Micronesia, and propagating material of 36 Micronesian types was distributed to other areas.

Climate

The breadfruit is ultra-tropical, much tenderer than the mango tree. It has been reported that it requires a temperature range of 60° to 100°F (15.56°-37.78°C), an annual rainfall of 80 to 100 in (203-254 cm), and a relative humidity of 70 to 80%. However, in southern India, it is cultivated at sea level and up humid slopes to an altitude of 3,500 ft (1,065 m), also in thickets in dry regions where it can be irrigated. In the "equatorial dry climate" of the Marquesas, where the breadfruit is an essential crop, there is an average rainfall of only 40 to 60 in (100-150 cm) and frequent droughts. In Central America, it is grown only below 2,000 ft (600 m).

Soil

According to many reports, the breadfruit tree must have deep, fertile, well-drained soil. But some of the best authorities on South Pacific plants point out that the seedless breadfruit does well on sandy coral soils, and seeded types grow naturally on "coraline limestone" islands in Micronesia. In New Guinea, the breadfruit tree occurs wild along waterways and on the margins of forests in the flood plain, and often in freshwater swamps. It is believed that there is great variation in the adaptability of different strains to climatic and soil conditions, and that each should be matched with its proper environment. The Tahitian 'Manitarvaka' is known to be drought-resistant. The variety 'Mai-Tarika', of the Gilbert Islands, is salt-tolerant. 'Mejwaan', a seeded variety of the Marshall Islands, is not harmed by brackish water nor salt spray and has been introduced into Western Samoa and Tahiti.

Propagation

The seeded breadfruit is always grown from seeds, which must be planted when fairly fresh as they lose viability in a few weeks. The seedless breadfruit is often propagated by transplanting suckers which spring up naturally from the roots. One can deliberately induce suckers by uncovering and injuring a root. Pruning the parent tree will increase the number of suckers, and root pruning each sucker several times over a period of months before taking it up will contribute to its survival when transplanted. For multiplication in quantity, it is better to make root cuttings about 1 to 2 1/2 in (2.5-6.35 cm) thick and 9 in (22 cm) long. The ends may be dipped into a solution of potassium permanganate to coagulate the latex, and the cuttings are planted close together horizontally in sand. They should be shaded and watered daily, unless it is possible to apply intermittent mist. Calluses may form in 6 weeks (though rooting time may vary from 2 to 5 months) and the cuttings are transplanted to pots, at a slant, and watered once or twice a day for several months or until the plants are 2 ft (60 cm) high. A refined method of rapid propagation uses stem cuttings taken from root shoots. In Puerto Rico, the cuttings are transplanted into plastic bags containing a mixture of soil, peat and sand, kept under mist for a week, then under 65% shade, and given liquid fertilizer and regular waterings. When the root system is well developed, they are allowed full sun until time to set out in the field.

In India, it is reported that breadfruit scions can be successfully grafted or budded onto seedlings of wild jackfruit trees.

Culture

Young breadfruit trees are planted in well-enriched holes 15 in (40 cm) deep and 3 ft (0. 9m) wide that are first prepared by burning trash in them to sterilize the soil and then insecticide is mixed with the soil to protect the roots and shoots from grubs. The trees are spaced 25 to 40 ft (7.5-12 m) apart in plantations. Usually there are about 25 trees per acre (84/ha). Those grown from root suckers will bear in 5 years and will be productive for 50 years. Some growers recommend pruning of branches that have borne fruit and would normally die back, because this practice stimulates new shoots and also tends to keep the tree from being too tall for convenient harvesting.

Standard mixtures of NPK are applied seasonally. When the trees reach bearing age, they each receive, in addition, 4.4 lbs (2 kg) superphosphate per year to increase the size and quality of the fruits.

Season

In the South Seas, the tree fruits more or less continuously, fruit in all stages of development being present on the tree the year around, but there are two or three main fruiting periods. In the Caroline Islands and the Gilbert Islands, the main ripening season is May to July or September; in the Society Islands and New Hebrides, from November to April, the secondary crop being in July and August. Breadfruits are most abundant in Hawaiian markets off and on from July to February. Flowering starts in March in northern India and fruits are ready for harvest in about 3 months. Seeded breadfruits growing in the Eastern Caroline Islands fruit only once a year but the season is 3 months long—from December to March. Seedless varieties introduced from Ponape bear 2 to 3 times a year. In the Bahamas, breadfruit is available mainly from June to November, but some fruits may mature at other times during the year.

Harvesting and Yield

Breadfruits are picked when maturity is indicated by the appearance of small drops of latex on the surface. Harvesters climb the trees and break the fruit stalk with a forked stick so that the fruit will fall. Even though this may cause some bruising or splitting, it is considered better than catching the fruits by hand because the broken pedicel leaks much latex. They are packed in cartons in which they are separated individually by dividers.

In the South Pacific, the trees yield 50 to 150 fruits per year. In southern India, normal production is 150 to 200 fruits annually. Productivity varies between wet and dry areas. In the West Indies, a conservative estimate is 25 fruits per tree. Studies in Barbados indicate a reasonable potential of 6.7 to 13.4 tons per acre (16-32 tons/ha). Much higher yields have been forecasted, but experts are skeptical and view these as unrealistic.

Keeping Quality

In Jamaica, surplus breadfruits are often kept under water until needed. Fully ripe fruits that have fallen from the tree can be wrapped in polyethylene, or put into polyethylene bags, and kept for 10 days in storage at a temperature of 53.6°F (12°C). At lower temperature, the fruit shows chilling injury. Slightly unripe fruits that have been caught by hand when knocked down can be maintained for 15 days under the same conditions. The thickness of the polyethylene is important: 38-or even 50-micrometer bags are beneficial, but not 25-micrometer.

Some Jamaican exporters partly roast the whole fruits to coagulate the latex, let them cool, and then ship them by sea to New York and Europe. Various means of preserving breadfruit for future local use are mentioned under "Food Uses", q.v.

Pests and Diseases

Soft-scales and mealybugs are found on breadfruit trees in the West Indies and ants infest branches that die back after fruiting. In southern India, the fruits on the tree are subject to soft rot. This fungus disease can be controlled by two sprays of Bordeaux mixture, one month apart. Young breadfruit trees in Trinidad have been killed by a disease caused by *Rosellinia* sp. In the Pacific Islands *Fusarium* sp. is believed to be the cause of die back, and *Pythium* sp. is suspected in cases of root rot. A mysterious malady, called "Pingalap disease", killed thousands of trees from 1957 to 1960 in the Gilbert and Ellice Islands, the Caroline Islands, Marshalls and Mariannas. The foliage wilts and then the branch dies back. Sometimes the whole tree is affected and killed to the roots; occasionally only half of a tree declines. The fungus, *Phytophthora palmivora*, attacks the fruit on the island of Truk. *Phomopsis, Dothiorella* and *Phylospora* cause stem-end rot.

Food Uses

Like the banana and plantain, the breadfruit may be eaten ripe as a fruit or underripe as a vegetable. For the latter purpose, it is picked while still starchy and is boiled or, in the traditional Pacific Island fashion, roasted in an underground oven on pre-heated rocks. Sometimes it is cored and stuffed with coconut before roasting. Malayans peel firm-ripe fruits, slice the pulp and fry it in sirup or palm sugar until it is crisp and brown. Filipinos enjoy the cooked fruit with coconut and sugar.

Fully ripe fruits, being sweeter, are baked whole with a little water in the pan. Some cooks remove the stem and core before cooking and put butter and sugar in the cavity, and serve with more of the same. Others may serve the baked fruit with butter, salt and pepper. Ripe fruits may be halved or quartered and steamed for 1 or 2 hours and seasoned in the same manner as baked fruits. The steamed fruit is sometimes sliced, rolled in flour and fried in deep fat. In Hawaii, underripe fruits are diced, boiled, and served with butter and sugar, or salt and pepper, or diced and cooked with other vegetables, bacon and milk as a chowder. In the Bahamas, breadfruit soup is made by boiling underripe chunks of breadfruit in water until the liquid begins to thicken, then adding cooked salt pork, chopped onion, white pepper and salt, stirring till thick, then adding milk and butter, straining, adding a bit of sherry and simmering until ready to serve.

The pulp scraped from soft, ripe breadfruits is combined with coconut milk (not coconut water), salt and sugar and baked to make a pudding. A more elaborate dessert is concocted of mashed ripe breadfruit, with butter, 2 beaten eggs, sugar, nutmeg, cinnamon and rosewater, a dash of sherry or brandy, blended and boiled. There are numerous other dishes peculiar to different areas. Breadfruit is also candied, or sometimes prepared as a sweet pickle.

In Micronesia, the peel is scraped off with a sharpened cowrie shell, or the fruits are peeled with a knife, cored, cut up and put into sacks or baskets, soaked in the sea for about 2 hours while being beaten or trampled; allowed to drain on shore for a few days; then packed in banana leaf-lined boxes to ferment for a month or much longer, the leaves being changed weekly.

In Polynesia and Micronesia, a large number of fruits are baked in a native oven and left there to ferment. Over a period of a few weeks, batches are taken out as needed. In the New Hebrides, peeled breadfruits are wrapped in leaves and placed to ferment in piles of stones on open beaches where they will be flooded at high tide. In Samoa, seeded breadfruits are skinned, washed, quartered and left to ferment in a pit lined and covered with layers of banana and *Heliconia* leaves, and topped with earth and rocks. The fruits ferment for long periods, sometimes for several years, and form a pasty mass called *masi*. The seeds are squeezed out, the paste is wrapped in *Heliconia* leaves smeared with coconut cream and the product is baked for 2 hours. There is a strong, cheese-like odor, but it is much relished by the natives.

The original method of poi making involved peeling, washing and halving the fruit, discarding the core, placing the fruits in stone pits lined with leaves of Cordylme terminalis Kunth, alternating the layers of fruit with old fermented pod, covering the upper layer with leaves, topping the pit with soil and rocks and leaving the contents to ferment, which acidifies and preserves the breadfruit for several years.

Modern poi is made from firm-ripe fruits, boiled whole until tender, cored, sliced, ground, pounded to a paste, kneaded with added water to thin it, strained through cloth, and eaten. If it is to be kept in the refrigerator for 2 days, only a little water is added in kneading; more is added and it is strained just before serving. Food value and digestibility are improved by mixing with poi made from taro which is rated highly as a non-allergenic food. In the Seychelles, the seedless breadfruit is cut into slices 1/2 in (1.25 cm) thick, dried for 4 days at 120°F (48.89°C). In some Pacific Islands, the fruits are partly roasted, then peeled, dried and formed into loaves for long-time storage. The Ceylonese dip breadfruit slices into a salt solution, then blanch them in boiling water for 5 minutes, dry them at 158°F (70°C) for 4 to 6 hours before storing. The slices will keep in good condition for 8 to 10 months. In Guam, cooked fruits may be mashed to a paste which is spread out thin, dried in the sun, and wrapped in leaves for storage. It is soaked in water to soften it for eating. This might be called "breadfruit leather". On the small Kapingamarangi Atoll in the Caroline Islands, the cooked paste is pressed into sheets 5 ft (1.5 m) long and 20 in (50 cm) wide, dried in the sun on coconut leaf mats, then rolled into cylinders, wrapped in *Pandanus* leaves and stored for at least 3 years.

The dried fruit has been made into flour and improved methods have been explored in Barbados and Brazil with a view to substituting breadfruit in part for wheat flour in breadmaking. The combination has been found more nutritious than wheat flour alone. Breadfruit flour is much richer than wheat flour in lysine and other essential amino acids. In Jamaica, the flour is boiled, sweetened, and eaten as porridge for breakfast.

Soft or overripe breadfruit is best for making chips and these are being manufactured commercially in Trinidad and Barbados. Some breadfruit is canned in Dominica and Trinidad for shipment to London and New York.

In Jamaica, Puerto Rico and the South Pacific, fallen male flower spikes are boiled, peeled and eaten as vegetables or are candied by recooking, for 2-3 hours, in sirup; then rolled in powdered sugar and sun-dried.

The seeds are boiled, steamed, roasted over a fire or in hot coals and eaten with salt. In West Africa, they are sometimes made into a puree. In Costa Rica, the cooked seeds are sold by street vendors.

Underripe fruits are cooked for feeding to pigs. Soft-ripe fruits need not be cooked and constitute a large part of the animal feed in many breadfruit-growing areas of the Old and New World. Breadfruit has been investigated as potential material for chickfeed but has been found to produce less weight gain than cassava or maize despite higher intake, and it also causes delayed maturity.

Experiments by technologists at the United States Department of Agriculture's Western Regional Research Laboratory in Berkeley, California, have demonstrated that breadfruit can be commercially dehydrated by tunnel drying or freeze-drying and the waste from these processes constitutes a highly-digestible stock feed.

Food Value Per 100 g of Edible Portion*

	Fruit (underripe, raw)	*Ripe (cooked)*	*Seeds (fresh)*	*Seeds (roasted)*	*Seeds (dried)*
Calories	105-109				
Moisture	62.7-89.16 g	67.8 g	35.08-56.80 g	43.80 g	
Protein	1.3-2.24 g	1.34 g	5.25-13.3 g	7.72 g	13.8-19.96 g
Fat	0.1-0.86 g	0.31 g	2.59-5.59 g	3.30 g	5.1-12.79 g
Carbohydrates	21.5 29.49 g	27.82 g	30.83-44.03 g	41.61 g	15.95 g
Fiber	1.08 2.1 g	1.5 g	1.34-2.14g	1.67 g	3.0-3.87 g
Ash	0.56-1.2 g	1.23 g	1.50-5.58 g	1.90 g	3.42-3.5 g

Calcium	0.05 mg	0.022 g	0.11 mg	40 mg	0.12 mg
Phosphorus	0.04 mg	0.062mg	0.35 mg	178 mg	0.37 mg
Iron	0.61-2.4 mg		3.78 mg	2.66 mg	
Carotene	0.004 mg (35-40 I.U.)				
Thiamine	0.08-0.085 mg		0.25 mg	0.32 mg	180 mcg
Riboflavin	0.033-0.07 mg		0.10 mg	0.10 mg	84 mcg
Niacin	0.506 0.92 mg		3.54 mg	2.94 mg	2.6 mg
Ascorbic Acid	15 33 mg		13.70 mg	14 mg	
Amino Acids	[N = 16 p. 100])				
Arginine	4.9		0.66		
Cystine	-		0.62		
Histidine	1.6		0.91		
Isoleucine	6.7		2.41		
Leucine	7.4		2.60		
Lysine	5.8				
Methionine	1.2		3.17		
Phenylalanine	8.3		1.05		
Threonine	6.8		0.78		
Tryptophan	7.0				
Valine	7.8				
Aspartic Acid	10.8				
Glutamic Acid	11.3		0.98		
Alanine	3.9		1.53		
Glycine	7.2		0.95		
Proline	6.5		0.72		
Serine	5.7		2.08		
Tyrosine			1.45		

*A composite of analyses made in Central America, Mexico, Colombia, Africa and India.

Note: There are reportedly two enzymes in the breadfruit—*papayotin* and *artocarpine*.

Negron de Bravo and colleagues in Puerto Rico show niacin content up to 8.33 mg in dried, ground seeds collected locally.

It will be seen from the above that the seedless breadfruit is low in protein, the seeds considerably higher, and therefore the seeded breadfruit is actually of more value as food.

Breadfruit flour contains 4.05% protein; 76.70% carbohydrates, and 331 calories, while cassava flour contains,1.16% protein, 83.83% carbobydrates, and 347 calories per 100 g.

Toxicity

Most varieties of breadfruit are purgative if eaten raw. Some varieties are boiled twice and the water thrown away, to avoid unpleasant effects, while there are a few named cultivars that can be safely eaten without cooking.

The cyclopropane-containing sterol, *cycloartenol*, has been isolated from the fresh fruit. It contitutes 12% of the non-saponifiable extract.

Other Uses

Leaves: Breadfruit leaves are eagerly eaten by domestic livestock. In India, they are fed to cattle and goats; in Guam, to cattle, horses and pigs. Horses are apt to eat the bark of young trees as well, so new plantings must be protected from them.

Latex: Breadfruit latex has been used in the past as birdlime on the tips of posts to catch birds. The early Hawaiians plucked the feathers for their ceremonial cloaks, then removed the gummy substance from the birds' feet with oil from the candlenut, *Aleurites moluccana* Willd., or with sugarcane juice, and released them.

After boiling with coconut oil, the latex serves for caulking boats and, mixed with colored earth, is used as a paint for boats.

Wood: The wood is yellowish or yellow-gray with dark markings or orange speckles; light in weight; not very hard but strong, elastic and termite resistant (except for drywood termites) and is used for construction and furniture. In Samoa, it is the standard material for house-posts and for the rounded roof-ends of native houses. The wood of the Samoan variety 'Aveloloa' which has deeply cut leaves, is most preferred for house-building, but that of 'Puou', an ancient variety, is also utilized. In Guam and Puerto Rico the wood is used for interior partitions. Because of its lightness, the wood is in demand for surfboards. Traditional Hawaiian drums are made from sections of breadfruit trunks 2 ft (60 cm) long and 1 ft (30 cm) in width, and these are played with the palms of the hands during Hula dances. After seasoning by burying in mud, the wood is valued for making household articles. These are rough-sanded by coral and lava, but the final smoothing is accomplished with the dried stipules of the breadfruit tree itself.

Fiber: Fiber from the bark is difficult to extract but highly durable. Malaysians fashioned it into clothing. Material for tape cloth is obtained from the inner bark of young trees and branches. In the Philippines, it is made into harnesses for water buffalo.

Flowers: The male flower spike used to be blended with the fiber of the paper mulberry, *Broussonetia papyrifera* Vent. to make elegant loincloths. When thoroughly dry, the flower spikes also serve as tinder.

Medicinal Uses: In Trinidad and the Bahamas, a decoction of the breadfruit leaf is believed to lower blood pressure, and is also said to relieve asthma. Crushed leaves are applied on the tongue as a treatment for thrush. The leaf juice is employed as ear-drops. Ashes of burned leaves are used on skin infections. A powder of roasted leaves is employed as a remedy for enlarged spleen. The crushed fruit is poulticed on tumors to "ripen" them. Toasted flowers are rubbed on the gums around an aching tooth. The latex is used on skin diseases and is bandaged on the spine to relieve sciatica. Diluted latex is taken internally to overcome diarrhea.

Morton, J. 1987. Jackfruit. p. 58–64. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Jackfruit

Artocarpus heterophyllus

The jackfruit, *Artocarpus heterophyllus* Lam. (syns. *A. integrifolius* Auct. NOT L. f.; *A integrifolia* L. f.; *A. integra* Merr.; *Rademachia integra* Thunb.), of the family Moraceae, is also called jak-fruit, jak, jaca, and, in Malaysia and the Philippines, *nangka*; in Thailand, *khanun*; in Cambodia, *khnor*; in Laos, *mak mi* or *may mi*; in Vietnam, *mit*. It is an excellent example of a food prized in some areas of the world and allowed to go to waste in others. O.W. Barrett wrote in 1928: ";The jaks . . . are such large and interesting fruits and the trees so well-behaved that it is difficult to explain the general lack of knowledge concerning them.";

Description

The tree is handsome and stately, 30 to 70 ft (9-21 m) tall, with evergreen, alternate, glossy, somewhat leathery leaves to 9 in (22.5 cm) long, oval on mature wood, sometimes oblong or deeply lobed on young shoots. All parts contain a sticky, white latex. Short, stout flowering twigs emerge from the trunk and large branches, or even from the soil-covered base of very old trees. The tree is monoecious: tiny male flowers are borne in oblong clusters 2 to 4 in (5-10 cm) in length; the female flower clusters are elliptic or rounded. Largest of all tree-borne fruits, the jackfruit may be 8 in to 3 ft (20-90 cm) long and 6 to 20 in (15-50 cm) wide, and the weight ranges from 10 to 60 or even as much as 110 lbs (4.5-20 or 50 kg). The "rind' or exterior of the compound or aggregate fruit is green or yellow when ripe and composed of numerous hard, cone-like points attached to a thick and rubbery, pale yellow or whitish wall. The interior consists of large "bulbs" (fully developed perianths) of yellow, banana-flavored flesh, massed among narrow ribbons of thin, tough undeveloped perianths (or perigones), and a central, pithy core. Each bulb encloses a smooth, oval, light-brown "seed" (endocarp) covered by a thin white membrane (exocarp). The seed is 3/4 to 1 1/2 in (2-4 cm) long and 1/2 to 3/4 in (1.25-2 cm) thick and is white and crisp within. There may be 100 or up to 500 seeds in a single fruit. When fully ripe, the unopened jackfruit emits a strong disagreeable odor, resembling that of decayed onions, while the pulp of the opened fruit smells of pineapple and banana.

Fig. 15: A heavily fruiting jackfruit (*Artocarpus heterophyllus*) on the grounds of the old Hobson estate, Coconut Grove. Miami, Eila.

Plate 6: JACKFRUIT, *Artocarpus heterophyllus*

Origin and Distribution

No one knows the jackfruit's place of origin but it is believed indigenous to the rainforests of the Western Ghats. It is cultivated at low elevations throughout India, Burma, Ceylon, southern China, Malaya, and the

East Indies. It is common in the Philippines, both cultivated and naturalized. It is grown to a limited extent in Queensland and Mauritius. In Africa, it is often planted in Kenya, Uganda and former Zanzibar. Though planted in Hawaii prior to 1888, it is still rare there and in other Pactfic islands, as it is in most of tropical America and the West Indies. It was introduced into northern Brazil in the mid-19th Century and is more popular there and in Surinam than elsewhere in the New World.

In 1782, plants from a captured French ship destined for Martinique were taken to Jamaica where the tree is now common, and about 100 years later, the jackfruit made its appearance in Florida, presumably imported by the Reasoner's Nursery from Ceylon. The United States Department of Agriculture's *Report on the Conditions of Tropical and Semitropical Fruits in the United States in 1887* states: "There are but few specimens in the State. Mr. Bidwell, at Orlando, has a healthy young tree, which was killed back to the ground, however, by the freeze of 1886. " There are today less than a dozen bearing jackfruit trees in South Florida and these are valued mainly as curiosities. Many seeds have been planted over the years but few seedlings have survived, though the jackfruit is hardier than its close relative, the breadfruit (q.v.).

In South India, the jackfruit is a popular food ranking next to the mango and banana in total annual production. There are more than 100,000 trees in backyards and grown for shade in betelnut, coffee, pepper and cardamom plantations. The total area planted to jackfruit in all India is calculated at 14,826 acres (26,000 ha). Government horticulturists promote the planting of jackfruit trees along highways, waterways and railroads to add to the country's food supply.

There are over 11,000 acres (4,452 ha) planted to jack fruit in Ceylon, mainly for timber, with the fruit a much-appreciated by-product. The tree is commonly cultivated throughout Thailand for its fruit. Away from the Far East, the jackfruit has never gained the acceptance accorded the breadfruit (except in settlements of people of East Indian origin). This is due largely to the odor of the ripe fruit and to traditional preference for the breadfruit.

Varieties

In South India, jackfruits are classified as of two general types: 1) *Koozha chakka*, the fruits of which have small, fibrous, soft, mushy, but very sweet carpels; 2) *Koozha pazham*, more important commercially, with crisp carpers of high quality known as *Varika*. These types are apparently known in different areas by other names such as *Barka*, or *Berka* (soft, sweet and broken open with the hands), and *Kapa* or *Kapiya* (crisp and cut open with a knife). The equivalent types are known as *Kha-nun nang* (firm; best) and *Kha-nun lamoud* (soft) in Thailand; and as *Vela* (soft) and *Varaka*, or *Waraka* (firm) in Ceylon. *The Peniwaraka*, or honey jak, has sweet pulp, and some have claimed it the best of all. The *Kuruwaraka* has small, rounded fruits. Dr. David Fairchild, writing of the honey jak in Ceylon, describes the rind as dark-green in contrast to the golden yellow pulp when cut open for eating, but the fruits of his own tree in Coconut Grove and those of the Matheson tree which he maintained were honey jaks are definitely yellow when ripe. The *Vela* type predominates in the West Indies.

Firminger described two types: the *Khuja* (green, hard and smooth, with juicy pulp and small seeds); the *Ghila* (rough, soft, with thin pulp, not very juicy, and large seeds). Dutta says *Khujja*, or *Karcha*, has pale-brown or occcasionally pale-green rind, and pulp as hard as an apple; *Ghila*, or *Ghula*, is usually light-green, occasionally brownish, and has soft pulp, sweet or acidulously sweet. He describes 8 varieties, only one with a name. This is *Hazari*; similar to *Rudrakshi*; which has a relatively smooth rind and flesh of inferior quality.

The **'Singapore'**, or **'Ceylon'**, jack, a remarkably early bearer producing fruit in 18 months to 2 1/2 years from transplanting, was introduced into India from Ceylon and planted extensively in 1949. The fruit is of medium size with small, fibrous carpers which are very sweet. In addition to the summer crop (June and July), there is a second crop from October to December. In 1961, the Horticultural Research Institute at Saharanpur, India, reported the acquisition of air-layered plants of the excellent varieties, **'Safeda'**, **'Khaja'**, **'Bhusila'**, **'Bhadaiyan'** and **'Handia'** and others. The Fruit Experimental Station at Burliar, established a collection of 54 jackfruit clones from all producing countries, and ultimately selected **'T Nagar Jack'** as the best in quality and yield. The Fruit Experimental Station at Kallar, began breeding work in 1952 with a view to developing short, compact, many-branched trees, precocious and productive, bearing large, yellow, high quality fruits, 1/2 in the main season, 1/2 late. 'Singapore Jack' was chosen as the female parent because of its early and late crops; and, as the male parent, **'Velipala'**, a local selection from the forest having large fruits with large carpers of superior quality, and borne regularly in the main summer season. After 25 years of testing, one hybrid was rated as outstanding for precocity, fruit size, off-season as well as main season production, and yield excelling its parents. It had not been named when reported on by Chellappan and Roche in 1982. In Assam, nurserymen have given names such as 'Mammoth', 'Everbearer', and 'Rose-scented' to preferred types.

Pollination

Horticulturists in Madras have found that hand-pollination produces fruits with more of the fully developed bulbs than does normal wind-pollination.

Climate

The jackfruit is adapted only to humid tropical and near-tropical climates. It is sensitive to frost in its early life and cannot tolerate drought. If rainfall is deficient, the tree must be irrigated. In India, it thrives in the Himalayan foothills and from sea-level to an altitude of 5,000 ft (1,500 m) in the south. It is stated that jackfruits grown above 4,000 ft (1,200 m) are of poor quality and usable only for cooking. The tree ascends to about 800 ft (244 m) in Kwangtung, China.

Soil

The jackfruit tree flourishes in rich, deep soil of medium or open texture, sometimes on deep gravelly or laterite soil. It will grow, but more slowly and not as tall in shallow limestone. In India, they say that the tree grows tall and thin on sand, short and thick on stony land. It cannot tolerate "wet feet". If the roots touch water, the tree will not bear fruit or may die.

Propagation

Propagation is usually by seeds which can be kept no longer than a month before planting. Germination requires 3 to 8 weeks but is expedited by soaking seeds in water for 24 hours. Soaking in a 10% solution of gibberellic acid results in 100% germination. The seeds may be sown *in situ* or may be nursery-germinated and moved when no more than 4 leaves have appeared. A more advanced seedling, with its long and delicate tap root, is very difficult to transplant successfully. Budding and grafting attempts have often been unsuccessful, though Ochse considers the modified Forkert method of budding feasible. Either jackfruit or champedak (q.v.) seedlings may serve as rootstocks and the grafting may be done at any time of year. Inarching has been practiced and advocated but presents the same problem of transplanting after separation from the scion parent. To avoid this and yet achieve consistently early bearing of fruits of known quality, air-layers produced with the aid of growth promoting hormones are being distributed in India. In Florida cuttings of young wood have been rooted under mist. At Calcutta University, cuttings have been successfully rooted only with forced and etiolated shoots treated with indole butyric acid (preferably at 5,000 mg/l) and kept under mist. Tissue culture experiments have been conducted at the Indian Institute of Horticultural Research, Bangalore.

Culture

Soaking one-month-old seedlings in a gibberellic acid solution (25-200 ppm) enhances shoot growth. Gibberellic acid spray and paste increase root growth. In plantations, the trees are set 30 to 40 ft (9-12 m) apart. Young plantings require protection from sunscald and from grazing animals, hares, deer, etc. Seeds in the field may be eaten by rats. Firminger describes the quaint practice of raising a young seedling in a 3 to 4 ft (0.9-1.2 m) bamboo tube, then bending over and coiling the pliant stem beneath the soil, with only the tip showing. In 5 years, such a plant is said to produce large and fine fruits on the spiral underground. In Travancore, the whole fruit is buried, the many seedlings which spring up are bound together with straw and they gradually fuse into one tree which bears in 6 to 7 years. Seedlings may ordinarily take 4 to 14 years to come into bearing, though certain precocious cultivars may begin to bear in 2 1/2 to 3 1/2 years. The jackfruit is a fairly rapid grower, reaching 58 ft (17.5 m) in height and 28 in (70 cm) around the trunk in 20 years in Ceylon. It is said to live as long as 100 years. However, productivity declines with age. In Thailand, it is recommended that alternate rows be planted every 10 years so that 20-year-old trees may be routinely removed from the plantation and replaced by a new generation. Little attention has been given to the tree's fertilizer requirements. Severe symptoms of manganese deficiency have been observed in India.

After harvesting, the fruiting twigs may be cut back to the trunk or branch to induce flowering the next season. In the Cachar district of Assam, production of female flowers is said to be stimulated by slashing the tree with a hatchet, the shoots emerging from the wounds; and branches are lopped every 3 to 4 years to maintain fruitfulness. On the other hand, studies at the University of Kalyani, West Bengal, showed that neither scoring nor pruning of shoots increases fruit set and that ringing enhances fruit set only the first year, production declining in the second year.

Season

In Asia, jackfruits ripen principally from March to June, April to September, orJune to August, depending on the climatic region, with some off-season crops from September to December, or a few fruits at other times of the year. In the West Indies, I have seen many ripening in June; in Florida, the season is late summer and fall.

Harvesting

Fruits mature 3 to 8 months from flowering. In Jamaica, an "X" is sometimes cut in the apex of the fruit to speed ripening and improve flavor.

Yield

In India, a good yield is 150 large fruits per tree annually, though some trees bear as many as 250 and a fully mature tree may produce 500, these probably of medium or small size.

Fig. 16: Much white, gummy latex flows from the jackfruit stalk when the slightly underripe fruit is harvested.

Storage

Jackfruits turn brown and deteriorate quickly after ripening. Cold storage trials indicate that ripe fruits can be kept for 3 to 6 weeks at 52° to 55°F (11.11°-12.78°C) and relative humidity of 85 to 95%.

Pests and Diseases

Principal insect pests in India are the shoot-borer caterpillar, *Diaphania caesalis*; mealybugs. *Nipaecoccus viridis, Pseudococcus corymbatus*, and *Ferrisia virgata*, the spittle bug, *Cosmoscarta relata*, and jack scale, *Ceroplastes rubina*. The most destructive and widespread bark borers are *Indarbela tetraonis* and *Batocera rufomaculata*. Other major pests are the stem and fruit borer, *Margaronia caecalis*, and the brown bud-weevil, *Ochyromera artocarpio*. In southern China, the larvae of the longicorn beetles, including *Apriona germarri*; *Pterolophia discalis, Xenolea tomenlosa asiatica*, and *Olenecamptus bilobus* seriously damage the fruit stem. The caterpillar of the leaf webbers, *Perina nuda* and *Diaphania bivitralis*, is a minor problem, as are aphids, *Greenidea artocarpi* and *Toxoptera aurantii*; and thrips, *Pseudodendrothrips dwivarna*.

Diseases of importance include pink disease, *Pelliculana (Corticium) salmonicolor*, stem rot, fruit rot and male inflorescence rot caused by *Rhizopus artocarpi*; and leafspot due to *Phomopsis artocarpina*, *Colletotrichum lagenarium*, *Septoria artocarpi*, and other fungi. Gray blight, *Pestalotia elasticola*, charcoal rot, *Ustilana zonata*, collar rot, *Rosellinia arcuata*, and rust, *Uredo artocarpi*, occur on jackfruit in some regions.

The fruits may be covered with paper sacks when very young to protect them from pests and diseases. Burkill says the bags encourage ants to swarm over the fruit and guard it from its enemies.

Food Uses

Westerners generally will find the jackfruit most acceptable in the full-grown but unripe stage, when it has no objectionable odor and excels cooked green breadfruit and plantain. The fruit at this time is simply cut into large chunks for cooking, the only handicap being its copious gummy latex which accumulates on the knife and the hands unless they are first rubbed with salad oil. The chunks are boiled in lightly salted water until tender, when the really delicious flesh is cut from the rind and served as a vegetable, including the seeds which, if thoroughly cooked, are mealy and agreeable. The latex clinging to the pot may be removed by rubbing with oil. The flesh of the unripe fruit has been experimentally canned in brine or with curry. It may also be dried and kept in tins for a year. Cross sections of dried, unripe jackfruit are sold in native markets in Thailand. Tender young fruits may be pickled with or without spices.

Fig. 17: Dried slices of peeled unripe jackfruit are commonly marketed in Southeast Asia

If the jackfruit is allowed to ripen, the bulbs and seeds may be extracted outdoors; or, if indoors, the odorous residue should be removed from the kitchen at once. The bulbs may then be enjoyed raw or cooked (with coconut milk or otherwise); or made into ice cream, chutney, jam, jelly, paste, "leather" or *papad*, or canned in sirup made with sugar or honey with citric acid added. The crisp types of jackfruit are preferred for canning. The canned product is more attractive than the fresh pulp and is sometimes called "vegetable meat". The ripe bulbs are mechanically pulped to make jackfruit nectar or reduced to concentrate or powder. The addition of synthetic flavoring—ethyl and *n*-butyl esters of 4-hydroxybutyric acid at 120 ppm and 100 ppm, respectively greatly improves the flavor of the canned fruit and the nectar.

Fig 18: Jackfruit seeds, salvaged from the ripe fruits, are sold for boiling or roasting like chestnuts.

If the bulbs are boiled in milk, the latter when drained off and cooled will congeal and form a pleasant, orange colored custard. By a method patented in India, the ripe bulbs may be dried, fried in oil and salted for eating like potato chips. Candied jackfruit pulp in boxes was being marketed in Brazil in 1917. Improved methods of preserving and candying jackfruit pulp have been devised at the Central Food Technological Research Institute, Mysore, India. Ripe bulbs, sliced and packed in sirup with added citric acid, and frozen, retain good color, flavor and texture for one year. Canned jackfruit retains quality for 63 weeks at room temperature—75° to 80°F (23.89°-26.67°C), with only 3% loss of B-carotene. When frozen, the canned pulp keeps well for 2 years.

In Malaya, where the odor of the ripe fruit is not avoided, small jackfruits are cut in half, seeded, chilled, and brought to the table filled with ice cream.

The ripe bulbs, fermented and then distilled, produce a potent liquor.

The seeds, which appeal to all tastes, may be boiled or roasted and eaten, or boiled and preserved in sirup like chestnuts. They have also been successfully canned in brine, in curry, and, like baked beans, in tomato sauce. They are often included in curried dishes. Roasted, dried seeds are ground to make a flour which is blended with wheat flour for baking.

Where large quantities of jackfruit are available, it is worthwhile to utilize the inedible portion, and the rind has been found to yield a fair jelly with citric acid. A pectin extract can be made from the peel, undeveloped perianths and core, or just from the inner rind; and this waste also yields a sirup used for tobacco curing.

Tender jackfruit leaves and young male flower clusters may be cooked and served as vegetables.

Food Value Per 100 g of Edible Portion

	Pulp (ripe-fresh)	Seeds (fresh)	Seeds (dried)
Calories	98		
Moisture	72.0-77.2 g	51.6-57.77 g	
Protein	1.3-1.9 g	6.6 g	
Fat	0.1-0.3 g	0.4 g	
Carbohydrates	18.9-25.4 g	38.4 g	
Fiber	1.0-1.1 g	1.5 g	
Ash	0.8-1.0 g	1.25-1.50 g	2.96%
Calcium	22 mg	0.05-0.55 mg	0.13%
Phosphorus	38 mg	0.13-0.23 mg	0.54%
Iron	0.5 mg	0.002-1.2 mg	0.005%
Sodium	2 mg		
Potassium	407 mg		
Vitamin A	540 I.U.		
Thiamine	0.03 mg		
Niacin	4 mg		
Ascorbic Acid	8-10 mg		

The pulp constitutes 25-40% of the fruit's weight.

In general, fresh seeds are considered to be high in starch, low in calcium and iron; good sources of vitamins B_1 and B2.

Toxicity

Even in India there is some resistance to the jackfruit, attributed to the belief that overindulgence in it causes digestive ailments. Burkill declares that it is the raw, unripe fruit that is astringent and indigestible. The ripe fruit is somewhat laxative; if eaten in excess it will cause diarrhea. Raw jackfruit seeds are indigestible due to the presence of a powerful trypsin inhibitor. This element is destroyed by boiling or baking.

Other Uses

Fruit: In some areas, the jackfruit is fed to cattle. The tree is even planted in pastures so that the animals can avail themselves of the fallen fruits. Surplus jackfruit rind is considered a good stock food.

Leaves: Young leaves are readily eaten by cattle and other livestock and are said to be fattening. In India, the leaves are used as food wrappers in cooking, and they are also fastened together for use as plates.

Latex: The latex serves as birdlime, alone or mixed with *Ficus* sap and oil from *Schleichera trijuga* Willd. The heated latex is employed as a household cement for mending chinaware and earthenware, and to caulk boats and holes in buckets. The chemical constituents of the latex have been reported by Tanchico and Magpanlay. It is not a substitue for rubber but contains 82.6 to 86.4% resins which may have value in varnishes. Its bacteriolytic activity is equal to that of papaya latex.

Wood: Jackwood is an important timber in Ceylon and, to a lesser extent, in India; some is exported to Europe. It changes with age from orange or yellow to brown or dark-red; is termite proof, fairly resistant to fungal and bacterial decay, seasons without difficulty, resembles mahogany and is superior to teak for furniture, construction, turnery, masts, oars, implements, brush backs and musical instruments. Palaces were built of jackwood in Bali and Macassar, and the limited supply was once reserved for temples in Indochina. Its strength is 75 to 80% that of teak. Though sharp tools are needed to achieve a smooth surface, it polishes beautifully. Roots of old trees are greatly prized for carving and picture framing. Dried branches are employed to produce fire by friction in religious ceremonies in Malabar.

From the sawdust of jackwood or chips of the heartwood, boiled with alum, there is derived a rich yellow dye commonly used for dyeing silk and the cotton robes of Buddhist priests. In Indonesia, splinters of the wood are put into the bamboo tubes collecting coconut toddy in order to impart a yellow tone to the sugar. Besides the yellow colorant, *morin*, the wood contains the colorless *cyanomaclurin* and a new yellow coloring matter, *artocarpin*, was reported by workers in Bombay in 1955. Six other flavonoids have been isolated at the National Chemical Laboratory, Poona.

Bark: There is only 3.3% tannin in the bark which is occasionally made into cordage or cloth.

Medicinal Uses: The Chinese consider jackfruit pulp and seeds tonic, cooling and nutritious, and to be "useful in overcoming the influence of alcohol on the system." The seed starch is given to relieve biliousness and the roasted seeds are regarded as aphrodisiac. The ash of jackfruit leaves, burned with corn and coconut shells, is used alone or mixed with coconut oil to heal ulcers. The dried latex yields artostenone, convertible to artosterone, a compound with marked androgenic action. Mixed with vinegar, the latex promotes healing of abscesses, snakebite and glandular swellings. The root is a remedy for skin diseases and asthma. An extract of the root is taken in cases of fever and diarrhea. The bark is made into poultices. Heated leaves are placed on wounds. The wood has a sedative property; its pith is said to produce abortion.

Related Species

The **Champedak**, *A. integer* Merr. (syns. *A. champeden* Spreng., *A. polyphena* Pers.), is also known as *chempedak, cempedak, sempedak, temedak* in Malaya; *cham-pa-da in* Thailand, *tjampedak* in Indonesia; *lemasa* in the Philippines. The wild form in Malaya is called *bangkong* or *baroh*. The fruit is borne by a deciduous tree, reaching about 60 ft (18 m) in cultivation, up to 100 or 150 ft (30-45.5 m) in the wild. It is easy to distinguish from the jackfruit by the long, stiff, brown hairs on young branchlets, leaves, buds and peduncles. The leaves, often 3-lobed when young, are obovate oblong or elliptical when mature and 6 to 11 in (15-28 cm) long. The male flower spikes are only 2 in (5 cm) long and the fruit cylindrical or irregular, no more than 14 in (35.5 cm) long and 6 in (15 cm) thick, mustard-yellow to golden-brown, reticulated, warty, and highly odoriferous when ripe. In fact, it is described as having the "strongest and richest smell of any fruit in creation." The rind is thinner than that of the jackfruit and the seeds and surrounding pulp can be extracted by cutting open the base and pulling on the fruit stalk. The pulp is deep-yellow, tender, slimy, juicy and sweet. That of the wild form is thin, subacid and odorless.

The tree is native and common in the wild in Malaya up to an altitude of 4,200 ft (1,300 m) and is cultivated throughout Malaysia and by many preferred to jackfruit. It is grown from seed or budded onto self-seedlings or jackfruit or other *Artocarpus* species. Seedlings bear in 5 years. The pulp is eaten with rice and the seeds are roasted and eaten. The wood is strong and durable and yields yellow dye, and the bark is rich in tannin.

The **Lakoocha**, *A. lakoocha* Roxb., is also known as monkey jack or *lakuchi* in India; *tampang* and other similar native names in Malaya; as *lokhat* in Thailand. The tree is 20 to 30 ft (6-9 m) tall with deciduous, large, leathery leaves, downy on the underside. Male and female flowers are borne on the same tree, the former orange-yellow, the latter reddish. The fruits are nearly round or irregular, 2 to 5 in (5-12.5 cm) wide, velvety, dull-yellow tinged with pink, with sweet sour pulp which is occasionally eaten raw but mostly made into curries or chutney. The male flower spike, acid and astringent, is pickled.

A native of the humid sub-Himalayan region of India, up to 4,000 ft (1,200 m), also Malaya and Ceylon, it is sometimes grown for shade or for its fruit. Seedlings come into production in 5 years. A specimen was planted at the Federal Experiment Station, Mayaguez, Puerto Rico, in 1921. There was a large tree in Bermuda in 1918.

The wood, sold as *lakuch*, is heavier than that of the jackfruit, similar to teak, durable outdoors and under water, but does not polish well. It is used for piles, and in construction; for boats, furniture and cabinetwork. The bark contains 8.5% tannin and is chewed like betelnut. It yields a fiber for cordage. The wood and roots yield a dye of richer color than that obtained from the jackfruit. Both seeds and milky latex are purgative. The bark is applied on skin ailments. The fruit is believed to act as a tonic for the liver.

The **Kwai Muk**, possibly *A. lingnanensis* Merr., was introduced into Florida as *A. hypargyraea* Hance, or *A. hypargyraeus* Hance ex Benth. The tree is a slow-growing, slender, erect ornamental 20 to 50 ft (6-15 m) tall, with much milky latex and evergreen leaves 2 to 5 in (5-12.5 cm) long. Tiny male and female flowers are yellowish and borne on the same tree, the female in globular heads to 3/8 in (1 cm) long.

The fruits are more or less oblate and irregular, 1 to 2 in (2.5-5 cm) wide, with velvety, brownish, thin, tender skin and replete with latex when unripe. When ripe, the pulp is orange-red or red, soft, of agreeable subacid to acid flavor and may be seedless or contain 1 to 7 small, pale seeds. The pulp is edible raw; can be preserved in sirup or dried. Ripens from August to October in Florida.

The tree is native from Kwangtung, China, to Hong Kong, and has been introduced sparingly abroad. It was planted experimentally in Florida in 1927 and was thriving in Puerto Rico in 1929. It grows at an altitude of 500 ft (152 m) in China. Young trees are injured by brief drops in temperature to 28° to 30°F (-2.22°-1.11°C). Mature trees have endured 25° to 26°F (-3.89°-3.33°C) in Homestead, Florida; have been killed by 20°F (-6.67°C) in central Florida.

Morton, J. 1987. Cherimoya. p. 65–69. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Cherimoya

Annona cherimola

Certainly the most esteemed of the fruits of the genus *Annona* (family Annonaceae), the cherimoya, *A. cherimola* Mill., because of its limited distribution, has acquired few colloquial names, and most are merely local variations in spelling, such as *chirimoya, cherimolia, chirimolla*, *cherimolier*, *cherimoyer*. In Venezuela, it is called *chirimorrinon*; in Brazil, *graveola*, *graviola*, or *grabiola*; and in Mexico, *pox* or *poox*; in Belize, *tukib*; in El Salvador it is sometimes known as *anona poshte*; and elsewhere merely as *anona*, or *anona blanca*. In France, it is *anone*; in Haiti, *cachiman la Chine*. Indian names in Guatemala include *pac*, *pap*, *tsummy* and *tzumux*. The name, *cherimoya*, is sometimes misapplied to the less-esteemed custard apple, *A. reticulata* L. In Australia it is often applied to the atemoya (a cherimoya-sugar apple hybrid).

Description

The tree is erect but low branched and somewhat shrubby or spreading; ranging from 16 to 30 ft (5 to 9 m) in height; and its young branchlets are rusty-hairy. The leaves are briefly deciduous (just

Plate 7: CHERIMOYA, *Annona cherimola*

before spring flowering), alternate, 2-ranked, with minutely hairy petioles 1/4 to 1/2 in (6 to 12.5 mm) long; ovate to elliptic or ovate-lanceolate, short blunt-pointed at the apex; slightly hairy on the upper surface, velvety on the underside; 3 to 6 in (7.5-15 cm) long, 1 1/2 to 3 1/2 in (3.8-8.9 cm) wide.

Fragrant flowers, solitary or in groups of 2 or 3, on short, hairy stalks along the branches, have 3 outer, greenish, fleshy, oblong, downy petals to 1 1/4 in (3 cm) long and 3 smaller, pinkish inner petals. A compound fruit, the cherimoya is conical or somewhat heart-shaped, 4 to 8 in (10 to 20 cm) long and up to 4 in (10 cm) in width, weighing on the average 5 1/2 to 18 oz (150-500 g) but extra large specimens may weigh 6 lbs (2.7 kg) or more. The skin, thin or thick, may be smooth with fingerprint like markings or covered with conical or rounded protuberances. The fruit is easily broken or cut open, exposing the snow-white, juicy flesh, of pleasing aroma and delicious, subacid flavor; and containing numerous hard, brown or black, beanlike, glossy seeds, 1/2 to 3/4 in (1.25 to 2 cm) long.

Origin and Distribution

The cherimoya is believed indigenous to the interandean valleys of Ecuador, Colombia and Bolivia. In Bolivia, it flourishes best around Mizque and Ayopaya, in the Department of Cochabamba, and around Luribay, Sapahaqui and Rio Abajo in the Department of La Paz. Its cultivation must have spread in ancient times to Chile and Brazil for it has become naturalized in highlands throughout these countries. Many authors include Peru as a center of origin but others assert that the fruit was unknown in Peru until after seeds were sent by P. Bernabe Cobo from Guatemala in 1629 and that thirteen years after this introduction the cherimoya was observed in cultivation and sold in the markets of Lima. The often-cited representations of the cherimoya on ancient Peruvian pottery are actually images of the soursop, *A. muricata* L. Cobo sent seeds to Mexico also in 1629. There it thrives between 4,000 and 5,000 ft (1312-1640 m) elevations.

It is commonly grown and naturalized in temperate areas of Costa Rica and other countries of Central America. In Argentina, the cherimoya is mostly grown in the Province of Tucuman. In 1757, it was carried to Spain where it remained a dooryard tree until the 1940's and 1950's when it gained importance in the Province of Granada, in the Sierra Nevada mountains, as a replacement for the many orange trees that succumbed to disease and had to be taken out. By 1953, there were 262 acres (106 ha) of cherimoyas in this region.

In 1790 the cherimoya was introduced into Hawaii by Don Francisco de Paulo Marin. It is still casually grown in the islands and naturalized in dry upland forests. In 1785, it reached Jamaica, where it is cultivated and occurs as an escape on hillsides between 3,500 and 5,000 ft (1,066-1,524 m). It found its way to Haiti sometime later. The first planting in Italy was in 1797 and it became a favored crop in the Province of Reggio Calabria. The tree has been tried several times in the

Botanic Gardens, Singapore first around 1878—but has always failed to survive because of the tropical climate. In the Philippines, it does well in the Mountain Province at an altitude above 2,460 ft (750 m). It was introduced into India and Ceylon in 1880 and there is small-scale culture in both countries at elevations between 1,500 and 7,000 ft (457-2,134 m). The tree was planted in Madeira in 1897, then in the Canary Islands, Algiers, Egypt and, probably via Italy, in Libya, Eritrea and Somalia.

The United States Department of Agriculture imported a number of lots of cherimoya seeds from Madeira in 1907 (S.P.I. Nos. 19853, 19854, 19855, 19898, 19901, 19904, 19905).

Seeds from Mexico were planted in California in 1871. There were 9,000 trees in that state in 1936 but many of them were killed by a freeze in 1937. Several small commercial orchards were established in the 1940's. At present there may be less than 100 acres (42 ha) in the milder parts of San Diego County. Seeds, seedlings and grafted trees from California and elsewhere have been planted in Florida many times but none has done well. Any fruits produced have been of poor quality.

Varieties

In Peru, cherimoyas are classed according to degree of surface irregularity, as: **'Lisa'**, almost smooth; **'Impresa'**, with "fingerprint" depressions; **'Umbonada'**, with rounded protrusions; **'Papilonado'**, or **'Tetilado'**, with fleshy, nipple-like protrusions; **'Tuberculada'**, with conical protrusions having wartlike tips. At the Agricultural Experiment Station "La Molina", several named and unnamed selections collected in northern Peru are maintained and evaluated. Among the more important are: #1, **'Chavez'**, fruits up to 3.3 lbs (1 1/2 kg); February to May; #2, **'Names'**, fruits January to April; #3, **'Sander'**, fruits with moderate number of seeds; July and early August; #4, fruit nearly smooth, not many seeds, 1.1 to 2.2 lbs (1/2-1 kg), June to August; #5, nearly smooth, very sweet, 2.2 Ibs (1 kg), March to June; #6, fruit with small protuberances, 1.1 to 2.2 Ibs (1/2-1 kg), not many seeds; #7 fruit small, very sweet, many seeds, March to May; #8, fruit very sweet, 1.1 to 2.2 Ibs (1/2 1 kg), with very few seeds, February to April.

In the Department of Antioquia, Colombia, a cultivar called **'Rio Negro'** has heart shaped fruits weighing 1 3/4 to 2.2 Ibs (0.8-1 kg). The cherimoyas of Mizque, Cochabamba, Bolivia, are locally famed for their size and quality. **'Concha Lisa'** and **'Bronceada'** are grown commercially in Chile. Other cultivars mentioned in Chilean literature are **'Concha Picuda'** and **'Terciopelo'.**

Dr. Ernesto Saavedra, University of Chile, after ex perimenting with growth regulators for 4 years, developed a super cherimoya, 4 to 6 in (10-15 cm) wide and weighing up to 4 Ibs (1.8 kg); symmetrical, easy to peel and seedless, hence having 25% more flesh than an ordinary cherimoya. However, the larger fruits are subject to cracking.

The leading commercial cultivars in Spain are **'Pinchua'** (thin-skinned) and **'Baste'** (thick-skinned.)

Named cultivars in California include:

'Bays'—rounded, fingerprinted, light green, medium to large, of excellent flavor; good bearer; early.

'Whaley'—long-conical, sometimes shouldered at the base, slightly and irregularly tuberculate, with fairly thick, downy skin. Of good flavor, but membranous sac around each seed may adhere to flesh. Bears well; grown commercially; early.

'Deliciosa'—long-conical, prominently papillate; skin tbin, slightly downy; variable in flavor; only fair in quality; generally bears well but doesn't ship well; cold-resistant. Midseason.

'Booth'—short-conical, fingerprinted, medium to large; of good flavor; next to 'Deliciosa in hardiness. Late.

'McPherson'—short conical, fingerprinted but umbonate at the base; medium to large; of high quality; bears well. Midseason.

'Carter'—long-conical, but not shouldered; smooth or faintly fingerprinted; skin green to bronze; bears well. Late. Leaves wavy or twisted.

'Ryerson'—long-conical, smooth or fingerprinted, with tbick, tough, green or yellow green skin; of fair quality; ships well. Leaves wavy or twisted.

'White'—short-conical with rounded apex; slightly papil late to umbonate; medium to large; skin medium thick; of good flavor; doesn t bear well near the coast.

'Chaffey'—introduced in 1940s; rounded, short, finger printed; of medium size; excellent quality; bears well, even without hand-pollination.

'Ott'—(Patent #656)—introduced in 1940's; long conical to heart shaped, slightly tuberculate; of excellent flavor; ships well.

Among others that have been planted in California but considered inferior are: **'Horton'**, **'Golden Russet'**, **'Loma'**, **'Mire Vista'**, **'Sallmon'**.

Pollination

A problem with the cherimoya is inadequate natural pollination because the male and female structures of each flower do not mature simultaneously. Few insects visit the flowers. Therefore, hand-pollination is highly desirable and must be done in a 6- to 8-hour period when the stigmas are white and sticky. It has been found in Chile that in the first flowers to open the pollen grains are loaded with starch, whereas flowers that open later have more abundant pollen, no starch grains, and the pollen germinates readily. Partly-opened flowers are collected in the afternoon and kept in a paper bag overnight. The next morning the shed pollen is put, together with moist paper, in a vial and transferred by brush to the receptive stigmas. Usually only a few of the flowers on a tree are pollinated each time, the operation being repeated every 4 or 5 days in order to extend the season of ripening. The closely related *A. senegalensis* Pers., if available, is a good source of abundant pollen for pollinating the cherimoya. The pollen of the sugar apple is not satisfactory. Fruits from hand-pollinated flowers will be superior in form and size.

Climate

The cherimoya is subtropical or mild-temperate and does not succeed in the lowland tropics. It requires long days. In Colombia and Ecuador, it grows naturally at elevations between 4,600 and

6,600 ft (1,400-2,000 m) where the temperature ranges between 62.6° and 68°F (17°-20°C). In Peru, the ideal climate for the cherimoya is said to lie between 64.5° and 77°F (18°-25°C) in the summer and 64.5° and 41°F (18°-5°C) in winter. In Guatemala, naturalized trees are common between 4,000 and 8,200 ft (1,200-2,500 m) though the tree produces best between 4,000 and 5,900 ft (1,200-1,800 m) and can be grown at elevations as low as 2,950 ft (900 m). The tree cannot survive the cold in the Valle de Mexico at 7,200 ft (2,195 m). In Argentina, young trees are wrapped with dry grass or burlap during the winter. The cherimoya can tolerate light frosts. Young trees can withstand a temperature of 26°F (-3.33°C), but a few degrees lower will severely injure or kill mature trees. In February 1949, a small scale commercial grower (B. E. Needham) in Glendora, California, reported that most of his crop was lost because of frost and snow, the cherimoya suffering more cold damage than his avocados, oranges or lemons.

The tree prefers a rather dry environment as in southern Guatemala where the rainfall is 50 in (127 cm) and there is a long dry season. It is not adaptable to northern Guatemala where the 100 inch (254 cm) rainfall is spread throughout the year.

Finally, the tree should be protected from strong winds which interfere with pollination and fruit set.

Soil

The cherimoya tree performs well on a wide range of soil types from light to heavy, but seems to do best on a medium soil of moderate fertility. In Argentina, it makes excellent growth on rockstrewn, loose, sandy loam 2 to 3 ft (0.6-0.9 m) above a gravel subsoil. The optimum pH ranges from 6.5 to 7.6. A greenhouse trial in sand has demonstrated that the first nutritional deficiency evoked in such soil is lack of calcium.

Propagation

Cherimoya seeds, if kept dry, will remain viable for several years. While the tree is traditionally grown from seed in Latin America, the tendency of seedlings to produce inferior fruits has given impetus to vegetative propagation.

Seeds for rootstocks are first soaked in water for 1 to 4 days and those that float are discarded. Then planting is done directly in the nursery row unless the soil is too cool, in which case the seeds must be placed in sand peat seedbeds, covered with 1 in (2.5 cm) of soil and kept in a greenhouse. They will germinate in 3 to 5 weeks and when the plants are 3 to 4 in (7.5-10 cm) high, they are transplanted to pots or the nursery plot with 20 in (50 cm) between rows. When 12 to 24 months old and dormant, they are budded or grafted and then allowed to grow to 3 or 4 ft (0.9-1.2 m) high before setting out in the field. Large seedlings and old trees can be topworked by cleft-grafting. It is necessary to protect the trunk of topped trees to avoid sunburn.

The cherimoya can also be grafted onto the custard apple (*A. reticulata*). In India this rootstock has given 90% success. Cuttings of mature wood of healthy cherimoya trees have rooted in coral sand with bottom heat in 28 days.

Culture

The young trees should be spaced 25 to 30 ft (7.5-9 m) apart each way in pits 20 to 24 in (50-60 cm) wide, enriched with organic material. In Colombia, corn (maize), vegetables, ornamental foliage plants, roses or annual flowers for market are interplanted during the first few years. In Spain, the trees are originally spaced 16.5 ft (5 m) apart with the intention of later thinning them out. Thinning is not always done and around the village of Jete, where the finest cherimoyas are produced, the trees have grown so close together as to form a forest. In the early years they are interplanted with corn, beans and potatoes.

Pruning to eliminate low branches, providing a clean trunk up to 32 in (80 cm), to improve form, and open up to sunlight and pesticide control, is done preferably during dormancy. After 6 months, fertilizer (10-8-6 N, P, K) is applied at the rate of 1/2 lb (227 g) per tree and again 6 months later at 1 lb (454 g) per tree. In the 3rd year, the fertilizer formula is changed to 6-10-8 N,P,K and each year thereafter the amount per tree is increased by 1 lb (454 g) until the level of 5 lbs (2.27 kg) is reached. Thenceforth this amount is continued each year per tree. The fertilizer is applied in trenches 6 in (15 cm) deep and 8 in (20 cm) wide dug around each tree at a distance of 5 ft (1.5 m) from the base, at first; later, at an appropriately greater distance.

Young trees are irrigated every 15 to 20 days for the first few years except during the winter when they must be allowed to go dormant—ideally for 4 months. When the first leafbuds appear, irrigation is resumed. With bearing trees, watering is discontinued as soon as the fruits are full-grown.

In Chile, attempts to increase fruit set with chemical growth regulators have been disappointing. Spraying flowers with gibberellic acid has increased fruit set and improved form and size but induces deep cracking prior to full maturity, far beyond the normal rate of cracking in fruits from natural or hand-pollinated flowers.

Cropping and Yield

The cherimoya begins to bear when 3 1/2 to 5 years old and production steadily increases from the 5th to the 10th year, when there should be a yield of 25 fruits per tree—2,024 per acre (5,000 per ha). Yields of individual trees have been reported by eyewitnesses as a dozen, 85, or even 300 fruits annually. In Colombia, the average yield is 25 fruits; as many as 80 is exceptional. In Italy, trees 30 to 35 years old produce 230 to 280 fruits annually.

The fruits must be picked when full grown but still firm and just beginning to show a slight hint of yellowish-green and perhaps a bronze cast. Bolivians judge that a fruit is at full maturity by shaking it and listening for the sound of loose seeds. Italians usually wait for the yellowish hue and the sweet aroma noticeable at a distance, picking the fruits only 24 to 28 hours prior to consumption. However, if the fruits must travel to markets in central Italy, they are harvested when the skin turns from dark-green to lighter green.

In harvesting, the fruits must be clipped from the branch so as to leave only a very short stem attached to the fruit to avoid stem caused damage to the fruits in handling, packing and shipping.

Keeping Quality and Storage

Firm fruits should be held at a temperature of 50°F (10°C) to retard softening. When transferred to normal room temperature, they will become soft and ready to eat in 3 to 4 days. Then they can be kept chilled in the home refrigerator if not to be consumed immediately. A California grower has shipped cherimoyas ('Deliciosa' and 'Booth') packed in excelsior in 12 lb (5.5-kg) boxes to Boston and New York quite satisfactorily. And the fruit has been shipped from Madeira to London for many years.

In Bolivia, fruits for home use are wrapped in woollen cloth as soon as picked and kept at room temperature so that they can be eaten 3 days later.

Pests and Diseases

The cherimoya tree is resistant to nematodes. Very few problems have been noted in California except for infestations of mealybugs, especially at the base of the fruit, and these can be flushed off. In Colombia, on the other hand, it is said that a perfectly healthy tree is a rarity. In the Valle de Tenza, formerly an important center of production, lack of control of pests greatly reduced the plantations before 1960 when programs were launched to improve cherimoya culture here and in various other regions of the country.

Caterpillars (*Thecla* sp. and Oiketicus kubeyi) may defoliate the tree. A scale insect, *Conchaspis angraeci* attacks the trunk and branches. Prime enemies are reported to be fruit flies (*Anastrepha* s p.); leaf miners (*Leucoptera* sp.), particularly in the Valle de Tenza, which necessitate the collection and burning of affected leaves plus the application of systemic insecticides; and the seed borer (*Bephrata maculicollis*). The latter pest deposits eggs on the surface of the developing fruits, the larvae invade the fruit and consume the seeds, causing premature and defective ripening and rendering the fruits susceptible to fungal diseases. This pest is difficult to combat. Borers attack the tree in Argentina reducing its life span from 60 to 30 years.

The coccid, *Pseudococcus filamentosus* attacks the fruit in Hawaii, and *Aulacaspis miranda* and *Ceropute yuccae* in Mexico. In Spain, the thin-skinned cultivar 'Pinchua' is subject to attack by the Mediterranean fruit-fly, *Ceratitis capitata*.

Stored seeds for planting are subject to attack by weevils. To avoid damping-off of young seedlings, dusting of seeds with fungicide is recommended. The tree may succumb to root-rot in clay soils or where there is too much moisture and insufficient drainage. Sooty mold may occur on leaves and fruits where ants, aphids and other insects have deposited honeydew.

Fig. 19: Cherimoyas (Annona cherimola) from the highlands are sold at fruit stands along Venezuelan roadways.

Food Uses

The flesh of the ripe cherimoya is most commonly eaten out of-hand or scooped with a spoon from the cut open fruit. It really needs no embellishment but some people in Mexico like to add a few drops of lime juice. Occasionally it is seeded and added to fruit salads or used for making sherbet or ice cream. Colombians strain out the juice, add a slice of lemon and dilute with ice-water to make a refreshing soft drink. The fruit has been fermented to produce an alcoholic beverage.

Food Value Per 100 g of Edible Portion

Analysis of cherimoyas in Ecuador		*Colombian Analysis*	
Moisture	74.6 g	Moisture	77.1 g
Ether Extract	0.45 g	Protein	1.9 g
Crude Fiber	1.5 g	Fat	0.1 g
Nitrogen	.227 g	Carbohydrates	18.2 g
Ash	0.61 g	Fiber	2.0 g
Calcium	21.7 g	Ash	0.7 g
Phosphorus	30.2 mg	Calcium	32.0 mg
Iron	0.80 mg	Phosphorus	37.0 mg
Carotene	0.000 mg	Iron	0.5 mg
Thiamine	0.117 mg	Vitamin A (Carotene)	0.0 I.U.
Riboflavin	0.112 mg	Thiamine	0.10 mg
Niacin	1.02 mg	Riboflavin	0.14 mg
Ascorbic Acid	16.8 mg	Niacin	0.9 mg
		Ascorbic Acid	5.0 mg

Toxicity

The seeds, like those of other *Annona* species, are crushed and used as insecticide. Paul Allen, in his *Poisonous and Injurious Plants of Panama*, (see Bibliography), implies personal knowledge of a case of blindness resulting from "the juice of the crushed seeds coming in contact with the eyes. " The seeds contain several alkaloids: caffeine, (+)-reticuline, (-)-anonaine, liriodenine, and lanuginosine.

Human ingestion of 0.15 g of the dark-yellow resin isolated from the seeds produces dilated pupils, intense photophobia, vomiting, nausea, dryness of the mouth, burning in the throat, flatulence, and other symptoms resembling the effects of atropine. A dose of 0.5 g, injected into a medium-sized dog, caused profuse vomiting.

Wilson Popenoe wrote that hogs feed on the fallen fruits in southern Ecuador where there are many cherimoya trees and few people. One wonders whether the hogs swallow the hard seeds whole and avoid injury.

The twigs possess the same alkaloids as the seeds plus michelalbine. A team of pharmacognosists in Spain and France has reported 8 alkaloids in the leaves: (+)-isoboldine, (-)-stepholidine, (+)-corytuberine, (+) nornantenine, (+)-reticuline, (-)-anonaine, liriodenine, and lanuginosine.

Other Uses

In Jamaica, the dried flowers have been used as flavoring for snuff.

Medicinal Uses: In Mexico, rural people toast, peel and pulverize 1 or 2 seeds and take the powder with water or milk as a potent emetic and cathartic. Mixed with grease, the powder is used to kill lice and is applied on parasitic skin disorders. A decoction of the skin of the fruit is taken to relieve pneumonia.

Morton, J. 1987. Sugar Apple. p. 69–72. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sugar Apple

Annona squamosa

The most widely grown of all the species of *Annona*, the sugar apple, *A. squamosa* L., has acquired various regional names: *anon* (Bolivia, Costa Rica, Cuba, Panama); *anon de azucar*, *anon domestico, hanon, mocuyo* (Colombia); *anona blanca* (Honduras, Guatemala, Dominican Republic); *anona de castilla* (El Salvador); *anona de Guatemala* (Nicaragua); applebush (Grenadines); *ata, fruta do conde, fruta de condessa, frutiera deconde, pinha, araticutitaia*, or *ati* (Brazil); *ates* or *atis* (Philippines); *atte* (Gabon); *chirimoya* (Guatemala, Ecuador); *cachiman* (Argentina); *cachiman cannelle* (Haiti); *kaneelappel* (Surinam); *pomme cannelle* (Guadeloupe, French Guiana, French West Africa); *rinon* (Venezuela); *saramulla, saramuya, ahate* (Mexico); *scopappel* (Netherlands Antilles); sweetsop (Jamaica, Bahamas); *ata, luna, meba, sharifa, sarifa, sitaphal, sita pandu*, custard apple, scaly custard apple (India); *bnah nona, nona, seri kaya* (Malaya) *manonah, noinah, pomme cannelle du Cap* (Thailand); *qu a na* (Vietnam); *mang cau ta* (Cambodia); *mak khbieb* (Laos); *fan-li-chi* (China).

Description

Plate 8: SUGAR APPLE, *Annona squamosa*

The sugar apple tree ranges from 10 to 20 ft (3-6 m) in height with open crown of irregular branches, and some-what zigzag twigs. Deciduous leaves, alternately arranged on short, hairy petioles, are lanceolate or oblong, blunt tipped, 2 to 6 in (5-15 cm) long and 3/4 to 2 in (2-5 cm) wide; dull-green on the upperside, pale, with a bloom, below; slightly hairy when young; aromatic when crushed. Along the branch tips, opposite the leaves, the fragrant flowers are borne singly or in groups of 2 to 4. They are oblong, 1 to 1 1/2 in (2.5-3.8 cm) long, never fully open; with 1 in (2.5 cm) long, drooping stalks, and 3 fleshy outer petals, yellow-green on the outside and pale-yellow inside with a purple or dark-red spot at the base. The 3 inner petals are merely tiny scales. The compound fruit is nearly round, ovoid, or conical; 2 1/3 to 4 in (6-10 cm) long; its thick rind composed of knobby segments, pale-green, gray-green, bluish-green, or, in one form, dull, deep-pink externally (nearly always with a bloom); separating when the fruit is ripe and revealing the mass of conically segmented, creamy-white, glistening, delightfully fragrant, juicy, sweet, delicious flesh. Many of the segments enclose a single oblong-cylindric, black or dark-brown seed about 1/2 in (1.25 cm) long. There may be a total of 20 to 38, or perhaps more, seeds in the average fruit. Some trees, however, bear seedless fruits.

Origin and Distribution

The original home of the sugar apple is unknown. It is commonly cultivated in tropical South America, not often in Central America, very frequently in southern Mexico, the West Indies, Bahamas and Bermuda, and occasionally in southern Florida. In Jamaica, Puerto Rico, Barbados, and in dry regions of North Queensland, Australia, it has escaped from cultivation and is found wild in pastures, forests and along roadsides.

The Spaniards probably carried seeds from the New World to the Philippines and the Portuguese are assumed to have introduced the sugar apple to southern India before 1590. It was growing in Indonesia early in the 17 th century and has been widely adopted in southern China, Queensland, Australia, Polynesia, Hawaii, tropical Africa, Egypt and the lowlands of Palestine. Cultivation is most extensive in India where the tree is also very common as an escape and the fruit exceedingly popular and abundant in markets. The sugar apple is one of the most important fruits in the interior of Brazil and is conspicuous in the markets of Bahia.

Cultivars

The **'Seedless Cuban'** sugar apple was introduced into Florida in 1955, has produced scant crops of slightly malformed fruits with mere vestiges of undeveloped seeds. The flavor is less appealing than that of normal fruits but it is vegetatively propagated and distributed as a novelty. Another seedless type was introduced from Brazil.

Indian horticulturists have studied the diverse wild and cultivated sugar apples of that country and recognize ten different types: **'Red'** (A. *squamosa* var. *Sangareddyiz*)—red-tinted foliage and flowers, deep-pink rind, mostly non-reducing sugars, insipid, with small, blackish-pink seeds; poor quality; comes true from seed. **'Red-speckled'**—having red spots on green rind. **'Crimson'**—conspicuous red-toned foliage and flowers, deep-pink rind, pink flesh. **'Yellow'**; **'White-stemmed'**; **'Mammoth'** (A. *squamosa* var. *mammoth*)—pale yellow petals, smooth, broad, thick, round rind segments that are light russet green; fruits lopsided, pulp soft, white, very sweet; comes true from seed. **'Balangar'**—large, with green rind having rough, warty [tuberculate], fairly thick rind segments with creamy margins; sweet; high yielding. **'Kakarlapahad'**—very high yielding. **'Washington'**—acute tuberculate rind segments, orange-yellow margins; high yielding; late in season, 20 days after others. **'Barbados'** and **'British Guiana'**—having green rind, orange-yellow margins; high-yielding; late.

Named cultivars growing at the Sabahia Experiment Station, Alexandria, Egypt, include: **'Beni Mazar'**—nearly round, large, 5 1/4 to 6 1/2 oz (150-180 g); 56-60% flesh; 15 30 seeds. **'Abd El Razik'**—light-green or reddish rind; nearly round, large, maximum 8 1/3 oz (236.3 g); 69.5% flesh; 14 seeds.

Climate

The sugar apple tree requires a tropical or near-tropical climate. It does not succeed in California because of the cool winters though in Israel it has survived several degrees below freezing. Generally, it does best in dry areas and it has high drought tolerance. However, in Ceylon it flourishes in the wet as well as the dry zones from sea level to 3,500 ft (1,066 m) elevation. During the blooming season, drought interferes with pollination and it is, therefore, concluded that the sugar apple should have high atmospheric humidity but no rain when flowering. In severe droughts, the tree sheds its leaves and the fruit rind hardens and will split with the advent of rain.

Soil

The sugar apple is not particular as to soil and has performed well on sand, oolitic limestone and heavy loam with good drainage. Water-logging is intolerable. The tree is shallow-rooted and doesn't need deep soil. Irrigation water containing over 300 ppm chlorine has done the tree no harm.

Propagation

Sugar apple seeds have a relatively long life, having kept well for 3 to 4 years. They germinate better a week after removal from the fruit than when perfectly fresh. Germination may take 30 days or more but can be hastened by soaking for 3 days or by scarifying. The percentage of germination is said to be better in unsoaked seeds. While the tree is generally grown from seed, vegetative propagation is practiced where the crop is important and early fruiting is a distinct advantage.

Seedlings may be budded or grafted when one-year old. In India, selected clones grafted on *A.*

reticulata seedlings have flowered within 4 months and fruited in 8 months after planting out, compared with 2 to 4 years in seedlings. The grafted trees are vigorous, the fruits less seedy and more uniform in size. *A. senegalensis* is employed as a rootstock in Egypt. *A. glabra* is suitable but less hardy. The sugar apple itself ranks next after *A. reticulata* as a rootstock. In India, budding is best done in January, March and June. Results are poor if done inJuly, August, November or December unless the scions are defoliated and debudded in advance and cut only after the petioles have dehisced. Side-grafting can be done only from December to May, requires much skill and the rate of success has not exceeded 58.33%. Shield-budding gives 75% success and is the only commercially feasible method.

Inarching is 100% successful. Cuttings, layers, airlayers have a low rate of success, and trees grown by these techniques have shallow root systems and cannot endure drought as well as seedlings do.

Culture

In Egypt, sugar apple trees are spaced at 10 x 10 ft (3x3 m) in order to elevate atmospheric humidity and improve pollination. Palestinian growers were spacing at 16 x 16 ft (5x5 m) but changed to 16 x 10 ft (5x3 m) as more feasible. On light soils, they apply 132 to 176 lbs (60-80 kg) manure per tree annually and they recommend the addition of nitrogen. Commercial fertilizer containing 3% N, 10 % P and 10% K significantly increases flowering, fruit set and yield. Judicious pruning to improve shape and strength of tree must be done only in spring when the sap is rising, otherwise pruning may kill the tree. Irrigation during the dry season and once during ripening will increase fruit size.

Cropping and Yield

Seedlings 5 years old may yield 50 fruits per tree in late summer and fall. Older trees rarely exceed 100 fruits per tree unless hand-pollinated. With age, the fruits become smaller and it is considered best to replace the trees after 10 to 20 years. The fruits will not ripen but just turn black and dry if picked before the white, yellowish or red tint appears between the rind segments, the first signs of separation. If allowed to ripen on the tree, the fruit falls apart.

Keeping Quality

In India, mature fruits treated with 50-60 g carbide ripened in 2 days and thereafter remained in good condition only 2 days at room temperature, while those packed in straw ripened in 5-6 days and kept well for 4 days.

Storage trials in Malaya indicate that the ripening of sugar apples can be delayed by storage at temperatures between 59° and 68°F (15°-20°C) and 85-90% relative humidity, with low O2 and C2 H2. To speed ripening at the same temperature and relative humidity, levels of O2 and CO2 should be high. Storing at 39.2°F (4°C) for 5 days resulted in chilling injury.

In Egypt, of 'Beni Mazar' fruits, picked when fullgrown, ll5 days from set, and held at room temperature, 86°,to ripened in 10 days. Of 'Abd E1 Razik' fruits, 140 days from set, 56% were ripe in 15 days. Therefore, 'Abd E1 Razik' is better adapted to Upper Egypt where the climate should promote normal ripening.

Pests and Diseases

In Florida and the Caribbean, a seed borer (chalcid fly), *Bephratelloides cubensis*, infests the seeds and an associated fungus mummifies the partly grown fruits on the tree. This has discouraged many from growing the sugar apple, though in the past it was a fairly common dooryard fruit tree. Similar damage is caused by *B. maculicollis* in Colombia, Venezuela and Surinam, by *B. ruficollis* in Panama, and *B. paraguayensis* in Paraguay. The soft scale, *Philephedra* sp., attacks leaves and twigs and deposits honeydew on which sooty mold develops. Ambrosia beetles lay eggs on young stems and the larvae induce dieback during the winter.

The mealybug is the main pest in Queensland, Australia, but is easily controlled. The green tree ant is a nuisance because of the nests it makes in the tree. Bird and animal predators force Indian growers to cover the tree with netting or pick the fruits prematurely and ripen them in straw.

A serious leaf blight in India is caused by the fungus *Colletotrichum annonicola*. In 1978 a new fruit rot of sugar apple was observed in India, beginning with discoloration at one end which turns brown or black in 4 or 5 days, and 2 or 3 days later the entire fruit starts to rot. Later, the fruit is covered with gray-black mycelium and spherical bodies. The isolated fungus was identified as the *Colletotrichum* state of *Glomerella cingulata*.

Food Uses

The ripe sugar apple is usually broken open and the flesh segments enjoyed while the hard seeds are separated in the mouth and spat out. It is so luscious that it is well worth the trouble. In Malaya, the flesh is pressed through a sieve to eliminate the seeds and is then added to ice cream or blended with milk to make a cool beverage. It is never cooked.

Toxicity

The seeds are acrid and poisonous. Bark, leaves and seeds contain the alkaloid, anonaine. Six other aporphine alkaloids have been isolated from the leaves and stems: corydine, roemerine, norcorydine, norisocarydine, isocorydine and glaucine. Aporphine, norlaureline and dienone may be present also. Powdered seeds, also pounded dried fruits serve as fish poison and insecticides in India. A paste of the seed powder has been applied to the head to kill lice but must be kept away from the eyes as it is highly irritant and can cause blindness. If applied to the uterus, it induces abortion. Heat-extracted oil from the seeds has been employed against agricultural pests. Studies have shown the ether extract of the seeds to have no residual toxicity after 2 days. High concentrations are potent for 2 days and weaken steadily, all activity being lost after 8 days. In Mexico, the leaves are rubbed on floors and put in hen's nests to repel lice.

Other Uses

The **seed kernels** contain 14-49% of whitish or yellowish, non-drying oil with saponification index of 186.40. It has been proposed as a substitute for peanut oil in the manufacture of soap and can be detoxified by an alkali treatment and used for edible purposes. The leaves yield an excellent oil rich in terpenes and sesquiterpenes, mainly B-caryophyllene, which finds limited use in perfumes, giving a woody spicy accent.

Fiber extracted from the bark has been employed for cordage. The **tree** serves as host for lac-excreting insects.

Medicinal Uses: In India the crushed leaves are sniffed to overcome hysteria and fainting spells; they are also applied on ulcers and wounds and a leaf decoction is taken in cases of dysentery. Throughout tropical America, a decoction of the leaves alone or with those of other plants is imbibed either as an emmenagogue, febrifuge, tonic, cold remedy, digestive, or to clarify the urine. The leaf decoction is also employed in baths to alleviate rheumatic pain. The green fruit, very astringent, is employed against diarrhea in El Salvador. In India, the crushed ripe fruit, mixed with salt, is applied on tumors. The bark and roots are both highly astringent. The bark decoction is given as a tonic and to halt diarrhea. The root, because of its strong purgative action, is administered as a drastic treatment for dysentery and other ailments.

Food Value Per 100 g of Edible Portion*

Calories	88.9-95.7 g
Moisture	69.8-75.18 g
Fat	0.26-1.10 g
Carbohydrates**	19.16-25.19 g
Crude Fiber	1.14-2.50 g
Protein	1.53-2.38 g
Amino Acids:	
Tryptophan	9-10 mg
Methionine	7-8 mg
Lysine	54-69 mg
Minerals:	
Ash	0.55-1.34 mg
Phosphorus	23.6-55.3 mg
Calcium	19.4-44.7 mg
Iron	0.28-1.34 mg
Vitamins:	
Carotene	5-7 I.U.
Thiamine	0.100-0.13 mg
Riboflavin	0.113-0.167 mg
Niacin	0.654-0.931 mg
Ascorbic Acid	34.7-42.2 mg

*Minimum and maximum levels of constituents from analyses made in the Philippines, Central America and Cuba.

**The average sugar content is 14.58% and is about 50-50 glucose and sucrose.

Morton, J. 1987. Atemoya. p. 72–75. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Atemoya

Annona squamosa × Annona cherimola

The atemoya, *Annona squamosa* × *A. cherimola*, is a hybrid of the sugar apple and cherimoya, qq.v. It was for many years mistakenly called custard apple or cherimoya in Queensland and New South Wales. The name applied in Venezuela is *chirimorinon*.

Description

The tree closely resembles that of the cherimoya; is fast-growing; may reach 25 to 30 ft (7.5-9 m) and is short-bunked, the branches typically drooping and the lowest touching the ground. The leaves are deciduous, alternate, elliptical, leathery, less hairy than those of the cherimoya; and up to 6 in (15 cm) in length. The flowers are long-stalked, triangular, yellow, 2 3/8 in (6 cm) long and 1 1/2 to 2 in (4-5 cm) wide. The fruit is conical or heart-shaped, generally to 4 in (10 cm) long and to 3 3/4 in(9.5 cm) wide; some weighing as much as 5 lbs(2.25 kg); pale bluish-green or pea-green, and slightly yellowish between the areoles. The rind, 1/8 in (3 mm) thick, is composed of fused areoles more prominent and angular than those of the sugar apple, with tips that are rounded or slightly upturned; firm, pliable, and indehiscent. The fragrant flesh is snowy-white, of fine texture, almost solid, not conspicuously divided into segments, with fewer seeds than the sugar apple; sweet and subacid at the same time and resemblirig the cherimoya in flavor. The seeds are cylindrical, 3/4 in (2 cm) long and 5/16 in (8 mm) wide; so dark a brown as to appear black; hard and smooth.

Plate 9: ATEMOYA, *Annona squamosa* × *Annona cherimola*

Origin and Distribution

The first cross was made by the horticulturist, P.J. Wester, at the United States Department of Agriculture's subtropical laboratory, Miami, in 1908. Seedlings were planted out in 1910. Other crosses made in 1910 fruited in 1911 and seeds were taken by Wester to the Philippines. The hybrids grew there to 7 1/2 ft (2.3 m) high in one year, had to be moved to another location; one bloomed in 1913 and was pollinated by the custard apple, q.v. The rest of the plants fruited in 1914. Resulting fruits were superior in quality to the sugar apple and were given the name "atemoya", a combinetion of "ate", an old Mexican name for sugar apple, and "moya" from cherimoya. Cuttings of 9 of the hybrids were sent by Wester to the United States Department of Agriculture in January of 1915. (S.P.I. Nos. 39808-39816), #39809 representing the hybrid tree pollinated by the custard apple. In 1917, Wester sent cuttings of #39809 under the name "cuatemoya" to the United States Department of Agriculture (S.P.I. Nos. 44671-44673). In the meantime, Edward Simmons, at the Plant Introduction Field Station, Miami, had successfully grown hybrids and they had survived an early February 1917 drop in temperature to 26.5ºF (-3.10ºC), showing the hardiness derived from the cherimoya. Another introduction was received from the Philippines in 1918 (S.P.I. #45571).

A few experimental growers in southern Florida maintained atemoya trees (apparently distributed by the United States Department of Agriculture) for many years while there was a general lapse of interest in this fruit. Today, there are a few small commercial plantings and the fruits are being sent to some northern fruit dealers.

In the early 1930's or 1940's, what were apparently chance hybrids between adjacent sugar apple and cherimoya orchards attracted attention in Israel and work was begun to choose and standardize the best of these for vegetative propagation.

Varieties

One of the first named selections of atemoya was the **'Page'**, so-named by Roy Page of Coral Gables who took budwood from superior atemoya trees on the property of Morrison Page in the Redlands. Perhaps the second was the **'Bradley'** which the Newcomb Nursery sold grafted onto custard apple.

An early hybrid that arose in Queensland after the introduction of cherimoya seeds from South America, was named **'Mammoth'** (or 'Pink's Prolific', or 'Pink's Mammoth') and became the basis of the commercial production of atemoyas there and on the north coast of New South Wales, though the flesh of this cultivar immediately below the rind is usually brownish and bitter. **'Island Beauty'**, a vigorous selection with excellent fruit quality was grown to a lesser extent. 'Mammoth' was introduced into Hawaii from Queensland in 1960 and grafted plants were soon being distributed by agricultural stations of the University of Hawaii in Kona and Hilo, and being sold by nurseries in Honolulu.

'African Pride' is an improved clone that originated in South Africa. It was introduced into Queensland by Langbecker Nurseries and 3,000 trees were released for commercial planting in July 1961. It was quickly adopted as a replacement for 'Mammoth' as it was free of the discoloration and bitterness next to the skin. In 1963, 6 plants of 'African Pride' were obtained from Landbecker's by private experimenters and planted at several locations in southern Florida. They began fruiting in 1965. The fruits appeared to be superior in quality to the 'Page' and 'Bradley'.

Israeli selections tried at the University of Florida's Agricultural Research and Education Center, Homestead, and the United States Department of Agriculture's Subtropical Horticulture Research Unit, Miami, are **'Geffner'**, **'Malamud'**, **'Bernitski'**, **'Kabri'** and **'Malai #1'**. Other named selections that have been grown in Florida over the years are **'Caves'**, **Chirimorinon** A, B and C, **'Island Gem'**, **'Keller'**, **'Lindstrom'**, **'Priestly'** and **'Stermer'**. 'Geffner' is being propagated at the AREC, Homestead; 'Priestly' by the Zill Nursery in Boynton Beach. None of the others have outstanding features; some develop hard spots in the flesh. In 'Keller' there is frequently a black membrane around each seed-containing carper.

'Cherimata' and **'Finny'** are Egyptian clones. 'Finny' is somewhat cylindrical, is more productive than'Cherimata', has been grown in Egypt for many years and is considered the best for commercial production in coastal districts.

Pollination

The atemoya and other annona trees bear hermaphroditic protogynous flowers and self-pollination is rare. Atemoyas are sometimes misshapen, underdeveloped on one side, as the result of inadequate pollination. The flower, in its female stage, opens between 2 and 4 o'clock in the afternoon. Between 3 and 5 o'clock on the following afternoon, the flower converts to its male stage. In cold and humid climates it releases pollen even though it is sticky. Where the climate is hot and the humidity low at the blooming season, the carpers are short lived and the stigmatic surface soon dries up and insects are necessary to transfer the pollen. Studies in Israel have identified the principal insect pollinators as nitidulid beetles—*Carpophilus hemipterus*, C. *mutilatus*, *Haptoncus luteolus*, and *Uroporus humeralis*. Even where these beetles are present, hand-pollination will enhance fruit-setting and this is commonly practiced in Egypt. Spraying the flowers several times with gibberellin at 1,000 ppm has increased fruit yield. The resulting fruits are seedless but smaller and less flavorful than fruits with seeds.

Climate

The atemoya is slightly hardier than the sugar apple but still is limited to tropical or near-tropical lowlands. In New South Wales, it is said to do best near the coast where rainfall and humidity are high and winters are warm. Rainy weather during the ripening season, however, may cause the fruits to split.

Soil

The tree thrives in various types of soil, from sandy loam to red basalt or heavy clay, but best growth and productivity occur in deep, rich loam of medium texture, with good organic content and a moderate amount of moisture. Good drainage is essential; waterlogging is fatal.

Propagation

Atemoyas for rootstocks are raised from seeds which germinate in about 4 weeks in seedbeds. Seedlings are transplanted to nursery rows when they are a year old and they are placed 18 in (45 cm) apart in rows 3 ft (90 cm) apart. Grafting is done in the spring, using the whip- or tongue-graft. If older trees are top worked, it is done by cleft- or bark-grafting. Scion wood is taken from selected cultivars after the leaves have fallen. In Florida and India, the atemoya is usually grafted onto the custard apple or sugar apple. Cherimoya is used as a rootstock in Israel.

Culture

When transferred to the field at the near-dormant period, grafted plants are spaced 28 to 30 ft (8.5-9 m) apart each way and cut back to a height of 24 to 30 in (60-75 cm). Weeds are eliminated to avoid competition with the spreading, shallow root system. During the next 2 or 3 years, the trees are kept pruned to form a strong frame. Thereafter, only light pruning is done. No fertilizer is applied until after the trees are well established, since the young roots are very sensitive. A 6-10-16 formula is recommended for broadcasting over the root area, the amount gradually increased to 10 to 12 lbs (4.5-5.4 kg) annually for mature trees. Half is given in the spring a month before flowering. Irrigation during flowering and fruit setting improves yield and fruit quality.

Season

In Florida, the atemoya ripens in the fall. In Queensland, the main blooming period is October and November and the fruits mature in April and May. If there is light fruit set in October/November, flowering may continue to February and the fruit from such late blooms may have to be picked prematurely and ripened artificially to avoid cold night temperatures, but it will not develop the highest quality.

Harvesting

The fruits must be clipped from the branch, taking care that the stalk left on the fruit does not protrude beyond the shoulders. Frequent picking is necessary to harvest the fruit at the ideal stage, that is, when creamy lines appear around the areoles showing that the spaces between them are widening. If picked too soon, the fruit will not ripen but will darken and shrivel.

Fruits colonized by mealybugs have to be cleaned by brushing or the use of compressed air before marketing. The fruits should not be wrapped because this will speed ripening, but they need to be packed in boxes with padding between layers. Because of the irregular form, the fruits must be carefully fitted together with the base of each fruit against the wall of the container and the more delicate apex inward.

Yield

The atemoya is a shy yielder, mainly for the reason mentioned under "Pollination". Trees 5 years old are expected to bear 50 fruits annually. In Queensland, commercial groves have produced 5 bushels of fruit per tree—67 bushels per acre (165.5 bu/ha). An exceptionally large atemoya tree in Florida yielded 11 bushels of fruits in the 1972 season.

Keeping Quality

Atemoyas keep very well in cool, shady, well-ventilated storage for at least 3 weeks. The rind may darken before the interior shows any signs of spoilage. The ideal temperature for refrigerated storage is 68ºF (20ºC), though an acceptable temperature range is 59º to 77ºF (15º-25ºC). Lower temperatures cause chilling injury.

Pests and Diseases

The citrus mealybug, *Planococcus citri*; which congregates around the base of the fruit, is the most common pest, and sooty mold develops on its exodate.

In Queensland, the protective activities of the natural enemies of the mealybug are disrupted by the coastal brown ant, *Pheidole megacephala*, which carries mealybugs up the trunk and around between the fruits. Australian growers have tried sticky-banding the trunks and this has reduced the numbers of ants but not sufficiently.

The chalcid fly that lays eggs in the seeds and makes exit holes in the fruit permitting entrance of fungi, occasionally causes mummification of the atemoya. White wax, pink wax, and brown olive scales may be found on the foliage but are shed along with the leaves.

A condition called "littleleaf" is not a disease but zinc deficiency which can be corrected by foliar spraying.

Atemoyas are prone to collar rot (*Phytophthora* sp.), the first sign being an exudation of gum near the base of the trunk and on the crown roots.

Food Value Per 100 g of Edible Portion of Ripe Fruit*

Calories	94
Moisture	71.48-78.7 g
Protein	1.07-1.4 g
Fat	0.4-0.6 g
Carbohydrates	24 g
Fiber	0.05-2.5 g
Ash	0.4-0.75 g
Sodium	4-5 mg
Potassium	250 mg

Iron	0.3 mg
Calcium	17 mg
Magnesium	32 mg
Zinc	0.2 mg
Thiamine	0.05 mg
Riboflavin	0.07 mg
Niacin	0.8 mg
a-carotene	10 mcg
B-carotene	10 mcg
Cryptoxanthin	10 mcg
Ascorbic Acid	50 mg

*Analyses made in Florida, the Philippines and at the University of New South Wales.

Food Uses

The atemoya, preferably chilled, is one of the most delicious of fruits. It needs no seasoning. It may be simply cut in half or quartered and the flesh eaten from the "shell" with a spoon. Slices or cubes of the pulp may be added to fruit cups or salads or various dessert recipes. Some people blend the pulp with orange juice, lime juice and cream and freeze as ice cream.

Toxicity

The seeds, like those of all *Annona* species, are toxic and care should be taken to seed the pulp before it is mechanically blended.

Morton, J. 1987. Soursop. p. 75–80. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Soursop

Annona muricata

Of the 60 or more species of the genus *Annona*, family Annonaceae, the soursop, *A. muricata* L., is the most tropical, the largest-fruited, and the only one lending itself well to preserving and processing.

It is generally known in most Spanish-speaking countries as *guanabana*; in E1 Salvador, as *guanaba*; in Guatemala, as *huanaba*; in Mexico, often as *zopote de viejas*, or *cabeza de negro*; in Venezuela, as *catoche* or *catuche*; in Argentina, as *anona de puntitas* or *anona de broquel*; in Bolivia, *sinini*; in Brazil, *araticum do grande, graviola*, or *jaca do Para*; in the Netherlands Antilles, *sorsaka* or *zunrzak*, the latter name also used in Surinam andJava; in French-speaking areas of the West Indies, West Africa, and Southeast Asia, especially North Vietnam, it is known as *corossol, grand corossol, corossol epineux*, or *cachiman epineux*. In Malaya it may be called *durian belanda, durian maki*; or *seri kaya belanda*; in Thailand, *thu-rian-khack*.

In 1951, Prof. Clery Salazar, who was encouraging the development of soursop products at the

College of Agriculture at Mayaguez, Puerto Rico, told me that they would like to adopt an English name more appealing than the word "soursop", and not as likely as *guanabana* to be mispronounced. To date, no altematives have been chosen.

Description

The soursop tree is low-branching and bushy but slender because of its upturned limbs, and reaches a height of 25 or 30 ft (7.5-9 m). Young branchlets are rusty-hairy. The malodorous leaves, normally evergreen, are alternate, smooth, glossy, dark green on the upper surface, lighter beneath; oblong, elliptic or narrowobovate, pointed at both ends, 2 1/2 to 8 in (6.25-20 cm) long and 1 to 2 1/2 in (2.5-6.25 cm) wide. The flowers, which are borne singly, may emerge anywhere on the trunk, branches or twigs. They are short stalked, 1 1/2 to 2 in (4 5 cm) long, plump, and triangular-conical, the 3 fleshy, slightly spreading, outer petals yellow-green, the 3 close-set inner petals pale-yellow.

Plate 10: SOURSOP, *Annona muricata*

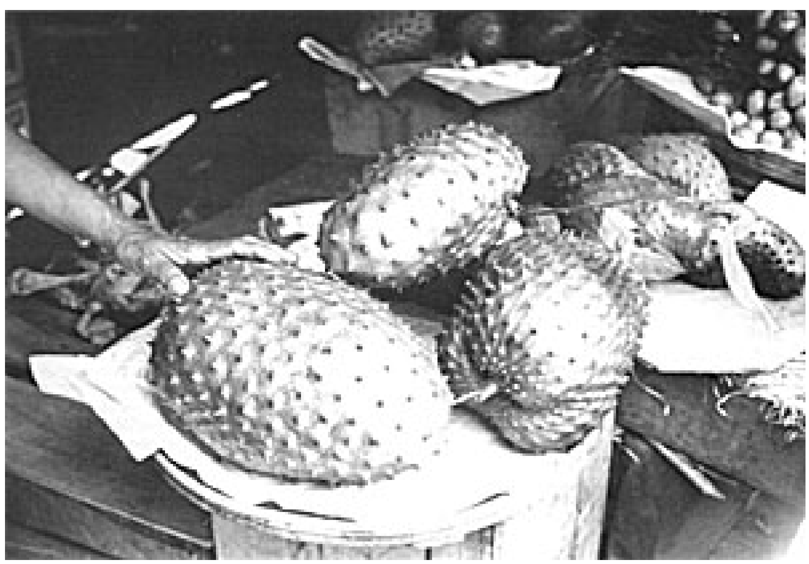


Fig. 20: Exceptionally large and well-formed soursops (*Annona muricata*) in a Saigon market, 1968.

The fruit is more or less oval or heart-shaped, some times irregular, lopsided or curved, due to improper carper development or insect injury. The size ranges from 4 to 12 in (10-30 cm) long and up to 6 in (15 cm) in width, and the weight may be up to 10 or 15 lbs (4.5-6.8 kg). The fruit is compound and covered with a reticulated, leathery-appearing but tender, inedible, bitter skin from which protrude few or many stubby, or more elongated and curved, soft, pliable "spines". The tips break off easily when the fruit is fully ripe. The skin is dark-green in the immature fruit, becoming slightly yellowish-green before the mature fruit is soft to the touch. Its inner surface is cream-colored and granular and separates easily from the mass of snow-white, fibrous, juicy segments—much like flakes of raw fish—surrounding the central, soft-pithy core. In aroma, the pulp is somewhat pineapple-like, but its musky, subacid to acid flavor is unique. Most of the closely-packed segments are seedless. In each fertile segment there is a single oval, smooth, hard, black seed, l/2 to 3/4 in (1.25-2 cm) long; and a large fruit may contain from a few dozen to 200 or more seeds.

Origin and Distribution

Oviedo, in 1526, described the soursop as abundant in the West Indies and in northern South America. It is today found in Bermuda and the Bahamas, and both wild and cultivated, from sea-level to an altitude of 3,500 ft (1,150 m) throughout the West Indies and from southern Mexico to Peru and Argentina. It was one of the first fruit trees carried from America to the Old World Tropics where it has become widely distributed from southeastern China to Australia and the warm lowlands of eastern and western Africa. It is common in the markets of Malaya and southeast Asia. Very large, symmetrical fruits have been seen on sale in South Vietnam. It became well established at an early date in the Pacific Islands. The tree has been raised successfully but has never fruited in Israel.

In Florida, the soursop has been grown to a limited extent for possibly 110 years. Sturtevant noted that it was not included by Atwood among Florida fruits in 1867 but was listed by the American Pomological Society in 1879. A tree fruited at the home of John Fogarty of Manatee before the freeze of 1886. In the southeastern part of the state and especially on the Florida Keys, it is often planted in home gardens.

In regions where sweet fruits are preferred, as in South India and Guam, the soursop has not enjoyed great popularity. It is grown only to a limited extent in Madras. However, in the East Indies it has been acclaimed one of the best local fruits. In Honolulu, the fruit is occasionally sold but the demand exceeds the supply. The soursop is one of the most abundant fruits in the Dominican Republic and one of the most popular in Cuba, Puerto Rico, the Bahamas, Colombia and northeastern Brazil.

In 1887, Cuban soursops were selling in Key West, Florida, at 10 to 50 cents apiece. In 1920, Wilson Popenoe wrote that: "In the large cities of tropical America, there is a good demand for the fruits at all times of the year, a demand which is not adequately met at present." The island of Grenada produces particularly large and perfect soursops and regularly delivers them by boat to the market of Port-of Spain because of the shortage in Trinidad. In Colombia, where the soursop is generally large, well-formed and of high quality, this is one of the 14 tropical fruits recommended by the Instituto Latinoamericano de Mercadeo Agricola for large-scale planting and marketing. Soursops produced in small plots, none over 5 acres (2.27 ha), throughout Venezuela supply the processing plants where the frozen concentrate is packed in 6 oz (170 g) cans. In 1968, 2,266 tons (936 MT) of juice were processed in Venezuela. The strained pulp is also preserved commercially in Costa Rica. There are a few commercial soursop plantations near the south coast of Puerto Rico and several processing factories. In 1977, the Puerto Rican crop totaled 219,538 lbs (99,790 kg).

At the First International Congress of Agricultural and Food Industries of the Tropical and Subtropical Zones, held in 1964, scientists from the Research Laboratories of Nestle Products in Vevey, Switzerland, presented an evaluation of lesser-known tropical fruits and cited the soursop, the guava and passionfruit as the 3 most promising for the European market, because of their distinctive aromatic qualities and their suitability for processing in the form of preserved pulp, nectar and jelly.

Varieties

In Puerto Rico, the wide range of forms and types of seedling soursops are roughly divided into 3 general classifications: sweet, subacid, and acid; then subdivided as round, heart-shaped, oblong or angular; and finally classed according to flesh consistency which varies from soft and juicy to firm and comparatively dry. The University of Puerto Rico's Agricultural Experiment Station at one time cataloged 14 different types of soursops in an area between Aibonito and Coamo. In El Salvador, 2 types of soursops are distinguished: *guanaba azucaron* (sweet) eaten raw and used for drinks; and *guanaba acida* (very sour), used only for drinks. In the Dominican Republic, the *guanabana dulce* (sweet soursop) is most sought after. The term "sweet" is used in a relative sense to indicate low acidity. A medium-sized, yellow-green soursop called *guanabana sin fibre* (fiberless) has been vegetatively propagated at the Agricultural Experiment Station at Santiago de las Vegas, Cuba. The foliage of this superior clone is distinctly bluish-green. In 1920, Dr. Wilson Popenoe sent to the United States Department of Agriculture, from Costa Rica, budwood of a soursop he named 'Bennett' in honor of G.S. Bennett, Agricultural Superintendent of the Costa Rican Division of the United Fruit Company. He described the fruit as large and handsome (as shown in the photograph accompanying the introduction record No. 51050) and he declared the tree to be the most productive he had seen.

Climate

The soursop is truly tropical. Young trees in exposed places in southem Florida are killed by only a few degrees of frost. The trees that survive to fruiting age on the mainland are in protected situations, close to the south side of a house and sometimes near a source of heat. Even so, there will be temporary defoliation and interruption of fruiting when the temperature drops to near freezing. In Key West, where the tropical breadfruit thrives, the soursop is perfectly at home. In Puerto Rico, the tree is said to prefer an altitude between 800 and 1,000 ft (244300 m), with moderate humidity, plenty of sun and shelter from strong winds.

Fig. 21: The soursop tree may bear fruits anywhere on its trunk or branches. Multiple-stems of this tree are the result of its having been frozen to the ground more than once.

Soil

Best growth is achieved in deep, rich, well-drained, semi-drysoil, but the soursop tree can be and is commonly grown in acid and sandy soil, and in the porous, oolitic limestone of South Florida and the Bahama Islands.

Propagation

The soursop is usually grown from seeds. They should be sown in flats or containers and kept moist and shaded. Germination takes from 15 to 30 days. Selected types can be reproduced by cuttings or by shield-budding. Soursop seedlings are generally the best stock for propagation, though grafting onto custard apple (*Annona reticulata*), the mountain soursop (*A. montana*), or pond apple (*A. glabra*), is usually successful. The pond apple has a dwarfing effect. Grafts on sugar apple (*A. squamosa*) and cherimoya (*A. cherimola*) do not live for long, despite the fact that the soursop is a satisfactory rootstock for sugar apple in Ceylon and India.

Culture

In ordinary practice, seedlings, when 1 ft (30 cm) or more in height are set out in the field at the beginning of the rainy season and spaced 12 to 15 ft (3.65-4.5 m) apart, though 25 ft (7.5 m) each way has been suggested. A spacing of 20 x 25 ft (6x7.5 m) allows 87 trees per acre (215/ha). Close-spacing, 8 x 8 ft (2.4x2.4 m) is thought aufficient for small gardens in Puerto Rico. The tree grows rapidly and begins to bear in 3 to 5 years. In Queensland, well-watered trees have attained 15 to 18 ft (4.5-5.5 m) in 6 to 7 years. Mulching is recommended to avoid dehydration of the shallow, fibrous root system during dry, hot weather. If in too dry a situation, the tree will cast off all of its old leaves before new ones appear. A fertilizer mixture containing 10% phosphoric acid, 10% potash and 3% nitrogen has been advocated in Cuba and Queensland. But excellent results have been obtained in Hawaii with quarterly applications of 10-10-10 N P K—1\2 lb (.225 kg) per tree the first year, 1 lb (.45 kg)/tree the 2nd year, 3 lbs (1.36 kg)/tree the 3rd year and thereafter.

Season

The soursop tends to flower and fruit more or less continuously, but in every growing area there is a principal season of ripening. In Puerto Rico, this is from March to June or September; in Queensland, it begins in April; in southern India, Mexico and Florida, it extends from June to September; in the Bahamas, it continues through October. In Hawaii, the early crop occurs from January to April; midseason crop, June to August, with peak in July; and there is a late crop in October or November.

Harvesting

The fruit is picked when full grown and still firm but slightly yellow-green. If allowed to soften on the tree, it will fall and crush. It is easily bruised and punctured and must be handled with care. Firm fruits are held a few days at room temperature. When eating ripe, they are soft enough to yield to the slight pressure of one's thumb. Having reached this stage, the fruit can be held 2 or 3 days longer in a refrigerator. The skin will blacken and become unsightly while the flesh is still unspoiled and usable. Studies of the ripening process in Hawaii have determined that the optimum stage for eating is 5 to 6 days after harvest, at the peak of ethylene production. Thereafter, the flavor is less pronounced and a faint offodor develops. In Venezuela, the chief handicap in commercial processing is that the fruits stored on racks in a cool shed must be gone over every day to select those that are ripe and ready for juice extraction.

Yield

The soursop, unfortunately, is a shy-bearer, the usual crop being 12 to 20 or 24 fruits per tree. In Puerto Rico, production of 5,000 to 8,000 lbs per acre (roughly equal kg/ha), is considered a good yield from well-cared-for trees. A study of the first crop of 35 5 year-old trees in Hawaii showed an average of 93.6 lbs (42.5 kg) of fruits per tree. Yield was slightly lower the 2nd year. The 3rd year, the average yield was 172 lbs (78 kg) per tree. At this rate, the annual crop would be 16,000 lbs per acre (roughly equal kg/ha).

Pests & Diseases

Queensland's principal soursop pest is the mealybug which may occur in masses on the fruits. The mealybug is a common pest also in Florida, where the tree is often infessed with scale insects. Sometimes it may be infected by a lace-wing bug.

The fruit is subject to attack by fruit flies—*Anastrepha suspensa, A. striata* and *Ceratitis capitata*. Red spiders are a problem in dry climates.

Dominguez Gil (1978 and 1983), presents an extensive list of pests of the soursop in the State of Zulia, Venezuela. The 5 most damaging are: 1) the wasp, *Bephratelloides* (*Bephrata*) *maculicollis*, the larvae of which live in the seeds and emerge from the fully-grown ripe fruit, leaving it perforated and highly perishable; 2) the moth, *Cerconota* (*Stenoma*) *anonella*, which lays its eggs in the very young fruit causing stunting and malformation; 3) *Corythucha gossipii*; which attacks the leaves; 4) *Cratosomus inaequalis*, which bores into the fruit, branches and trunk; 5) *Laspeyresia* sp., which perforates the flowers. The first 3 are among the 7 major pests of the soursop in Colombia, the other 4 being: *Toxoptera aurantii*; which affects shoots, young leaves, flowers and fruits; present but not important in Venezuela; *Aphis spiraecola*; *Empoasca* sp., attacking the leaves; and *Aconophora concolor*, damaging the flowers and fruits. Important beneficial agents preying on aphids are *A phidius testataceipes, Chrysopa* sp., and *Curinus* sp. Lesser enemies of the soursop in South America include: *Talponia backeri* and *T. batesi* which damage flowers and fruits; *Horiola picta* and *H. lineolata*, feeding on flowers and young branches; *Membracis foliata*, attacking young branches, flower stalks and fruits; *Saissetia nigra*; *Escama ovalada*, on branches, flowers and fruits; *Cratosomus bombina*, a fruit borer; and *Cyclocephala signata*, affecting the flowers.

In Trinidad, the damage done to soursop flowers by *Thecla ortygnus* seriously limits the cultivation of this fruit. The sphinx caterpillar, *Cocytius antueus antueus* may be found feeding on soursop leaves in Puerto Rico. Bagging of soursops is necessary to protect them from *Cerconota anonella*. However, one grower in the Magdalena Valley of Colombia claims that bagged fruits are more acid than others and the flowers have to be handpollinated.

It has been observed in Venezuela and El Salvador that soursop trees in very humid areas often grow well but bear only a few fruits, usually of poor quality, which are apt to rot at the tip. Most of their flowers and young fruits fall because of anthracnose caused by *Collectotrichum gloeosporioides*. It has been said that soursop trees for cultivation near San Juan, Puerto Rico, should be seedlings of trees from similarly humid areas which have greater resistance to anthracnose than seedlings from dry zones. The same fungus causes damping-off of seedlings and die-back of twigs and branches. Occasionally the fungus, *Scolecotrichum* sp. ruins the leaves in Venezuela. In the East Indies, soursop trees are sometimes subject to the root-fungi, *Fomes lamaoensis* and *Diplodia* sp. and by pink disease due to *Corticum salmonicolor*.

Food Uses

Soursops of least acid flavor and least fibrous consistency are cut in sections and the flesh eaten with a spoon. The seeded pulp may be torn or cut into bits and added to fruit cups or salads, or chilled and served as dessert with sugar and a little milk or cream. For years, seeded soursop has been canned in Mexico and served in Mexican restaurants in New York and other northern cities.

Most widespread throughout the tropics is the making of refreshing soursop drinks (called *champola* in Brazil; *carato* in Puerto Rico). For this purpose, the seeded pulp may be pressed in a colander or sieve or squeezed in cheesecloth to extract the rich, creamy juice, which is then beaten with milk or water and sweetened. Or the seeded pulp may be blended with an equal amount of boiling water and then strained and sweetened. If an electric blender is to be used, one must first be careful to remove all the seeds, since they are somewhat toxic and none should be accidentally ground up in the juice.

Fig. 22: Canned soursop concentrate is produced in Venezuela. On the branch at the right is a soursop flower.

In Puerto Rican processing factories, the hand-peeled and cored fruits are passed through a mechanical pulper having nylon brushes that press the pulp through a screen, separating it from the seeds and fiber. A soursop soft drink, containing 12 to 15% pulp, is canned in Puerto Rico and keeps well for a year or more. The juice is prepared as a carbonated bottled beverage in Guatemala, and a fermented, cider-like drink is sometimes made in the West Indies. The vacuum-concentrated juice is canned commercially in the Philippines. There soursop drinks are popular but the normal "milk" color is not. The people usually add pink or green food coloring to make the drinks more attractive. The strained pulp is said to be a delicacy mixed with wine or brandy and seasoned with nutmeg. Soursop juice, thickened with a little gelatin, makes an agreeable dessert.

In the Dominican Republic, a soursop custard is enjoyed and a confection is made by cooking soursop pulp in sugar sirup with cinnamon and lemon peel. Soursop ice cream is commonly frozen in refrigerator ice-cube trays in warm countries.

In the Bahamas, it is simply made by mashing the pulp in water, letting it stand, then straining to remove fibrous material and seeds. The liquid is then blended with sweetened condensed milk, poured into the trays and stirred several times while freezing. A richer product is made by the usual method of preparing an ice cream mix and adding strained soursop pulp just before freezing. Some Key West restaurants have always served soursop ice cream and now the influx of residents from the Caribbean and Latin American countries has created a strong demand for it. The canned pulp is imported from Central America and Puerto Rico and used in making ice cream and sherbet commercially. The pulp is used, too, for making tarts and jelly, sirup and nectar. The sirup has been bottled in Puerto Rico for local use and export. The nectar is canned in Colombia and frozen in Puerto Rico and is prepared fresh and sold in paper cartons in the Netherlands Antilles. The strained, frozen pulp is sold in plastic bags in Philippine supermarkets.

Immature soursops are cooked as vegetables or used in soup in Indonesia. They are roasted or fried in northeastern Brazil. I have boiled the half-grown fruit whole, without peeling. In an hour, the fruit is tender, its flesh off-white and mealy, with the aroma and flavor of roasted ears of green corn (maize).

Food Value Per 100 g of Edible Portion*

Calories	61.3-53.1
Moisture	82.8g
Protein	1.00g
Fat	0.97g
Carbohydrates	14.63g
Fiber	0.79g
Ash	60g
Calcium	10.3 mg
Phosphorus	27.7 mg
Iron	0.64 mg
Vitamin A (B-carotene)	0
Thiamine	0.11 mg
Riboflavin	0.05 mg
Niacin	1.28mg
Ascorbic Acid	29.6 mg
Amino Acids:	
Tryptophan	11 mg
Methionine	7 mg
Lysine	60mg

*Analyses made at the Laboratorio FIM de Nutricion, Havana, Cuba.

Toxicity

The presence of the alkaloids anonaine and anoniine has been reported in this species. The alkaloids muricine, C19H21O4N (possibly des-N-methylisocorydine or des-N methylcorydine) and muricinine, C18H19O4 (possibly des-N-methylcorytuberine), are found in the bark. Muricinine is believed to be identical to reticuline. An unnamed alkaloid occurs in the leaves and seeds. The bark is high in hydrocyanic acid. Only small amounts are found in the leaves and roots and a trace in the fruit. The seeds contain 45% of a yellow non-drying oil which is an irritant poison, causing severe eye inflarnmation.

Other Uses

Fruit: In the Virgin Islands, the fruit is placed as a bait in fish traps.

Seeds: When pulverized, the seeds are effective pesticides against head lice, southern army worms and pea aphids and petroleum ether and chloroform extracts are toxic to black carpet beetle larvae. The seed oil kills head lice.

Leaves: The leaf decoction is lethal to head lice and bedbugs.

Bark: The bark of the tree has been used in tanning. The bark fiber is strong but, since fruiting trees are not expendable, is resorted to only in necessity. Bark, as well as seeds and roots, has been used as fish poison.

Wood: The wood is pale, aromatic, soft, light in weight and not durable. It has been used for ox yokes because it does not cause hair loss on the neck.

In Colombia, it is deemed to be suitable for pipestems and barrelstaves. Analyses in Brazil show cellulose content of 65 to 76%, high enough to be a potential source of paper pulp.

Medicinal Uses: The juice of the ripe fruit is said to be diuretic and a remedy for haematuria and urethritis. Taken when fasting, it is believed to relieve liver ailments and leprosy. Pulverized immature fruits, which are very astringent, are decocted as a dysentery remedy. To draw out chiggers and speed healing, the flesh of an acid soursop is applied as a poultice unchanged for 3 days.

In *Materia Medica* of British Guiana, we are told to break soursop leaves in water, "squeeze a couple of limes therein, get a drunken man and rub his head well with the leaves and water and give him a little of the water to drink and he gets as sober as a judge in no time." This sobering or tranquilizing formula may not have been widely tested, but soursop leaves are regarded throughout the West Indies as having sedative or soporific properties. In the Netherlands Antilles, the leaves are put into one's pillowslip or strewn on the bed to promote a good night's sleep. An infusion of the leaves is commonly taken internally for the same purpose. It is taken as an analgesic and antispasmodic in Esmeraldas Province, Ecuador. In Africa, it is given to children with fever and they are also bathed lightly with it. A decoction of the young shoots or leaves is regarded in the West Indies as a remedy for gall bladder trouble, as well as coughs, catarrh, diarrhea, dysentery and indigestion; is said to "cool the blood," and to be able to stop vomiting and aid delivery in childbirth. The decoction is also employed in wet compresses on inflammations and swollen feet. The chewed leaves, mixed with saliva, are applied to incisions after surgery, causing proudflesh to disappear without leaving a scar. Mashed leaves are used as a poultice to alleviate eczema and other skin afflictions and rheumatism, and the sap of young leaves is put on skin eruptions.

The roots of the tree are employed as a vermifuge and the root bark as an antidote for poisoning. A tincture of the powdered seeds and bay rum is a strong emetic. Soursop flowers are believed to alleviate catarrh.

Morton, J. 1987. Custard Apple. p. 80–83. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Custard Apple

Annona reticulata

Both in tree and in fruit, the custard apple, *Annona reticulata* L., is generally rated as the mediocre or "ugly duckling" species among the prominent members of this genus. Its descriptive English name has been widely misapplied to other species and to the hybrid ATEMOYA, and it is sometimes erroneously termed "sugar apple", "sweetsop" and, by Spanish-speaking people, "*anon*" or "*rinon*", in India, "*ramphal*", all properly applied only to Annona squamosa. It has, itself, acquired relatively few appropriate regional names. Most commonly employed as an alternate name in English-speaking areas is bullock's-heart or bull's-heart; in French, *coeur de boeuf*; Portuguese, *coracao de boi*; in Spanish, often merely *corazon*—all alluding to its form and external blush. The skin color is reflected in the Bolivian name, *chirimoya roia*, the Salvadoran *anona rosada*, and the Guatemalan *anona roja* or *anona colorada*. In the latter country it is also known as *anona de seso*. *Araticum ape* or *araticum do mato* are additional names in Brazil. Some people refer to it as Jamaica apple, or as netted custard apple, which is translated as *anona de redecilla* in Honduras and Nicaragua. *Cachiman, cachiman coeur de boeuf* and *corossol sauvage* may be heard in the French-influenced West Indies.

In the Netherlands Antilles it is *kasjoema*. This name and *boeah nona* are used in Surinam. In Cuba, it is *mamon* or *chirimoya*. Some Central Americans give it the name *anona*, or *anonillo*; Colombians, *anon pelon*. To the Carib Indians the fruit was known as *alacalyoua*; to the Aztecs, *quaultzapotl*, and to the Maya, *tsulimay*, *tsulilpox*, *tsulipox*, *pox*, *oop*, or *op*. It is generally called in the Philippines *sarikaya*; in India *ramphal*, *nona* or *luvuni*, in Malaya, *nona kapri*, or *lonang*; in Thailand, *noi nong*";; in Cambodia, *mo bat* or *mean bat*; in Laos, *khan tua lot*; in South Vietnam, *binh bat*; North Vietnam, *qua na*.

Description

The custard apple tree is not especially attractive. It is erect, with a rounded or spreading crown and trunk 10 to 14 in (25-35 cm) thick. Height ranges from 15 to 35 ft (4.5-10 m). The ill-smelling leaves are deciduous, alternate, oblong or narrow-lanceolate, 4 to 8 in (10-20 cm) long, 3/4 to 2 in (2 5 cm) wide, with conspicuous veins. Flowers, in drooping clusters, are fragrant, slender, with 3 outer fleshy, narrow petals 3/4 to 1 1/4 in (2 3 cm) long; light-green externally and pale-yellow with a dark-red or purple spot on the inside at the base. The flowers never fully open.

Fig. 23: Bahamian custard apples (*Annona reticulata*) show typical variability in form and roughness of surface.

The compound fruit, 3 l/4 to 6 1/2 in (8-16 cm) in diameter, may be symmetrically heart-shaped, lopsided, or irregular; or nearly round, or oblate, with a deep or shallow depression at the base. The skin, thin but tough, may be yellow or brownish when ripe, with a pink, reddish or brownish-red blush, and faintly, moderately, or distinctly reticulated. There is a thick, cream-white layer of custardlike, somewhat granular, flesh beneath the skin surrounding the concolorous moderately juicy segments, in many of which there is a single, hard, dark-brown or black, glossy seed, oblong, smooth, less than 1/2 in (1.25 cm) long. Actual seed counts have been 55, 60 and 76. A pointed, fibrous, central core, attached to the thick stem, extends more than halfway through the fruit. The flavor is sweet and agreeable though without the distinct character of the cherimoya, sugar apple, or atemoya.

Origin and Distribution

The custard apple is believed to be a native of the West Indies but it was carried in early times through Central America to southern Mexico. It has long been cultivated and naturalized as far south as Peru and Brazil. It is commonly grown in the Bahamas and occasionally in Bermuda and southern Florida.

Apparently it was introduced into tropical Africa early in the 17th century and it is grown in South Africa as a dooryard fruit tree. In India the tree is cultivated, especially around Calcutta, and runs wild in many areas. It has become fairly common on the east coast of Malaya, and more or less throughout southeast Asia and the Philippines though nowhere particularly esteemed. Eighty years ago it was reported as thoroughly naturalized in Guam. In Hawaii it is not well known.

Cultivars

No named cultivars are reported but there is considerable variation in the quality of fruit from different trees. The yellow-skinned types seem superior to the brownish, and, when well filled out, have thicker and juicier flesh. Seeds of a purple-skinned, purple-fleshed form, from Mexico, were planted in Florida and the tree has produced fruit of unremarkable quality.

Climate

The custard apple tree needs a tropical climate but with cooler winters than those of the west coast of Malaya. It flourishes in the coastal lowlands of Ecuador; is rare above 5,000 ft (1,500 m). In Guatemala, it is nearly always found below 4,000 ft (1,220 m). In India, it does well from the plains up to an elevation of 4,000 ft (1,220 m); in Ceylon, it cannot be grown above 3,000 ft (915 m). Around Luzon in the Philippines, it is common below 2,600 ft (800 m). It is too tender for California and trees introduced into Palestine succumbed to the cold. In southem Florida the leaves are shed at the first onset of cold weather and the tree is dormant all winter. Fully grown, it has survived temperatures of 27º to 28ºF (-2.78º to 2.22ºC) without serious harm. This species is less drought-tolerant than the sugar apple and prefers a more humid atmosphere.

Soil

The custard apple does best in low-lying, deep, rich soil with ample moisture and good drainage. It grows to full size on oolitic limestone in southern Florida and runs wild in light sand and various other types of soil in the New and Old World tropics but is doubtless less productive in the less desirable sites.

Propagation

Seed is the usual means of propagation. Nevertheless, the tree can be multiplied by inarching, or by budding or grafting onto its own seedlings or onto soursop, sugar apple or pond apple rootstocks. Experiments in Mexico, utilizing cherimoya, llama, soursop, custard apple, *Annona* sp. Af. *lutescens* and *Rollinia jimenezii* Schlecht. as rootstocks showed best results when custard apple scions were side-grafted onto self-rootstock, soursop, or A. sp. Af. *lutescens*. Custard apple seedlings are frequently used as rootstocks for the soursop, sugar apple and atemoya.

Culture

The tree is fast-growing and responds well to mulching, organic fertilizers and to frequent irrigation if there is dry weather during the growing period. The form of the tree may be improved by judicious pruning.

Harvesting and Yield

The custard apple has the advantage of cropping in late winter and spring when the preferred members of the genus are not in season. It is picked when it has lost all green color and ripens without splitting so that it is readily sold in local markets. If picked green, it will not color well and will be of inferior quality. The tree is naturally a fairly heavy bearer. With adequate care, a mature tree will produce 75 to 100 lbs (34-45 kg) of fruits per year. The short twigs are shed after they have borne flowers and fruits.

Pests and Diseases

The custard apple is heavily attacked by the chalcid fly. Many if not all of the fruits on a tree may be mummified before maturity. In India, the ripening fruits must be covered with bags or nets to avoid damage from fruit bats.

A dry charcoal rot was observed on the fruits in Assam in 1947. In 1957 and 1958 it made its appearance at Saharanpur. The causal fungus was identified as *Diplodia annonae*. The infection begins at the stem end of the fruit and gradually spreads until it covers the entire fruit.

Food Uses

In India, the fruit is eaten only by the lower classes, out-of-hand. In Central America, Mexico and the West Indies, the fruit is appreciated by all. When fully ripe it is soft to the touch and the stem and attached core can be easily pulled out. The flesh may be scooped from the skin and eaten as is or served with light cream and a sprinkling of sugar. Often it is pressed through a sieve and added to milk shakes, custards or ice cream. I have made a delicious sauce for cake and puddings by blending the seeded flesh with mashed banana and a little cream.

Food Value Per 100 g of Edible Portion*

Calories	80-101
Moisture	68.3-80.1 g
Protein	1.17-2.47 g
Fat	0.5-0.6 g
Carbohydrates	20-25.2 g
Crude Fiber	0.9-6.6 g
Ash	0.5-1.11 g
Calcium	17.6-27 mg
Phosphorus	14.7-32.1 mg
Iron	0.42-1.14 mg
Carotene	0.007-0.018 mg
Thiamine	0.075-0.119 mg
Riboflavin	0.086-0.175 mg
Niacin	0.528-1.190 m
Ascorbic Acid	15.0-44.4 mg
Nicotinic Acid	0.5 mg

*Minimum and maximum levels of constituents from analyses made in Central America, Philippines and elsewhere.

Toxicity

The seeds are so hard that they may be swallowed whole with no ill effects but the kernels are very toxic. The seeds, leaves and young fruits are insecticidal. The leaf juice kills lice. The bark contains 0.12% anonaine. Injection of an extract from the bark caused paralysis in a rear limb of an experimental toad. Sap from cut branches is acrid and irritant and can severely injure the eyes. The root bark has yielded 3 alkaloids: anonaine, liriodenine and reticuline (muricinine).

Other Uses

The leaves have been employed in tanning and they yield a blue or black dye. A fiber derived from the young twigs is superior to the bark fiber from *Annona squamosa*. Custard apple wood is yellow, rather soft, fibrous but durable, moderately close-grained, with a specific gravity of 0.650. It has been used to make yokes for oxen.

Medicinal Uses: The leaf decoction is given as a vermifuge. Crushed leaves or a paste of the flesh may be poulticed on boils, abscesses and ulcers. The unripe fruit is rich in tannin; is dried, pulverized and employed against diarrhea and dysentery. The bark is very astringent and the decoction is taken as a tonic and also as a remedy for diarrhea and dysentery. In severe cases, the leaves, bark and green fruits are all boiled together for 5 minutes in a liter of water to make an exceedingly potent decoction. Fragments of the root bark are packed around the gums to relieve toothache. The root decoction is taken as a febrifuge.

Morton, J. 1987. Ilama. p. 83–85. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Ilama

Annona diversifolia

This member of the Annonaceae was little known and the subject of much confusion until 1911, when it was investigated and fully described by W.E. Safford, of the United States Department of Agriculture's Bureau of Plant Industry, and given the botanical name of *Annona diversifolia* Safford. In Mexico, it has been called *llama, izlama, illamatzopotl* (translated as *zapote de las viejas*, or "old woman's sapote"), *hilama*, and *papuasa*. In Guatemala, it is called *anona blanca* or *papauce*; in El Salvador, *anona blanca*.

Description

The tree may be spreading or erect, to 25 ft (7.5 m), often branching from the ground. It has aromatic, pale brownish-gray, furrowed bark and glossy, thin, elliptic to obovate or oblanceolate leaves, 2 to 6 in (5-15 cm) long. There are 1 or 2 leaflike, nearly circular, glabrous bracts, 1 to 1 3/8 in (2.5 3.5 cm) long, clasping the base of the flowering branchlets. The new foliage is reddish or coppery. Solitary, long-stalked, maroon flowers, which open to the base, have small rusty hairy sepals, narrow, blunt, minutely hairy outer petals, and stamen-like, pollenbearing inner petals. The fruit is conical, heart-shaped, or ovoid globose, about 6 in (15 cm) long; may weigh as much as 2 Ibs (0.9 kg). Generally, the fruit is studded with more or less pronounced, triangular protuberances, though fruits on the same tree may vary from rough to fairly smooth. The rind, pale-green to deep-pink or purplish, is coated with a dense, velvety gray-white bloom. It is about 1/4 in (6 mm) thick, leathery, fairly soft and granular. In green types, the flesh is white and sweet; in the pink types, it is pink-tinged near the rind and around the seeds, all-pink or even deep-rose, and tart in flavor. It is somewhat fibrous but smooth and custardy near the rind; varies from dryish to fairly juicy, and contains 25 to 80 hard, smooth, brown, cylindrical seeds, 3/4 in (2 cm) long, 3/8 in (1 cm) wide, each enclosed in a close-fitting membrane easily slipped off when split.

Fig. 24: The ilama (*Annona daversifolia*), as grown in southern Florida, has a thick rind and dryish flesh.

Origin and Distribution

The ilama is native and grows wild in foothills from the southwest coast of Mexico to the Pacific coast of Guatemala and El Salvador. The earliest known record of the fruit was made by Francisco Hernandez who was sent by King Philip II of Spain in 1570 to take note of the useful products of Mexico. For many years, it was confused with either the soursop or the custard apple.

The United States Department of Agriculture introduced seeds from El Salvador in 1914 (P.I. No. 35567); from Guatemala in 1917 (P.I. No. 45548); and from Mexico in 1919, 1922 and 1923 (P.I. Nos. 46781, 55709, and 58030). One of the trees planted at the Plant Introduction Garden, Miami, Florida, bore its first fruits in 1923. Several thousand seedlings had been sent to Puerto Rico, St. Croix, various part of tropical America and Asia (including Ceylon), and the Philippines. Apparently few survived. Only in its homeland is the ilama commonly grown in dooryards, occasionally in orchards of 100 trees or more. Dr. Victor Patino took seeds from Mexico to Colombia for planting in the Cauca Valley in 1957. In spite of early enthusiasm for this species, it is seldom mentioned in horticultural literature. In 1942, there were no more than 50 trees in southern Florida, only 3 of bearing age. In 1965, Dr. John Popenoe, Director of Fairchild Tropical Garden, brought seeds from Guatemala and raised a number of seedlings for distribution, but the tree is still quite rare in Florida. It is too tender even for southern California.

Varieties

One named cultivar, 'Imery', introduced into Florida from El Salvador and grown at the Agricultural Research and Education Center, Homestead, is large and pinkfleshed but not as flavorful as some of the white-fleshed acquisitions from Guatemala.

Climate

The ilama is strictly tropical; grows naturally not higher than 2,000 ft (610 m) in Mexico; is cultivated up to 5,000 ft (1,524 m) in El Salvador; up to 5,900 ft (1,800 m) in Guatemala. It seems to do best where there is a long dry season followed by plentiful rainfall. In areas where rainfall is scant, the tree is irrigated.

Soil

Dr. Wilson Popenoe observed that the tree was not particular as to soil but should prosper in rich, loose loam. In Florida, it performs better on deep sand than on oolitic limestone.

Propagation

Ilama seeds, taken from ripe fruits, remain dormant for several weeks or even months and the germination rate thereafter is low. Applications of gibberellic acid at 350 ppm greatly increases germination. Higher concentrations cause malformations in the seedlings. Whip-or cleft-grafting onto custard apple (*A. reticulata*) rootstocks has been successful. Seedlings begin to bear when 3 to 5 years old.

Harvesting

The harvesting season begins in late June in Mexico and lasts only a few weeks. It extends from late July to September in Guatemala; from July to December in Florida. Traditionally, the fruits are not picked until they have begun to crack open, but they can be picked a little earlier and held up to 3 days to soften. They will not ripen if harvested too early.

Yield

The yield is typically low. In Mexico, during the normal fruiting period, some trees will have no fruits, others only 3 to 10; exceptional trees may bear as many as 85 to 100 fruits in a season.

Pests

The Ilama is not as susceptible to the chalcid fly as are its more popular relatives in Florida.

Food Value Per 100 g of Edible Portion*

Moisture	71.5 g
Protein	0.447 g
Fat	0.16 g
Fiber	1.3 g
Ash	1.37 g
Calcium	31.6 mg
Phosphorus	51.7 mg
Iron	0.70 mg
Carotene	0.011 mg
Thiamine	0.235 mg
Riboflavin	0.297 mg
Niacin	2.177 mg
Ascorbic Acid	13.6 mg

*According to analyses made in El Salvador.

Food Uses

The early plant explorers of the United States Department of Agriculture and their contacts in

Mexico and Central America described the ilama as resembling the cherimoya or atemoya in flavor and expected it to be well received in this country and abroad. However, as grown in Florida, it is not as appealing as the sugar apple. There is a slightly unpleasant flavor close to the rind. The flesh is always consumed raw, either in the half shell or, better still, shallowly scooped out, chilled, and served with a little cream and sugar to intensify the flavor, or with a dash of lime or lemon juice.

Morton, J. 1987. Biriba. p. 88–90. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Biriba

Rollinia mucosa

Of the approximately 65 species of the genus *Rollinia* (family Annonaceae), only a few have edible fruit and the best-known is the biriba, *R. mucosa* Baill. (syns. *R. orthopetala* A. DC.; *Annona mucosa* Jacq.; *A. sieberi* A. DC.; and possibly *R. deliciosa* Safford?). The popular Brazilian name has been widely adopted, but in that country it may also be called *biriba de Pernambuco, fruta da condessa, jaca de pobre, araticu, araticum, araticum pitaya*. In Peru, it is *anon*; in Ecuador, *chirimoya*; in Colombia, *mulato*; in Venezuela, *rinon or rinon de monte*; in Mexico, *anona babosa* or *zambo*. In Trinidad it is called wild sugar apple; in Guadeloupe, *cachiman morveux, cachiman cochon* or *cachiman montagne*, in Puerto Rico, *cachiman* or *anon cimarron*, in the Dominican Republic, *candongo* or *anona*.

Description

This fast-growing tree ranges from 13 to 50 ft (4-15 m) in height; has brown, hairy twigs and alternate, deciduous, oblong-elliptic or ovate-oblong leaves, pointed at the apex, rounded at the base, 4 to 10 in (10-25 cm) long, thin but somewhat leathery and hairy on the underside. The flowers, borne 1 to 3 or occasionally more together in the leaf axils, are hermaphroditic, 3/4 to 1 3/8 in (23.5 cm) wide; triangular, with 3 hairy sepals, 3 large, fleshy outer petals with upturned or horizontal wings, and 3 rudimentary inner petals. The fruit is conical to heart-shaped, or oblate; to 6 in (15 cm) in diameter; the rind yellow and composed of more or less hexagonal, conical segments, each tipped with a wart-like protrusion; nearly 1/8 in (3 mm) thick, leathery, tough and indehiscent. The pulp is white, mucilaginous, translucent, juicy, subacid to sweet. There is a slender, opaque-white core and numerous dark-brown, elliptic or obovate seeds 5/8 to 3/4 in (1.6-2 cm) long.

Fig. 26: The biriba (*Rollinia mucosa*) is an attractive light-yellow at first.

Origin and Distribution

This species has an extensive natural range, from Peru and northern Argentina, Paraguay and Brazil and northward to Guyana, Venezuela, Colombia and southern Mexico; Trinidad, the Lesser Antilles including Guadeloupe, Martinique and St. Vincent; and Puerto Rico and Hispaniola. It is much cultivated around Iquitos, Peru, and Rio de Janeiro, Brazil and the fruits are marketed in abundance. It is the favorite fruit in western Amazonia.

Seeds were first introduced into the United States from Para, Brazil, by O.W. Barrett in 1908 (S.P.I. #22512); a second time from Parain 1910 (S.P.I. #27579) and again in 1912 (S.P.I. #27609). The United States Department of Agriculture received seeds from Rio de Janeiro in 1914 (S.P.I. #38171). P.J. Wester may have taken seeds to the Philippines where the species first fruited in 1915. Seedlings were distributed to pioneers in southern Florida but only a very few trees exist here today.

Varieties

The only named selection referred to in the literature is **'Regnard'** reported by P.J. Wester in 1917 as the best variety introduced into the Philippines. A form in the western Amazon region has very pronounced points; weighs up to 8.8 lbs (4 kg).

Pollination

Brazilian scientists have found that 4 species of beetles of the family Chrysomelidae pollinate the flowers, but only 32% of the blooms set fruit. Fruiting begins 55 days after the onset of flowering.

Climate and Soil

The biriba is limited to warm lowlands, from 20º north to 30º south latitudes in tropical America. In Puerto Rico, it occurs at elevations between 500 and 2,000 ft (150-600 m). It has succumbed to temperature drops to 26.5ºF (-3.10ºC) in southern Florida. In Brazil, the tree grows naturally in low areas along the Amazon subject to periodic flooding and it was expected to do well in the Florida Everglades. In the Philippines it is said to flourish where the rainfall is equally distributed throughout the year. Calcareous soils do not seem to be unsuitable in Florida or Puerto Rico as long as they are moist.

Season and Harvesting

In Amazonia, the tree may flower and fruit off and on during the year but the fruits are most abundant from January to June. The fruits ripen in February and March in Rio de Janeiro. In Florida, fruits have matured in November and December. In South America, the fruit is picked when still green and hard in order to transport it intact to urban markets where it gradually turns yellow and soft. When the fruit is fully ripe, handling causes the wart-like protuberances on the rind to turn brown or near-black, rendering it unattractive.

Fig. 27: Handling causes the conical projections on the fruit to turn black.

Pests and Diseases

The most important pests in Brazil are the larvae of *Cerconota anonella* (*Lepidopterae*) which attack fruits in the process of maturing. The borer, *Cratosomus bombina*, penetrates the bark and trunk. A stinging caterpillar, *Sabine* sp., feeds on the leaves. A white fly, *Aleurodicus cocois*, attacks foliage of young and adult plants. *Pseudococcus brevipes* and *Aspidiotus destructor* are found on the leaves and sometimes on the fruits. Black spots on the leaves are caused by the fungus *Cercospora anonae*. *Glomerella cingulata* causes dieback and fruit rot in Florida.

Food Value Per 100 g of Edible Portion*

Calories	80
Moisture	77.2 g
Protein	2.8 g
Lipids	0.2 g
Glycerides	l9.1 g
Fiber	1.3 g
Ash	0.7 g
Calcium	24 mg
Phosphorus	26 mg
Iron	1.2 mg
Vitamin B1	0.04 mg
Vitamin B2	0.04 mg
Niacin	0.5 mg
Ascorbic Acid	33.0 mg
Amino Acids	(mg per g of Nitrogen (N = 6.25):
Lysine	316 mg
Methionine	178 mg
Threonine	219 mg
Tryptophan	57 mg

*According to Brazilian analyses.

Food Uses

The fruit is eaten fresh and is fermented to make wine in Brazil.

Other Uses

The wood of the tree is yellow, hard, heavy, strong and is used for ribs for canoes, boat masts, boards and boxes.

Medicinal Uses: The fruit is regarded as refrigerant, analeptic and antiscorbutic. The powdered seeds are said to be a remedy for enterocolitis.

Morton, J. 1987. Avocado. p. 91–102. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Avocado

Persia americana

The avocado, unflatteringly known in the past as alligator pear, midshipman's butter, vegetable butter, or sometimes as butter pear, and called by Spanish-speaking people *aguacate*, *cura*, *cupandra*, or *palta*; in Portuguese, *abacate*; in French, *avocatier*; is the only important edible fruit of the laurel family, Lauraceae. It is botanically classified in three groups: A), *Persea americana* Mill. var. *americana* (P. *gratissima* Gaertn.), West Indian Avocado; B) *P. americana* Mill. var. *drymifolia* Blake (*P. drymifolia* Schlecht. & Cham.), the Mexican Avocado; C) *P. nubigena* var. *guatemalensis* L. Wms., the Guatemalan Avocado.

Description

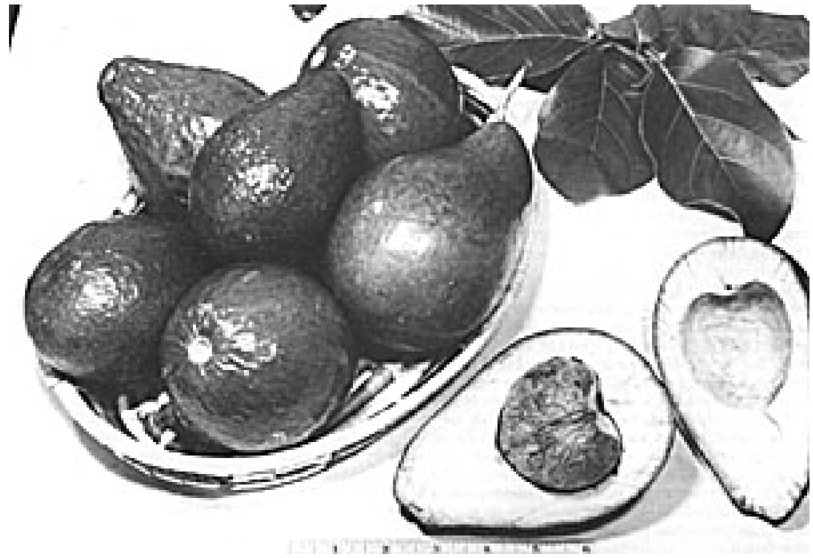


Fig. 28: West Indian avocados (*Persea americana*). The fruit cut open is a 'Hall'.

The avocado tree may be erect, usually to 30 ft (9 m) but sometimes to 60 ft (18 m) or more, with a trunk 12 to 24 in (30-60 cm) in diameter, (greater in very old trees) or it may be short and spreading with branches beginning close to the ground. Almost evergreen, being shed briefly in dry seasons at blooming time, the leaves are alternate, dark-green and glossy on the upper surface, whitish on the underside; variable in shape (lanceolate, elliptic, oval, ovate or obovate), 3 to 16 in (7.5-40 cm) long. Those of the Mexican race are strongly anise-scented. Small, pale-green or yellow-green flowers are borne profusely in racemes near the branch tips. They lack petals but have 2 whorls of 3 perianth lobes, more or less pubescent, and 9 stamens with 2 basal orange nectar glands. The fruit, pear-shaped, often more or less necked, oval, or nearly round, may be 3 to 13 in (7.5-33 cm) long and up to 6 in (15 cm) wide. The skin may be yellow-green, deep-green or very dark-green, reddish-purple, or so dark a purple as to appear almost black, and is sometimes speckled with tiny yellow dots, it may be smooth or pebbled, glossy or dull, thin or leathery and up to 1/4 in (6 mm) thick, pliable or granular and brittle. In some fruits, immediately beneath the skin there is a thin layer of soft, bright-green flesh, but generally the flesh is entirely pale to rich-yellow, buttery and bland or nutlike in flavor. The single seed is oblate, round, conical or ovoid, 2 to 2 1\2 in (5-6.4 cm) long, hard and heavy, ivory in color but enclosed in two brown, thin, papery seedcoats often adhering to the flesh cavity, while the seed slips out readily. Some fruits are seedless because of lack of pollination or other factors.

Origin and Distribution

The avocado may have originated in southern Mexico but was cultivated from the Rio Grande to central Peru long before the arrival of Europeans. Thereafter, it was carried not only to the West Indies (where it was first reported in Jamaica in 1696), but to nearly all parts of the tropical and subtropical world with suitable environmental conditions. It was taken to the Philippines near the end of the 16th Century; to the Dutch East Indies by 1750 and Mauritius in 1780; was first brought to Singapore between 1830 and 1840 but has never become common in Malaya. It reached India in 1892 and is grown especially around Madras and Bangalore but has never become very popular because of the preference for sweet fruits. It was planted in Hawaii in 1825 and was common throughout the islands by 1910; it was introduced into Florida from Mexico by Dr. Henry Perrine in 1833 and into California, also from Mexico, in 1871. Vegetative propagation began in 1890 and stimulated the importation of budwood of various types, primarily to extend the season of fruiting. Some came from Hawaii in 1904 (S. P. I. Nos. 19377-19380).

Now the avocado is grown commercially not only in the United States and throughout tropical America and the larger islands of the Caribbean but in Polynesia, the Philippines, Australia, New Zealand, Madagascar, Mauritius, Madeira, the Canary Islands, Algeria, tropical Africa, South Africa, southern Spain and southern France, Sicily, Crete, Israel and Egypt.

Though the Spaniards took the avocado to Chile, probably early in the 17th Century and it was planted from the Peruvian border southward for over 1000 mi (1,600 km) actual commercial plantings were not established until California cultivars were introduced about 1930 into two areas within 100 mi (160 km) of Santiago where the industry is now centered.

The first trees were planted in Israel in 1908, but named cultivars ('Fuerte' and 'Dickinson') were not introduced until 1924. These aroused interest in the feasibility of the crop for the southern half of the coastal plain and the interior valleys, and development of the industry has steadily gone forward, except for a period in the 1960's when much planting stock was destroyed because of marketing problems. In 1979, Israel produced 33,000 tons (30,000 MT) and exported 28,600 tons (26,000 MT).

In just the last few years, New Zealand has launched a program to expand commercial production, especially in the Bay of Plenty area, with protection from wind and frost, with a view to becoming a major exporter of avocados.

California produced 265 million lbs (12,045 MT) in 1976; 486 million lbs (22,090 MT) in 1981. The Florida avocado potential is estimated at 150 million lbs (6,818 MT). Both states suffer fluctuations because of the impact of periodic freezes, droughts, high winds or other seasonal factors.

Presently, Mexico, with 150,000 acres (62,500 ha) is the leading producer—267,786 tons (243,000 MT); the Dominican Republic is second—144,362 tons (131,000 MT); U.S.A. (California and Florida combined) with 52,000 acres (21,666 ha), third—131,138 tons (119,000 MT); Brazil is fourth—128,934 tons (117,000 MT). Israel, with 16,000 acres (6,666 ha), is fifth; and South Africa sixth. Half of California's plantings are in San Diego County close to Mexico.

As an exporter, Mexico again leads, followed by California, Israel, South Africa and Florida, in that order. Nearly all of Brazil's crop is consumed domestically.

Varieties

WEST INDIAN race: Florida avocados were at first mainly of the summer fruiting West Indian race, but these had to compete commercially with similar fruits imported from Cuba, and growers sought other cultivars maturing at a later season. This led to the development of West Indian X Guatemalan hybrids. The cessation of trade with Cuba in the early 1960's brought about a shift back to summer cultivars in new groves to fill the gap. The majority of the avocados grown in the West Indies, Bahamas and Bermuda and the tropics of the Old World are still of the West Indian race. The skin is leathery, pliable, non-granular, and the flesh low in oil. The leaves are not aromatic. The following are the most prominent of early and more recent West Indian cultivars which have played an important role in the development of the avocado industry in Florida and elsewhere. New selections appear from time to time that may have special adaptability to certain locales or conditions.

'Butler' (a USDA selection in Florida; fruited in 1909, propagated from 1914 to 1918) pear shaped; medium-large; skin smooth; seed of medium size, tight in the cavity. Season: Aug.-Sept. No longer grown in Florida. Cultivated in Puerto Rico.

'Fuchs' ('Fuchsia') (seed of unknown origin planted in Homestead, Florida, in 1910; propagated commercially in 1926); pear shaped to oblong, sometimes with a neck; of medium size; skin smooth; flesh pale greenish-yellow; 4 to 6% oil; seed loose. Season: earlyJune-Aug.; a poor shipper. Tree not very productive in Florida; no longer popular in commercial groves.

'Maoz' (a seedling selected from a plot near Maoz, Israel); pear-shaped; of medium size; skin rough, leathery, violet-purple when ripe; flesh sweetish and very low in oil. Season: medium-late (Oct.). Tree is an alternate bearer but is fairly small, highly salt-tolerant; used in Israel as rootstock on either saline or calcareous soils.

'Pollock' (originated in Miami before 1896; commercially propagated in 1901); oblong to pear shaped; very large, up to 5 lbs (2.27 kg); skin smooth; flesh green near skin, contains 3 to 5% oil; seed large, frequently loose in cavity. Season: early July to Aug. or Oct. Shy-bearing and too large but of superior quality.

'Ruchle' (a seedling of Waldin planted at the Agricultural Research and Education Center, Homestead, in 1923; first propagated in 1946); pear-shaped; of medium size, 10 to 20 oz (280-560 g); flesh low in oil (2-5%). Season begins in July in Florida; Jan. in Queensland. Heavy bearer in Florida.

'Russell' (originated in Islamorada in Florida Keys); pearshaped at apex with long neck giving it a total length up to 13 in (32.5 cm); skin, smooth, glossy, thin, leathery; flesh of excellent quality; seed small. Season: Aug. and Sept. Tree bears well and is recommended for home gardens.

'Simmonds' (possibly from a seed of Pollock, first fruited in Miami in 1913; propagated commercially in 1921); oblongoval to pear-shaped; large; skin smooth, light green; flesh of good flavor, 3 to 6% oil; seed of medium size, usually tight. Season: mid-July to mid-Sept. Tree bears more regularly than Pollock but is less vigorous; sometimes sheds many of its fruits; no longer planted commercially in Florida.

'Trapp' (originated in Miami in 1894; propagated in 1901); round to pear-shaped; medium to large; skin smooth; flesh golden-yellow, green near skin, of excellent quality, 3 to 6% oil; seed large, loose in cavity. Season: medium-late (Sept. to Nov. or Dec.); a good shipper. Was prominent in Florida for 25 years despite tendency to overbloom and bear lightly some years; usually bore regularly and well.

'Waldin' (seed planted in Florida in 1909; propagated commercially in 1917); oblong to oval; medium to large; skin smooth; flesh pale to greenish-yellow, of good flavor, 5 to 10%

oil; seed medium to large, tight. Season: fairly late (mid-Sept. through Oct.). Tree tends to overbear and die back; is hardy. Has been a leading commercial cultivar in central and southern Florida.

There are several Puerto Rican selections—'Alzamora', 'Avila', 'Faria', 'Garcia', 'Hernandez', 'St. Just'—and some cultivars of unknown ancestry: 'Amador', 'Galo', 'Gimenez', 'Torres', and 'Trujillo'.

GUATEMALAN race: (skin varies from thin to very thick and is granular or gritty). Among prominent early Florida and California cultivars were:

'Anaheim' (originated in California); oval to elliptical; large; skin glossy, rough, thick; flesh of fair to good flavor, up to 22% oil, but inferior to'Fuerte', 'Nabal' and 'Benik'; is best in Mar. and Apr. in Israel, July and Aug. in Queensland. Tree slender, erect, tall, cold-sensitive; bears regularly, up to 220 lbs (100 kg) annually in Israel. Considered of poor quality and subject to disease during ripening in Queensland.

'Benik' (introduced from Guatemala to California in 1917 and from California into Israel in 1934); pear-shaped; medium to large; skin rough, purple, medium-thick; flesh of good quality, 15 to 24% oil; seed nearly round, medium. Season: Apr. to Aug. in Calif.; Jan. to Mar. in Israel; July and Aug. in Queensland. The tree begins to bear late and yields only about 116 lbs (53 kg) per year. Color is not popular on the market. Not grown in Florida.

'Dickinson' (a California selection, first propagated in 1912); oval to obovate; small to medium; skin dark-purple with large maroon dots, rough, very thick, granular, brittle; flesh of good quality; seed small to medium, tight. Season: June-Oct. in California; Feb. and Mar. in Florida; Jan. and Feb. in Puerto Rico. Tree is a moderate but regular bearer. In Israel 'Dickinson' is described as round, small to large, very thick-skinned with very large seed; of poor quality, not worth growing. It is no longer grown in Florida or California.

'Edranol' (seedling planted at Vista, California in 1927; propagated in 1932), pear-shaped; of medium size; skin olivegreen, slightly rough, thin leathery; flesh of high quality and nutty flavor, 15 to 18% oil; seed small, tight. Season: Feb. to July at Vista; Apr. to Dec. at Santa Barbara; May and June in Queensland. Disease resistant. Rated as excellent. No longer planted in California but popular in Mexico.

'Hazzard' (seedling of 'Lyon'planted at Vista, California in 1928) pear-shaped; of medium size; skin rough, fairly thin; flesh of good quality, 15 to 34% oil; seed small. Season: Apr. to July in California, July and Aug. in Queensland where it is rated as excellent and free of external and internal diseases and discolorations in storage. The tree grows slowly, reaches only 12 to 15 ft (3.5-4.5 m), begins bearing early and is a dependable producer. Some fruits may crack if left on tree too long. More than 100 trees can be planted per acre (240 per ha).

'Itzamna' (budwood brought from Guatemala to Florida in 1916); oblong pear-shaped; medium large; skin rough; flesh yellow, 11% oil; seed small, tight. Season: very late (Mar. to May). May not bear well; little planted in Florida; a commercial cultivar in California and in Puerto Rico where it is a consistently heavy bearer.

'Linda' (budwood introduced into California from Guatemale in 1914; propagated in

Florida in 1917); elliptical; very large; skin rough, dull-purple when ripe; flesh yellow, 10 to 14% oil; seed small, tight. Season: May to Oct. in California; late (Dec. to Feb.) in Florida. A good shipper but not popular in Florida because of size and color. Of some commercial importance in California. Tree low, spreading, vigorous and bears regularly.

'Lyon' (originated in California; propagated in 1911); broad-pear-shaped; beyond medium to large; skin somewhat rough to rough; bright-green with many small yellowish or red-brown dots; medium-thick, granular and brittle; flesh greenish near skin, of high quality; seed medium-small to medium, tight. Season: Apr. to Aug. in California. Tree comes into bearing early and bears heavily, so much so as to weaken the tree. Grown in Florida only from 1918 to 1922.

'Macarthur' (originated in 1922 at Monrovia, California); pear-shaped; large; skin thin, pliable; flesh has sweet, nutty but watery flavor, contains 13 to 16.7% oil; seed medium to large. Season: Aug. to Nov. in California; Aug. and Sept. in Queensland where it is rated as of poor quality. It is one of the 6 leading commercial cultivars in California, where it is very cold-hardy.

'Nabal'(budwood brought from Guatemala in 1917; propagated in California since 1927, in Florida from 1937; in Israel since 1934); nearly round; medium to large; skin nearly smooth, thick, granular; flesh of high quality, green near skin; 10 to 15 % oil in Florida, 18 to 22 % in Queensland; seed small, tight. Season: June to Sept. in California; Jan. and Feb. in Florida; Oct. and Nov. in Queensland. Tree bears well in central Florida; bears late and poorly in Israel averaging 68 lbs (31 kg) per year in alternate years. In Queensland, bears in alternate years very heavily, but is rated as of medium quality and disease-prone during prolonged ripening.

'Nimlioh' (USDA budwood brought from Guatemala in 1917; propagated commercially in 1921); elliptical; large; skin slightly rough; flesh thick; seed fairly small, tight. Season: late (Jan. and Feb.) in Florida; May to Aug. in California. Tree bears moderate crops on south coast of Puerto Rico. Abandoned in Florida in 1925 because tree found to be weak and not prolific.

'Panchoy' (a USDA introduction into Florida from Guatemala; fruited in 1919); pear-shaped to almost elliptical; medium to large; skin rough, very thick; seed of medium size, tight. Season: very late (Mar. to early Apr.) in Florida; Apr. to Aug. in California. Formerly a heavy bearer in Florida and still is on the south coast of Puerto Rico but subject to die-back. Has been commercially important in California and Hawaii.

'Pinkerton' (seedling, probably of 'Rincon', found on Pinkerton ranch in Ventura Co., California, in 1970; patented); early crop roundish; later, pear shaped with neck; of medium size, 8 to 14 oz (227-397 g); skin medium-leathery, pliable; flesh thick, up to 10% more than in 'Hass' or 'Fuerte'; smooth textured, of good flavor, high in oil, rated as of good quality but inferior to 'Hess' and 'Fuerte'; tends to darken in the latter part of the season; seed small, separates readily from the flesh with the coat adhering to the seed. Season: first crop, Oct. or Nov., 2nd crop, Dec. or Jan. Fruit ships well and has good shelf life, but the neck is a disadvantage on the fresh fruit market; accordingly, the late-season fruits are sent to processing plants. The tree is of low, spreading habit; bears early and heavily; is as cold-sensitive as 'Hass'. About 1200 acres (486 ha) in California in 1984.

'Reed' (originated about 1948 on Reed property in Carlsbad, California, as a seedling, possibly of a 'Anaheim' X 'Nabal' hybrid; patented in 1960; patent now expired); round; medium to large, 8 to 18 oz (227-510 g); skin slightly rough, medium-thick, pliable; flesh cream-colored with rich, faintly nutty flavor; doesn't darken when cut; rated as excellent quality; seed small to medium, tight; coat adheres to seed. Season:July to Oct. in California; late Feb. to Apr. in New Zealand where it is one of the most promising cultivars. Tree erect, can be spaced 15 x 15 ft (4.6x4.6 m); bears early and regularly; about as cold-sensitive as 'Hass'. In 1984, about 1,000 acres (405 ha) in California.

'Schmidt' (budwood introduced into California in 1911; propagated in Florida in 1922); pear-shaped; medium to large; skin rough; flesh pale-yellow, 12 to 16% oil; seed of medium size, tight. Season: very late (Feb. and Mar.). The tree is a poor bearer and cold-sensitive and the fruit of poor keeping quality.

'Sharpless' (originated in California; propagated in 1913); slender-pear-shaped, sometimes with long neck; large to very large; skin slightly rough, greenish-purple to dark-purple with many yellowish dots, thick, granular; flesh of superior quality and flavor; seed small, tight. Very late (Oct. to Feb.) in California.

'Solano' (originated in California; propagated in 1912); obovate to oval; beyond medium to large; skin nearly smooth, bright-green with many yellowish dots, medium-thick, granular; flesh greenish near skin, of fair quality; seed small, tight. Season: Mar. to May in California; Oct. to mid Nov. or Dec. in Florida. A good bearer, but not grown in Florida for many years.

'Spinks' (originated in California; propagated in 1915); broad-obovate; very large; skin rough, dark-purple, thick, granular, brittle; flesh of very good quality and flavor; seed small, tight. Season: Aug. to Apr. in California. Formerly grown in central Florida.

'Taft' (originated in 1899 in California; propagated in 1912); broad pear-shaped; medium to very large; skin faintly rough, more so at base; many yellowish dots, thick, granular but somewhat pliable; flesh of excellent quality and flavor; seed of medium size, tight. Season: May to Dec. in California; Feb. and Mar. in Florida. Poor bearer in California; fair in Florida but cold-sensitive.

'Taylor' (seed of 'Royal' planted in Florida in 1908, propagated commercially in 1914); obovate to pear-shaped, occasionally with neck; small to medium size—12 to 18 oz (340510 g); skin rough, with many small yellow dots; fairly thin; flesh of excellent quality and flavor, 12 to 17% oil; seed of medium size, tight. Season: late (Dec. and Jan. or even to end of Mar.). The tree is cold-hardy but excessively tall and slender.

'Tonnage' (seed of 'Taylor' planted in Florida in 1916; propagated commercially in 1930); pear-shaped, medium large; skin dark green, rough, thick; flesh green near skin, rich in flavor, 8 to 15% oil; seed medium, fairly tight. Season: from mid-Oct. through Nov. in Florida; May to mid-Aug. inArgentine. Tree erect, fairly slender, requiring less distance between trees; is a heavy bearer. Cross pollinated by 'Lula' and 'Collieson' in Argentina.

'Wagner' (seed of 'Royal' planted in California in 1908; propagated in Florida in 1916);

rounded to obovate; small to medium; skin slightly rough; flesh light yellow, 16 to 20% oil; seed large, tight. Season: Late (mid-Jan. to mid-Mar.). Tree lower-growing than 'Taylor', a heavy bearer, but fruit more subject to black spot than 'Taylor'. Not recommended in Florida.

'Wurtz' (originated in 1935 at Encinitas, California; cultivated in Queensland for only the past 12 or 13 years); pearshaped, small to medium; 8 to 12 oz (226-240 g); seed large. Season: May to Sept. in Calif.; late in Queensland. Tree is small and slow growing, bears moderately but regularly. More than 100 trees may be planted per acre (240 per ha).

GUATEMALAN X WEST INDIAN hybrids: Inasmuch as pure Guatemalan avocados proved not well adapted to Florida, Guatemaian X West Indian hybrids have come to be of utmost importance in the Florida avocado industry, representing more than half of the more than 20 major and minor commercial cultivars grown in this state today. Prominent cultivars past and present include:

'Bonita' (seed planted in Florida in 1925); obovate, slightly flattened on one side; of medium size; skin slightly rough; flesh contains 8 to 10% oil; seed of medium size. Season: late (Dec. and Jan.). Hardy in California.

'Booth 1' (seed planted in Florida in 1920); round-obovate; medium-large; skin almost smooth, medium thick, brittle; flesh pale, 8 to 12% oil; seed large and loose; Season: late (Dec. and Jan.). The tree is a heavy bearer but the fruit is of poor quality and the seed is too big.

'Booth 7' (seed planted in Florida in 1920; propagated commercially in 1935); round obovate; of medium size; skin slightly rough, thick, brittle; flesh contains 7 to 14% oil; seed of medium size, tight. Season: late (Dec. to mid-Jan.). The fruit is commercially popular and the tree is a good bearer.

'Booth 8' (seed planted in Florida in 1920); oblong-obovate; medium-large; skin slightly rough, fairly thick, brittle; flesh contains 6 to 12% oil; seed medium large, tight. Season: late (Nov. to mid-Dec.). Popular commercially and the tree is a heavy bearer.

'Chequette' (originated in Miami from seed planted in 1929; propagated in 1939); oval; large; skin glossy, smooth, slightly leathery; flesh of good quality, 13% oil; seed medium, tight. Season: Jan. to Mar. Tree bears heavily in alternate years.

'Collinson' (seed planted in Florida in 1915); broad-obovoid to elliptical; large; skin smooth; flesh of excellent flavor, 10 to 16% oil; seed of medium size, tight. Season: late (Nov. and Dec.). Tree doesn't produce pollen in Florida; is a heavy bearer in Puerto Rico when interplanted with other cultivars. The flesh is apt to blacken around the seed in cold storage Cold-sensitive and unfruitful in Israel.

'Fuchs-20' (a seedling of 'Fuchs' selected in Israel); ellipsoid; medium to large; skin smooth, speckled with yellowish lenticels when ripe; flesh flavor is excellent. Season: medium late (Oct.). Tree is vigorous but a poor bearer; seedlings vary in salt-tolerance but cuttings of resistant selections perform well in saline conditions.

'Grande' (brought to California in 1911 from Atlixco, Mexico); pear-shaped; large; skin rough, green to purplish; seed of medium size, tight. Season: late (Dec. and Jan. in Fla.; Apr. and May in Calif.). Grown in California and Puerto Rico. Tree is a heavy bearer around Mayaguez.

'Hall' (originated in Miami; of unknown parentage; fruited in 1937, propagated in 1938); pear-shaped; large: skin smooth, fairly thick; flesh deep-yellow, 12 to 16% oil; seed medium large, tight. Season: Nov. and Dec. Heavy bearer and coldhardy but subject to scab.

'Herman' (seed planted in Florida in 1935); obovate; skin smooth, fairly thin, flexible; flesh yellow, 10 to 14% oil; seed small. Season: fairly late (mid-Nov. to mid-Jan.). Tree a heavy bearer and hardy.

'Hickson'(seedling, fruited in Florida in 1932; propagated commercially in 1938); obovate; medium to small; skin slightly rough, thick, brittle; flesh of fair to good quality, 8 to 10% oil; seed small, tight. Season: late (Dec. and Jan.). Tree bears heavily every other year; is cold-sensitive.

'Simpson' (a sprout of 'Collinson'; fruited in Florida in 1925); obovate-elliptical; rather large; skin slightly rough and thick but not brittle; flesh pale, 10 to 14% oil; seed medium-large, tight. Season: late (mid Nov. and December). The tree is a good bearer.

'Winslowson' (seed of 'Winslow' planted in Miami in 1911; propagated commercially in 1921); round-oblate; large; skin smooth; flesh pale, 9 to 15% oil; seed of medium size, loose. Season: late (Oct. to Dec. in Fla.; Dec. and Jan. in Puerto Rico). This hybrid is closer to the West Indian race than the Guatemalan and therefore popular in Puerto Rico. Formerly commercial in Florida but abandoned because of loose seed, overblooming, tendency to shed crop, and tree and fruit are susceptible to anthracnose.

In 1963, Puerto Rican horticulturists reported on the performance of 25 selections from 100 studied in the previous 5 years. Four of the selections preceded the establishment of the collection at the Isabela Substation of the University of Puerto Rico. One of the objectives was to identify late maturing varieties with superior quality and yield. Of the leading 10, all are presumed to be Guatemalan X West Indian hybrids except one, 'Kanan No. 1', which is probably Guatemalan, and this and 'Melendez No. 2' are the only ones of alternate bearing habit. 'Gripina' Nos. 2, 5 and 12 were highly rated as, respectively, better than 'Nabal', one of the best commercial cultivars, and most attractive of all. 'Semil' Nos. 23, 31, 34, 42, 43, and 44 seemed equally desirable, with Nos. 34 and 42 noted as wind-resistant.

Puerto Rican breeders have now developed the following Guatemalan X West Indian hybrids: 'Adjuntas', 'Guatemala', 'Melendez 2', 'Gripina 45', and 'Semil 34' and 43, as late-maturing (Nov. to Mar.), having medium oil content, rich-yellow flesh, and tight seed in order to be able to stand handling and shipment.

MEXICAN race: (skin thin and tender, clings to the flesh; flesh of high oil content, up to 30%. The foliage has a pronounced anise-like odor; the tree is more cold resistant than those of the other races or hybrids, thriving near Puebla, Mexico, at 500 ft (1,800 m) above sea-level.

'Duke' (originated in California in 1912); elongated; rather small 5 1\2 to 7 oz (150 200 g); flesh of good quality, 14.5% oil. Season: Sept. to Nov. in Calif.; late July or mid Aug. to mid-Sept. in Israel. Tree is large, symmetrical and wind and cold-resistant, and also highly resistant to root rot, especially when grown from cuttings. It is a poor bearer in some areas of California; has borne 168 lbs (78 kg) annually from the 6th to the 15th year in Israel.

'Ganter' (originated in 1905 in California; introduced into Israel in 1943); small, about 5 1/2 oz (150 g); of good quality, 18% oil; seed small to medium, usually loose. Season: Oct. to Dec. in Calif.; second half of Sept. in Israel. Tree is small, yields no more than 44 lbs (20 kg) per year. Poor shipper.

'Gottfried' (seed of a seedling on Key Largo planted at USDA, Miami, in 1906; distributed in 1918); pear shaped; medium size; skin smooth, purple; flesh of excellent quality, 9 to 13% oil; seed medium. Season: Aug. to Oct. Tree prolific in California; a poor bearer in southern Florida and subject to anthracnose, but hardy and desirable for home gardens on west coast of Florida.

'Mexicola' (originated about 1910 at Pasadena, California; propagated about 1912); very small; skin black; flesh of excellent flavor; seed large. Season: Aug. to Oct. Grown only in home gardens in California. Bears early and regularly; very heat- and cold-resistant; much used as a parent in California breeding programs.

'Northrop' (seedling from C.P. Taft planted about 1900 near Tustin, California; propagated about 1911); small, 3 1/2 to 5 1/2 oz (100-150 g); skin nearly black; flesh of good quality, 26% oil; seed medium. Season: Oct. and Nov. in California; mid July to mid-Sept. in Florida; mid Sept. to mid Oct. in Israel. Fruit does not keep well; flavor disagreeable when overripe. Tree bears regularly but has lower yield than 'Duke'.

'Puebla' (considered pure Mexican but some suggest may be a Mexican X Guatemalan hybrid; was found in 1911 at Atlixco near where 'Fuchs' originated). Of medium size; skin smooth, purple; flesh of good flavor; oil content nearly 20%; seed medium to large. Season: Sept. and Oct. in Florida; early to mid-winter in cool regions of California. Tree does not set fruit regularly in California or Israel and therefore is seldom planted now. Has been recommended for home gardens in Central Florida because of hardiness.

'Zutano' (hybrid, originated in 1926 at Fallbrook, California; registered in 1932); pear shaped; medium-small, skin light green, very thin, leathery; flesh watery, 15 to 22% oil; seed medium. Season: Dec. and Jan. in California; Apr. and May in Queensland where it is considered of poor quality delicate to handle, and prone to disease during ripening. Tree is a good bearer. Ranks among 6 leading commercial cultivars in California, being grown where it is too cold for 'Hass'.

GUATEMALAN X MEXICAN hybrids include:

'Bacon' Quality of flesh slightly better than 'Zutano'. Season: slightly later then 'Zutano'. Tends to be affected with end spot, an external blemish. This cultivar and 'Zutano' are the only 2 reasonably productive of 60 cultivars tried in Los Angeles and Orange Counties in California. In 1957, top working of all the others to these 2 cold hardy cultivars was strongly recommended. 'Bacon' is a good choice for tropical American highlands about 5,200 ft (160 m).

'Fuerte' (a natural hybrid originated at Atlixco, Mexico; introduced into California in 1911); pear shaped; small to medium or a little larger; skin slightly rough to rough, with many small yellow dots, thin, not adherent to flesh; flesh green near skin, 12 to 17% oil; seed small, tight. Season Jan. to Aug. in southern California; Dec. to Feb. in Israel; Apr. and May in Queensland, and New South Wales; mid-Aug. to Oct. in New Zealand. Tree is broad, very productive, but tends to bear biennially. Subject to scab and anthracnose in Florida. Formerly very popular in California (61 % of all avocados shipped); now second to 'Hess' because of a trend to summer instead of winter production and marketing that began in 1972. It is the leading cultivar in Chile where it bears more dependably than in California. It is a very erratic bearer in Israel. Represents 42% of all Australian plantings. Has long been the leading avocado on the European market.

'Hess' (seed planted at La Habra Heights, Calif.; registered in 1932); pear shaped to ovoid; of medium size; has a tendency to be undersized except in New Zealand; skin tough, leathery, dark-purple or nearly black when ripe; pebbled; fairly thin; flesh of good flavor, 18 to 22% oil, generally; up to 35% in Queensland; seed small. Season: begins in mid-Mar. in California; Nov. to Jan. in Queensland; mid-Nov. to Mar. in New Zealand; Aug. and Sept. in New South Wales. Formerly accounted for 20% of California avocados shipped; now is the leading cultivar (70% of the crop in 1984). Tree bears better then 'Nabal' in cool areas of California, but grows tall and requires topping. This is the leading cultivar in New Zealand, representing 50% of all commercial plantings; 25% in Queensland. It is second in importance to 'Fuerte' in Chile.

'Hayes' (a new hybrid in Hawaii, one parent being 'Hass'). Fruit resembles 'Hess' but is larger; skin is glossier, is pebbled, rough, thick and becomes brown-purple. Season: late (mid-Oct. to Dec. in New Zealand). Tree is erect with drooping branches and the fruit is largely sheltered by the foliage.

'Lula' (seed of 'Taft' planted in Miami in 1915); pearshaped, sometimes with neck; medium large; skin almost smooth; flesh pale-to greenish-yellow, 12 to 16% oil; seed large, tight. Season: medium-late (mid-Nov. and Dec.). Tree tall, bears early and heavily; cold resistant, successful in central and southern Florida where it was formerly the leading commercial cultivar. It is the principal cultivar in Martinique for exporting to France; represents 95% of the crop.

'Rincon' (originated at Carpinteria, California); pearshaped; small to medium; skin fairly thin, smooth, leathery; flesh buttery, contains 15 to 26.5% oil; fibers in flesh near base turn black when fruit is cut; seed of medium size. Season: Mar. and Apr. in Queensland, where it is rated as of poor quality. It is one of the 6 leading cultivars in California. Tree has a low spreading habit.

'Ryan' (perhaps seedling of 'amigo' found in 1927 at Whittier, California); pear-shaped; of medium size, 8 to 12 oz (226-340 g); skin medium-rough; flesh of fair quality; seed rather large. Season: May to Sept. in California; July to Oct. in Queensland. Tree large and bears regularly but not as heavily as 'Fuerte' or 'Hess' in Queensland. Important in Chile.

'Sharwil' (originated in Australia); similar to 'Fuerte' in shape but a little more oval; of medium size, skin rather rough, fairly thin; flesh rich in flavor, of high quality, 15 to 26% oil. Season: May and June in New South Wales and Queensland. Tree bears regularly but not heavily. Represents 18 to 20 % of all avocados in New South Wales and Queensland. Disease-free during ripening.

'Susan' (evaluated by California Avocado Society January 2, 1975; patented but patent has now expired); pear-shaped; of medium size, averaging 8 to 10 oz (227-283 g); skin light-green smooth, thin, peels well; flesh pale cream-color, of bland flavor; ripens unevenly with darkening spots; has slight tendency to turn dark when cut; not attractive; of only fair quality; seed large, loose; coat adheres to seed. Season: early fall; short. Tree of medium size; grown commercially only in the San Joaquin Valley because of its cold hardiness.

Many local and introduced cultivars representing all 3 races are being grown and evaluated at the experimental station at Minas Gerais, Brazil. A large collection is also maintained in Bahia. The U.S. Department of Agriculture has an international repository of 170 clones in Miami.

In general, small to medium-sized fruits are best for commercial production and especially for metropolitan markets. Large fruits are suitable for local use especially by large families. Smooth, thin or fairly thin, pliable, green skin is preferred by the consumer. The flesh should be virtually fiberless and of agreeable flavor and, for the dieter, of low oil content. The seed must be small and tight so as not to bruise the flesh during handling and shipping. The seed coats ought to adhere to the seed and not to the cavity. The fruit should ship well and stand cold storage. The tree should be of moderate height, slender enough to permit judiciously close planting without crowding. It should bear at an early age and regularly but not so heavily as to suffer die back, and, of course, should be disease-, insect-, and, in subtropical areas, cold-resistant. Cold-resistant cultivars stand cold-storage better than cold-sensitive cultivars.

Pollination

Many isolated avocado trees fail to fruit from lack of pollination. Commercial growers are careful to match Class A cultivars whose flowers will receive pollen in the morning with Class B cultivars that release pollen in the morning and every grower must be sure to include compatible pollinators in his grove. Bulletin 29 (1971) of the Ministry of Agriculture in Guatemala tabulates the flowering periods (varying from August to April) of 48 introduced and locally selected cultivars, and the hours of the day when each is receptive to or shedding pollen.

Climate

The West Indian race requires a tropical or near tropical (southern Florida) climate and high atmospheric humidity especially during flowering and fruitsetting. The Guatemalan race is somewhat hardier, having arisen in subtropical highlands of tropical America, and it is successful in coastal California. The Mexican race is the hardiest and the source of most of California avocados. It is not suited to southern Florida, Puerto Rico or other areas of similar climate. Temperatures as low as 25ºF (-4ºC) do it little harm. In areas of strong winds, wind-breaks are necessary. Wind reduces humidity, debydrates the flowers and interferes with pollination, and also causes many fruits to fall prematurely.

Soil

The avocado tree is remarkably versatile as to soil adaptability, doing well on such diverse types as red clay, sand, volcanic loam, lateritic soils, or limestone. In Puerto Rico, it has been found healthier on nearly neutral or slightly alkaline soils than on moderately or highly acid soils. The desirable pH level is generally considered to be between 6 and 7, but, in southern Florida, avocados are grown on limestone soils ranging from 7.2 to 8.3. Mexican and Guatemalan cultivars have shown chlorosis on calcareous soils in Israel. The tree's primary requirement is good drainage. It cannot stand excessive soil moisture or even temporary water-logging. Sites with underlying hardpan must be avoided. The water table should be at least 3 ft (.9 m) below the surface. Salinity is prejudicial but certain cultivars (see 'Fuchs-20' and 'Maoz') have shown considerable salt-tolerance in Israel. Avocados grafted onto 'Fuch-20' rootstocks and irrigated with water containing 380 to 400 ppm C1 performed well in a commercial orchard. In the Rio Grande Valley of Texas, cultivars of the Mexican race must be grafted onto salt tolerant West Indian rootstocks.

Propagation

Normally, avocado seeds lose viability within a month. 'Lula' seeds can be stored up to 5 months if placed in non-perforated polyethylene bags and kept at 40ºF (4.4ºC), thus indicating that it may be possible to successfully store seeds of other cultivars ripening at different seasons for later simultaneous planting. Fresh seeds germinate in 4 to 6 weeks, and many people in metropolitan areas grow avocado trees as novelty house plants by piercing the seed partway through with toothpicks on both sides to hold it on the top of a tumbler with water just covering 1/2 in (1.25 cm) of the base. When roots and leaves are well formed (in 2 to 6 weeks), the plant is set in potting soil. Of course, it must be given adequate light and ventilation. In nurseries, seeds that have been in contact with the soil are disinfected with hot water. Experiments with gibberellic acid and cutting of both ends of the seed with a view to achieving more uniform germination have not produced encouraging results. Seedlings will begin to bear in 4 or 5 years and the avocado tree will continue to bear for 50 years or more. Some bearing trees have been judged to be more than 100 years old.

In Australia, seeds planted in early fall germinate in 4 to 6 weeks; if planted later, they may remain dormant all winter and germinate in early spring. Seedlings should be kept in partial shade and not overwatered. While many important selections have originated from seeds, vegetative propagation is essential to early fruiting and the perpetuation of desirable cultivars. However, seedlings are grown for rootstocks.

For many years, shield budding was commonly practiced in Florida, but this method requires considerable skill and experience and is not successful with all cultivars. Therefore, it was largely replaced by whip, side-, or cleft-grafting, all of which make a stronger union than budding.

In the past, seedlings were grafted when 18 to 36 in (45-90 cm) high. It is now considered far better to graft when 6 to 9 in (15-23 cm) high, making the graft 1 to 3 in (2.5-7.5 cm) above ground level. West Indian rootstocks are desirable for overcoming chlorosis in avocados in Israel.

Avocado cuttings are generally difficult to root. Cuttings of West Indian cultivars will generally root only if they are taken from the tops or side shoots of young seed rings. But etiolated cuttings (new shoots) from gibberellin treated hardwood and semi hardwood cuttings of 'Pollock' as well as 'Lula' have been rooted with 50-60% success and, when treated with IBA, 66-83% success under mist in Trinidad. Cuttings of 'Fuchs-20' have rooted under mist with 40 to 50 or even 70% in Israel. Cuttings of 'Maoz' have rooted at the rate of 60% by a special technique developed in California. An Israeli selection, 'G.A. 13' has given 70 to 90% success in rooting cuttings under mist for the purpose of utilizing them as rootstocks in saline and high lime situations. Air-layering is sometimes done to obtain uniform material uninfluenced by rootstock, for research on specific problems. Degree of success depends on the cultivar (those of the Mexican race rooting most quickly), and air-layering is best done in spring and early summer.

At times, mature avocado groves are top worked to change from an unsatisfactory cultivar, or one declining in popularity, to a more profitable one, or an assortment of cultivars for different markets. In 1957, 2,700 ";obsolete"; avocado trees in Ventura, California, were being grafted (top-worked) to mainly 'Hass', some to 'Bacon' and 'Rincon'. This procedure may involve thousands of trees in a given region. It is done in December and January in Florida.

Inasmuch as avocado roots are sensitive to transplanting, it is now considered advisable to raise planting material in plastic bags which can be slit and set in the field without disturbing the root system.

Spacing

Spacing is determined by the habit of the cultivar and the character of the soil. In light soil, 25 x 25 ft (7.5x7.5 m) may be sufficient. In deep, rich soil, the tree makes its maximum growth and a spacing of 30 or 35 ft (9.1 or 10.7 m) may be necessary. If trees are planted so close that they will ultimately touch each other, the branches will die back. Some growers plant 10 to 15 ft (3-4.5 m) apart initially and remove every other tree at 7 to 8 years of age. If the surplus trees are not bulldozed but just cut down leaving a stump, application of herbicide may be needed to prevent regrowth. Ammonium sulfamate has been proven effective. In modernized plantings, space between rows is necessary for mechanical operations.

Holes at least 2 ft (0. 6 m) deep and wide are prepared well in advance with enriched soil formed into a mound. After the young plant is put in place a mulch is beneficial, weeds should be controlled, and watering is necessary until the roots are well established. Generally small amounts of fertilizer are given every 2 months with the amount gradually increasing until fruiting begins. Bearing trees need, on the average, 3 to 4 lbs (1 1/2-2 kg) 3 times a year, beginning when the tree is making vegetative growth. No fertilizer should be given at blooming time; one must wait until the fruits are firmly set. Nitrogen has the greatest influence on tree growth, its resistance to cold temperatures, and on fruit size and yield. Fertilizer mixes vary greatly with the type of soil. Mineral deficiencies determined by leaf analysis, are usually remedied by foliar spraying. Magnesium deficiency was formerly a serious handicap to avocado growers in Florida and Kenya. In California, zinc deficiency has been corrected by applying zinc chelates or zinc sulfate to the soil instead of spraying the foliage.

Keeping the upper soil moist has been greatly facilitated by drip irrigation, which also may carry 80% of the fertilizer requirement.

Because some cultivars tend to grow too tall for practical purposes, commercial growers cut trees back to 16 or 18 ft (4.8-5.4 m), let them grow back to 30 ft (9.1 m) and top them again. But decapitation is not a perfect remedy because the tendency of the avocado tree is to grow a new top very quickly. Recently it has been found that the growth-inhibiting chemical, TIBA (triiodobenzoic acid) slows down terminal growth and encourages lateral shoots. A system of pruning to encourage lower branching is being tried on 'Lula' in Martinique.

Avocado branches frequently need propping to avoid breaking with the weight of the developing fruits.

Some growers find it profitable to interplant bananas until the avocado trees reach bearing age.

Maturity and Harvesting

Avocados will not ripen while they are still attached to the tree, apparently because of an inhibitor in the fruit stem. Homeowners usually consider the entire crop pickable when a few mature (full grown) fruits have fallen. This is not a dependable guide because the prolonged flowering of the avocado results in fruits in varying stages of development on the tree at the same time. The largest fruits, of course, should be picked first but the problem is to determine when the largest are full grown (perfectly mature for later perfect ripening). If picked when full grown and firm, avocados will ripen in 1 to 2 weeks at room temperature. If allowed to remain too long on the tree, the fruits may be blown down by wind and they will be bruised or broken by the fall.

Florida maturity standards for marketing have been determined by weight and time of year for each commercial cultivar so that immature fruits will not reach the market. Immature fruits do not ripen but become rubbery, shriveled and discolored. Most West Indian cultivars will ripen properly if picked when the specific gravity becomes 0. 96 or lower, but 'Waldin' is fully mature when the specific gravity is still above 0.98. Guatemalan and Guatemalan X West Indian cultivars generally are harvest-mature when the specific gravity is 0.98 or lower. In California, physiological maturity of 'Bacon', 'Fuerte,' 'Hess' and 'Zutano' has been determined by measurement of length, diameter and volume, but dry weight, correlating with oil content, is considered a better maturity index. California law has, since 1925, required a minimum of 8 % oil, but oil content varies greatly among cultivars and also the climatic region where the fruit is grown. Some people complain that the 8% standard is too low for some cultivars. Maximum flavor of 'Fuerte' develops when the fruit is harvested at an oil content of 16%. Therefore, a minimum dry weight standard of 21 % has been recommended.

Formerly, avocados were detached by means of a forked stick and allowed to fall, but this causes much damage and loss. Nowadays harvesters usually use clippers for lowhanging fruits and for those higher up a long handled picking pole with a sharp ";V"; on the metal rim to cut the stem and a strong cloth bag to catch the fruit. Gloves are worn to avoid fingernail scratches on the fruit. In California, studies have been made of the effects of hand clipping (leaving stem on), hand snapping (which removes the stem), tree-shaking, and limb shaking (which removes the stem from some of the fruits). All methods are acceptable if the stem scar is waxed on stemless fruits to avoid weight loss before ripening at which time the stem detaches naturally. In Australia, some growers are using hydraulic lifts to facilitate hand-picking. A tractor fitted with a triple-decked picking platform has been adopted by some large growers in Chile. Efforts to develop dwarf avocado trees by means of sandwich interstocks from low growing types have been going on in California since 1964.

Avocados must be handled with care and are packed and padded in single or double-layer boxes or cartons for shipment. A special ";Bruce box";, holding 32 lbs (14.5 kg) is used for large fruit. The fruits may be held in position in molded trays.

Yield

It will be seen that the yield varies greatly with the cultivar, age of tree, the locale, weather and other conditions. The small tree, 'Ganter', has yielded 44 lbs (20 kg) annually; 'Nabal', 68 lbs (31 kg); 'Benik', 116 lbs (53 kg); 'Duke', 168 lbs (76 kg), and 'Anaheim', 220 lbs (100 kg). Close-planting in southern Florida provides yields averaging 11,000 lbs per acre (11,000 kg per ha) in young groves and nearly twice this amount is anticipated after the time has come to thin the planting by half.

Girdling has been tested in Florida, Australia and Israel as a means of increasing the yield of shy bearing but popular cultivars. It must be repeated every year to be fully effective. It may decrease the yield of normally fruitful cultivars.

Marketing

Inasmuch as the avocado, outside of Latin America, has been widely regarded as a luxury fruit, large scale marketing has been dependent on consumer education and advertising. Calavo Growers of California is an enterprising association of 2,600 avocado growers. The Mayflower Fruit Association, of which Blue Anchor is a member, packs over 60% of the avocados grown in the San Joaquin Valley. The California Avocado Commission spends millions of dollars in newspaper, magazine, television, radio and other publicity financed by grower assessments. The Florida Lime and Avocado Administrative Committees, together with the Florida Division of Marketing's Bureau of Market Expansion and Promotion, spend about 1/4 million dollars annually for advertising and publicity through the Press and by means of special marketing displays and distribution of recipes. The trademarks, ";Calavo"; and ";Flavocado"; (Florida Avocado Growers Exchange), are recognized nationally and internationally.

The 8% oil standard established in California kept Florida avocados out of the California market until a court decision in 1972 outlawed the discrimination against Florida fruits which average about half the oil content of California cultivars and are advocated by growers as having better flavor and fewer calories. Calavo Growers Cooperative of

California now handles 57% of the local avocado crop and 33% of the Florida crop, selling directly to the retail markets. Combined Florida and California efforts have raised the rate of regular avocado consumption in the United States from 6% in the late 1960's to over 15% today. In California, the Avocado Marketing Research Information Center was created in 1983 to gather and report information on production, foreign and domestic shipments and other activities.

Israel makes substantial investments in developing European markets for avocados and has attained the position of principal exporter to Europe. France and the United Kingdom are the chief consumers.

Storage

Ripening of avocados may be hastened by exposure to an atmosphere of at least 10 ppm ethylene 25 to 49 hours after harvest. The avocado does not respond to earlier treatment. Changes in pectinesterase activity and pectin content are being studied to measure ripening of avocados in storage. Dipping in latex has retarded decay in avocados stored at room temperature.

Avocados ship well and are sent to overseas markets under refrigeration in surface vessels. The fruits are subject to chilling injury (dark-brown or gray discoloration of the mesocarp) in refrigerated storage and degree of susceptibility varies with the cultivar and stage at harvesting and length of time in storage. Most commercial cultivars can be held safely at temperatures between 40º and 55ºF (4.5º-12.8ºC) for at least two weeks. The best ripening temperature after removal from storage is 60ºF (15.5ºC).

Removal of ethylene from controlled atmospheric storage (2% oxygen, 10% carbon dioxide) prolongs the marketable life of avocados. Reducing atmospheric pressure to subatmospheric 60 mm Hg in the refrigerated storage unit at 42.8ºF (6ºC) retards ripening of avocados by reducing respiration and ethylene production. Removed after 70 days, fruits have ripened normally at atmospheric pressure and 57.2ºF (14ºC). Experimental calcium treatments have delayed ripening and reduced internal chilling injury in storage but make the fruit externally less attractive and are, therefore, considered commercially undesirable.

'Hess' fruits dipped in fungicide 24 hours after harvest and sealed in polyethylene bags containing an ethylene absorbent (potassium permanganate on vermiculite or on aluminum silicate), have been successfully stored for 40 or 50 days at 50ºF (10ºC). Waxed 'Fuerte' avocados stored for 2 weeks at 41ºF (5ºC) and ripened at 68ºF (20ºC) ripened only 1 day later than non-waxed; however, waxing does reduce weight loss.

In 1965, to overcome the problem of oversupply during the harvesting season and undersupply during the offseason, California adopted liquid-nitrogen freezing of peeled or unpeeled avocado halves, which can be thawed and served as the equivalent of fresh fruits in restaurants, on airplanes and in institutions.

Pests and Diseases

Avocados have no major insect enemies in Florida but migrating cedar waxwings feed on leaves, flowers and very young fruits and the fruits are commonly attacked by squirrels, rats and mice. The avocado red mite, *Oligonychus yothersi*; is the most common predator on the leaves in some groves and not in others. Red-banded thrips, *Selenothrips rubrocinctus*, the greenhouse thrips, *Heliothrips haemorrhoidalis*, and red-spider, *Tetranychus mytilaspidis*, may feed on avocado leaves and blemish the fruits from time to time. There are several scales also which may feed on foliage, especially the Florida wax scale, *Ceroplastes floridensis*, the pyriform, or soft white, scale, *Protopulvinaria pyriformis*, Dictyospermum scale, *Chrysomphalus dictyospermi*; and the black scale, *Saissetia oleae*. Among two dozen other minor pests in Florida are the citrus mealybug, *Pseudococcus citri* and avocado mealybug, *P. nipae*. Stinkbugs may prick the fruits leaving little dents in the skin coupled with gritty areas at the same locations inside.

In California, 2 lepidopterous pests, *Amorbia cuneana* and the omnivorous looper, *Sabulodes aegrotata*, when present in large numbers, cause severe defoliation and fruit-scarring. Biological control is being achieved by release of the egg parasite, *Trichogramma platneri*; which is now commercially available to growers. Since 1949, the orange tortrix (a leaf roller), *Argyrotaenia citrana*, has been increasing as a menace to the avocado in California, the larvae feeding on twigs, terminal buds and foliage, flowers, and fruits. Since the pest requires shaded areas, it is best controlled by thinning out a close-planted grove or top-working to less susceptible cultivars.

The fruit-spotting bug, *Amblypelta nitida*, and banana spotting bug, *A. Iutescens*, are important pests requiring control in Queensland. The Mediterranean fruit fly is a major hazard in Israel, but very thick-skinned fruits such as 'Anaheim' are not attacked. The Queensland fruit fly, *Dacus tryoni*; seriously damages only Mexican cultivars or Guatemalan X Mexican hybrids in Australia. In 1971, a nematode survey in Bahia, Brazil, revealed 9 genera of known or suspected parasitic nematodes associated with avocado tree decline. Israeli avocado growers are seeking and testing means of biological control of the more serious of the 3 dozen insects and mites preying on the crop in that country. In Mexico, the avocado weevil, *Heilipus lauri*; tunnels into the seeds.

The major disease of avocados in South and Central America and some islands of the West Indies, in California, Hawaii, and various other areas, is root-rot caused by the fungus, *Phytophthora cinnamomi*, which is being combatted by the use of strict sanitary procedures and resistant rootstocks, especially 'Duke'. At the University of California, Riverside, over 750 seedlings and cuttings were being tested for root-rot resistance in 1976 and 1977 and the most promising tried out for grafting compatibility with commercial cultivars. Also, soil fumigation experiments with methyl bromide and newly developed chemicals were being carried forward. The disease has been so devastating in the high rainfall areas of New South Wales and Queensland that plantings have expanded into the semi-arid Murray Valley in the hope of avoiding it. In New Zealand, it is not a problem on deep, volcanic soils, but occurs on shallow, heavier soils. It was allegedly introduced into Chile with balled trees from California and vigorous measures are being taken to control it.

Mushroom root-rot from *Clitocybe tabescens* may occasionally occur. Cercospora spot (brown spots on the leaves and fruits), caused by the fungus, *Cercospora purpurea*, may cause cracks in affected areas of the skin and thus allow entrance of the anthracnose fungus, *Colletotrichum gloeosporioides*, which invades and spoils the flesh. *Glomerella cingulata* is an important source of anthracnose in Queensland. Some cultivars are subject to scab which is readily controlled by copper sprays.

More than 30 other pathogens are variously responsible for wood rot, collar rot, dieback, leafspot, stem-and rot of fruit, branch canker, and powdery mildew. Sunblotch viroid cripples young trees and damages fruits in California and Israel. So far, it is unknown in New Zealand. Stems of young trees may be affected by sunburm, and hot, dry winds cause tipburm of leaves. The avocado tree may show copper or zinc deficiency or tipburm from an excess of mineral salts.

Food Uses

Indians in tropical America break avocados in half, add salt and eat with tortillas and a cup of coffee—as a complete meal. In North America, avocados are primarily served as salad vegetables, merely halved and garnished with seasonings, lime juice, lemon juice, vinegar, mayonnaise or other dressings. Often the halves are stuffed with shrimp, crab or other seafood. Avocado flesh may be sliced or diced and combined with tomatoes, cocumbers or other vegetables and served as a salad. The seasoned flesh is sometimes used as a sandwich filling. Avocado, cream cheese and pineapple juice may be blended as a creamy dressing for fruit salads.

Mexican guacamole, a blend of the pureed flesh with lemon or lime juice, onion juice or powder, minced garlic, chili powder or Tabasco sauce, and salt and pepper has become a widely popular ";dip"; for crackers, potato chips or other snacks. The ingredients of guacamole may vary and some people add mayonnaise.

Because of its tannin content, the flesh becomes bitter if cooked. Diced avocado can be added to lemon-flavored gelatin after cooling and before it is set, and chunks of avocado may be added to hot foods such as soup, stew, chili or omelettes just before serving. In Guatemalan restaurants, a ripe avocado is placed on the table when a hot dish is served and the diner scoops out the flesh and adds it just before eating. For a ";gourmet"; breakfast, avocado halves are warmed in an oven at low heat, then topped with scrambled eggs and anchovies.

In Brazil, the avocado is regarded more as a true fruit than as a vegetable and is used mostly mashed in sherbet, ice cream, or milk shakes. Avocado flesh is added to heated ice cream mixes (such as boiled custard) only after they have cooled. If mashed by hand, the fork must be a silver one to avoid discoloring the avocado. A New Zealand recipe for avocado ice cream is a blend of avocado, lemon juice, orange juice, grated orange rind, milk, cream, sugar and salt, frozen, beaten until creamy, and frozen again.

Some Oriental people in Hawaii also prefer the avocado sweetened with sugar and they combine it with fruits such as pineapple, orange, grapefruit, dates, or banana.

In Java, avocado flesh is thoroughly mixed with strong black coffee, sweetened and eaten as a dessert.

Avocado slices have been pickled and marketed in glass jars. California began marketing frozen guacamole in 1951, and a frozen avocado whip, developed at the University of

Miami, was launched in 1955. To help prevent enzymatic browning of these products, it is recommended that sodium bisulfite and/or ascorbic acid be mixed in before freezing.

Avocado Oil

Oil expressed from the flesh is rich in vitamins A, B, G and E. It has a digestibility coefficient of 93.8% but has remained too costly to be utilized extensively as salad oil. The amino acid content has been reported as: palmitic, 7.0; stearic, 1.0; oleic, 79.0; linoleic, 13.0.

The oil has excellent keeping quality. Samples kept in a laboratory in Los Angeles at 40ºF (4.4ºC) showed only slight rancidity after 12 years. There is much interest in the oil in Italy and France. The Institut Francais de Recherches Fruitieres Outre Mer has studied the yield of oil in 25 cultivars. Joint Italian/Venezuelan studies of 5 prominent cultivars indicated that the fatty acid composition and tryglyceride structure was not influenced by variety. The oil is used as hair-dressing and is employed in making facial creams, hand lotions and fine soap. It is said to filter out the tanning rays of the sun, is non-allergenic and is similar to lanolin in its penetrating and skinsoftening action. In Brazil, 30% of the avocado crop is processed for oil, 2\3 of which is utilized in soap, 1/3 in cosmetics. The pulp residue after oil extraction is usable as stockfeed.

Food Value Per 100 g of Edible Portion (Flesh)*

Moisture	65.7-87.7 g
Ether Extract	5.13-19.80 g
Fiber	1.0-2.1 g
Nitrogen	0.130-.382 g
Ash	0.46-1 68 g
Calcium	3.6-20.4 mg
Phosphorus	20.7-64.1 mg
Iron	0.38-1.28 mg
Carotene	0.025-.0475 mg
Thiamine	0.033-0.117 mg
Riboflavin	0.065-0.176 mg
Niacin	0.999-2.220 mg
Ascorbic Acid	4.5-21.3 mg

*Analyses of West Indian, Guatemalen and Mexican avocados marketed in Central America.

Browning of the flesh of freshly cut avocado fruits is caused by polyphenol oxidase isoenzymes. Avocado halves average only 136 to 150 calories.

The avocado has a high lipid content-from 5 to 25% depending on the cultivar. Among the saturated fatty acids, myristic level may be .1%, palmitic, 7.2, 14.1 or 22.1%; stearic, 0.2, 0.6 or 1.7%. Of the unsaturated fatty acids, palmitoleic may range from 5.5 to 11.0%; oleic may be 51.9, 70.7 or 80.97%, linoleic, 9.3, 11.2 or 14.3%. Non saponifiable represents 1.6 to 2.4%. Iodine number is 94.4. In feeding experiments which excluded animal fat, 16 patients were given 1/2 to 1 l/2 avocados per day. Total serum cholesterol and phospholipid values in the blood began to fall in one week. Body weight did not increase. Cholesterol values did not rise and 8 patients showed decreases in total serum cholesterol and phospholipids.

Amino acids of the pulp (N = 16 p. 100) are recorded as: arginine, 3.4; cystine, 0: histidine, 1.8; isoleucine, 3.4; leucine, 5.5; lysine, 4.3;methionine, 2.1; phenylalanine, 3.5; threonine, 2.9; tryptophan, 0; tyrosine, 2.3; valine, 4.6; aspartic acid, 22.6; glutamic acid, 12.3; alanine, 6.0; glycine, 4.0; proline, 3.9; serine, 4.1.

Toxicity

Unripe avocados are said to be toxic. Two resins derived from the skin of the fruit are toxic to guinea pigs by subcutaneous and peritoneal injection. Dopamine has been found in the leaves. The leaf oil contains methyl chavicol. Not all varieties are equally toxic. Rabbits fed on leaves of 'Fuerte' and 'Nabal' died within 24 hours. Those fed on leaves of 'Mexicola' showed no adverse reactions. Ingestion of avocado leaves and/or bark has caused mastitis in cattle, horses, rabbits and goats. Large doses have been fatal to goats. Craigmill *et al*. at Davis, California, have confirmed deleterious effects on lactating goats which were allowed to graze on leaves of 'Anaheim' avocado an hour each day for 2 days. Milk was curdled and not milkable, the animals ground their teeth, necks were swollen and they coughed, but the animals would still accept the leaves on the 4th day of the experiment. By the 10th day, all but one goat were on the road to recovery. All abnormal signs had disappeared 20 days later. In another test, leaves of a Guatemalan variety were stored for 2 weeks in plastic bags and then given to 2 Nubian goats in addition to regular feed over a period of 2 days. Both suffered mastitis for 48 hours. Avocado leaves in a pool have killed the fish. Canaries have died from eating the ripe fruit. The seeds, ground and mixed with cheese or cornmeal, have been used to poison rodents. However, tests in Hawaii did not show any ill effect on a mouse even at the rate of 1/4 oz (7 g) per each 2.2 lbs (1 kg) of body weight, though the mouse refused to eat the dried, grated seed material until it was blended with cornmeal. Avocado seed extracts injected into guinea pigs have caused only a few days of hyperexcitability and anorexia. At Davis, mice given 10 to 14 g of half-and-half normal ration and either fresh or dried avocado seed died in 2 or 3 days, though one mouse given 4 times the dose of the others survived for 2 weeks.

The seed contains 13.6% tannin, 13.25% starch. Amino acids in the seed oil are reported as: capric acid, 0.6; myristic, 1.7; X, 13.5; palmitic, 23.4; X, 10.4; stearic, 8.7; oleic, 15.1; linoleic, 24.1; linolenic, 2.5%. The dried seed contains 1.33% of a yellow wax containing sterol and organic acid. The seed and the roots contain an antibiotic which prevents bacterial spoilage of food. It is the subject of two United States patents.

The bark contains 3.5% of an essential oil which has an anise odor and is made up largely of methyl chavicol with a little anethole.

Other Uses

The seed yields a milky fluid with the odor and taste of almond. Because of its tannin content, it turns red on exposure, providing an indelible red-brown or blackish ink which was used to write many documents in the days of the Spanish Conquest. These are now preserved in the archives of Popayan. The ink has also been used to mark cotton and linen textiles.

In Guatemala, the bark is boiled with dyes to set the color.

Much avocado wood is available when groves are thinned out or tall trees are topped. The sapwood is cream-colored or beige; the heartwood is pale red-brown, mottled, and dotted with small drops of gummy red sap; fine-grained; light—40 lbs per cu ft—(560-640 kg/cu m); moderately soft but brittle; not durable; susceptible to drywood termites and fungi. The wood has been utilized for construction, boards and turnery. An Australian woodworker has reported that it is suitable for carving, resembles White Beech (*Eucalyptus kirtonii*); is easy to work, and dresses and polishes beautifully. He has made it into fancy jewel boxes. It probably requires careful seasoning. A Florida experimenter made bowls of it but they cracked.

Honeybees gather a moderate amount of pollen from avocado flowers. The nectar is abundant when the weather is favorable. When unmixed by that from other sources it produces a dark, thick honey favored by those who like buckwheat honey or sugarcane sirup.

Medicinal Uses: The fruit skin is antibiotic; is employed as a vermifuge and remedy for dysentery. The leaves are chewed as a remedy for pyorrhea. Leaf poultices are applied on wounds. Heated leaves are applied on the forehead to relieve neuralgia. The leaf juice has antibiotic activity. The aqueous extract of the leaves has a prolonged hypertensive effect. The leaf decoction is taken as a remedy for diarrhea, sore throat and hemorrhage; it allegedly stimulates and regulates menstruation. It is also drunk as a stomachic. In Cuba, a decoction of the new shoots is a cough remedy. If leaves, or shoots of the purple-skinned type, are boiled, the decoction serves as an abortifacient. Sometimes a piece of the seed is boiled with the leaves to make the decoction.

The seed is cut in pieces, roasted and pulverized and given to overcome diarrhea and dysentery. The powdered seed is believed to cure dandruff. A piece of the seed, or a bit of the decoction, put into a tooth cavity may relieve toothache. An ointment made of the pulverized seed is rubbed on the face as a rubefacient—to redden the cheeks. An oil extracted from the seed has been applied on skin eruptions.

Related Species

Persea schiedeana Nees, called *coyo, coyocte, chalte, chinini; chucte, chupte, cotyo, aguacate de monte, aguacaton*, wild pear, and *yas*, grows wild in mountain forests from southern Mexico to Panama at altitudes between 4,600 and 6,200 ft (1,400-1,900 m). The tree is usually from 50 to 65 ft (15-20 m) tall, occasionally to 165 ft (50 m). Young branches are densely brown-hairy. The leaves are deciduous, obovate to oval, often cordate at the base; 5 to 12 in (12.5-30 cm) long, 2 3/4 to 6 in (7-15 cm) wide, white-hairy on the underside. Downy flowers, borne in densely grayish-hairy panicles, are light greenish-yellow, the perianth and stamens turning red with age. The fruit, resembling that of the avocado and equally variable, is generally pear-shaped, weighing 8 to 14 oz (227-397 g), with thick, leathery, flexible skin. Variously described as brownish-white, light-brown, pale-green, greenish-brown or dark-brown, the flesh is oily with a milky juice, few to many coarse fibers, but a very appealing, avocado-coconut flavor. The seed is very large. The cotyledons, unlike those of the avocado, are pink internally.

The tree is left standing when forests are cleared and is cultivated in Veracruz and on some farms in Guatemala. The fruits from the best of the wild and cultivated trees are marketed locally. The timber is used in construction and carpentry. This species was introduced into the USA from Guatemala and Honduras in 1948 as a wilt-resistant rootstock for the avocado. It is very sensitive to frost. In 1974 it was reported to be a poor bearer in Puerto Rico.

A more distant relative is *Beilschmiedia anay* Kosterm. (*Huielandia anay* Blake), called *anay, payta, escalalan* or *excalan*, which is native to moist, relatively low altitudes, 985 to 2,300 ft (300 to 700 m) in southern Mexico, Guatemala, Costa Rica and Colombia. Seeds were collected by Dr. Wilson Popenoe in 1917 and seedlings were set out in the Plant Introduction Garden of the U.S. Department of Agriculture, Miami.

The tree attains a height of 66 ft (20 m); the young branches are brown-hairy. Leathery leaves, broad-elliptic or broad-ovate, are 4 3/4 to 12 in (12-30 cm) long and 3 to 7 1/2 in (7.5-19 cm) wide, white-hairy only on the veins. The flowers (in December and January) are fragrant, greenish, in slender panicles to 5 in (13 cm) long. The fruit is ellipsoid-pyriform, 2 3/4 to 6 in (7-15 cm) long, with very thin, glossy, purplish-black skin and sparse green, oily flesh similar to that of the avocado in texture and flavor. The seed is obovoid, up to 2 3\4 in long, with thick, purplish-yellow, red spotted coat, and strong almond odor. In Guatemala, the fruit matures in August and September, falls while hard, and ripens in 2 or 3 days. Analyses in Guatemala show (per 100 g/flesh): moisture, 73.86 g; protein, 1.62-1.80 g; carbohydrates, 3.32-3.90 g; fat, 12.98-17.44 g; cellulose, 2.12 g; ash, 1.38 g.

Food Value Per 100 g of Edible Portion (*flesh*)*

Moisture	76.5-77.6 g
Ether Extract	5.55-7.59 g
Fiber	1.0-1.8 g
Nitrogen	0.191-0.204 g
Ash	0.72-0.91 g
Calcium	11.4-12.5mg
Phosphorus	35.5-36.2 mg
Iron	0.31-0.35 mg
Carotene	0.003-0.033 mg
Thiamine	0.048-0.070 mg
Riboflavin	0.067-0.089 mg

Niacin	0.598-0.718 mg
Ascorbic Acid	5.7-16.4mg

*Analyses by Munsell *et al*.

Morton, J. 1987. Loquat. p. 103–108. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Loquat

Eriobotrya japonica

A fruit of wide appeal, the loquat, *Eriobotrya japonica* Lindl., (syn. *Mespilus japonicus* Thunb.), of the rose family, Rosaceae, has been called Japan, or Japanese, plum and Japanese medlar. To the Italians, it is *nespola giapponese;* to French-speaking people, it is n*éflier du Japon*, or *bibassier*. In the German language, it is *japanische mispel,* or *wollmispel;* in Spanish, *nispero, nispero japonés*, or *nispero del Japón;* in Portuguese, *ameixa amarella,* or *ameixa do Japao.*

Description

A tree of moderate size, the loquat may reach 20 to 30 ft (6-9 in), has a rounded crown, short trunk, and woolly new twigs. The evergreen leaves, mostly whorled at the branch tips, are elliptical-lanceolate to obovate lanceolate, 5 to 12 in (12.5-30 cm) long and 3 to 4 in (7.5-10 cm) wide; dark-green and glossy on the upper surface, whitish-or rusty-hairy beneath, thick, stiff, with conspicuous parallel, oblique veins, each usually terminating at the margin in a short, prickly point. Sweetly fragrant flowers, borne in rusty-hairy, terminal panicles of 30 to 100 blooms, are white, 5-petalled, 1/2 to 3/4 in (1.25-2 cm) wide. The fruits, in clusters of 4 to 30, are oval, rounded or pear-shaped, 1 to 2 in (2.5-5 cm) long, with smooth or downy, yellow to orange, sometimes red-blushed, skin, and white, yellow or orange, succulent pulp, of sweet to subacid or acid flavor. There may be 1 to 10 seeds, though, ordinarily, only 3 to 5, dark-brown or light-brown, angular -ellipsoid, about 5/8 in (1.5 cm) long and 5/16 in (8 mm) thick.


Plate XI: LOQUAT, *Eriobotrya japonica*

Origin and Distribution

The loquat is indigenous to southeastern China and possibly southern Japan, though it may have been introduced into Japan in very early times. It is said to have been cultivated in Japan for over 1, 000 years. The western world first learned of it from the botanist Kaempfer in 1690. Thunberg, who saw it in Japan in 1712, provided a more elaborate description. It was planted in the National Gardens, Paris, in 1784 and plants were taken from Canton, China, to the Royal Botanical Gardens at Kew, England, in 1787. Soon, the tree was grown on the Riviera and in Malta and French North Africa (Algeria) and the Near East and fruits were appearing on local markets. In 1818, excellent fruits were being produced in hothouses in England. The tree can be grown outdoors in the warmest locations of southern England.

Cultivation spread to India and southeast Asia, the medium altitudes of the East Indies, and Australia, New Zealand and South Africa. Chinese immigrants are assumed to have carried the loquat to Hawaii.

In the New World, it is cultivated from northern South America, Central America and Mexico to California: also, since 1867, in southern Florida and northward to the Carolinas, though it does not fruit north of Jacksonville. It was quite common as a small-fruited ornamental in California gardens in the late 1870's. The horticulturist, C.P. Taft, began seedling selection and distributed several superior types before the turn of the century, but further development was slow. Dwarfing on quince root-stocks has encouraged expansion of loquat cultivation in Israel since 1960. In the northern United States and Europe, the tree is grown in greenhouses as an ornamental, especially var. *variegata* with white and pale-green splashes on the leaves.

In India and many other areas, the tree has become naturalized, as it volunteers readily from seed.

Japan is the leading producer of loquats, the annual crop amounting to 17,000 tons. Brazil has 150,000 loquat trees in the State of Sao Paulo.

Varieties

The loquat has been the subject of much horticultural improvement, increasing the size and quality of the fruit. There are said to be over 800 varieties in the Orient. T. Ikeda catalogued 46 as more or less important in Japan; over 15 have originated in Algeria through the work of L. Trabut; C.P. Taft selected and introduced at least 8 into cultivation in California; 5 or 6 have been selected in Italy; only 1 in Florida. A number of widely planted, named cultivars have been classed as either "Chinese" or "Japanese". In the Chinese group, the trees have slender leaves, the fruit is pear-shaped or nearly round with thick, orange skin and dark-orange flesh, not very juicy, subacid, but of distinct flavor. The seeds are small and numerous. The harvesting period is midseason to late and the fruits are of good keeping quality.

In the Japanese group, the tree has broad leaves, the fruit is pear-shaped or long-oval, the skin is usually pale-yellow, the flesh whitish, very juicy, acid but otherwise not very distinct in flavor. The seeds are large and there may be just a few or only one. The harvesting period is early to midseason. Keeping quality is fair to poor.

In Egypt, most loquats are of Lebanese origin. Egyptian horticulturists have selected from seedlings of 'Premier' 2 superior clones, 'Golden Ziad' and 'Maamora Golden Yellow' and have vegetatively propagated them on quince rootstocks for commercial distribution.

Some of the oldtime selections, 'Advance', 'Champagne', 'Premier', 'Success' and 'Tanaka' are no longer popular in California but are performing well in other areas. In Florida, 'Oliver' has always been the most common cultivar, though a number of others–'Advance', 'Champagne', 'Early Red', 'Pineapple', 'Premier', 'Tanaka' and 'Thales' have been more or less successful.

In the State of Sao Paulo, Brazil, 2 cultivars are raised on a commercial scale–'Precoce de Itaquera' and 'Mizuho'. In the southernmost state of the U.S.S.R., Georgia, several loquat cultivars are grown, including 'Champagne', 'Comune', 'Grossa de Sicilia', 'Premier', 'Tanaka', and 'Thales'.

The following are the cultivars most commonly described:

'Advance' (Japanese group)–A seedling selected by C. P. Taft in California in 1897. Fruit is borne in large clusters; pear-shaped to elliptic-round; of medium to large size; skin downy, yellow, thick and tough; flesh thick, cream-colored, juicy, subacid, of excellent flavor. Seeds of medium size, may be as many as 4 or 5; average is 3.20 per fruit. A late cultivar though it ripens earlier than 'Champagne' which it other-wise closely resembles. Tree is a natural dwarf, to a little over 5 ft (1.58 m); is highly resistant to pear blight. Self-infertile; a good pollinator for other cultivars. It is interplanted with 'Golden Yellow' and 'Pale Yellow' in India.

'Ahdar' (Lebanese; grown in India)–oval, of medium size; greenish-yellow with white flesh; bears moderately; late-ripening; of poor keeping quality.

'Ahmar' (Lebanese; grown in India)–pear-shaped, large, with reddish-orange skin; yellow flesh, firm, juicy; early ripening; of good keeping quality. A leading cultivar in Lebanon. Very precocious. Self-infertile.

'Akko 1' or 'Acco 1' (of Japanese origin)–long-oval to pear-shaped, 20 to 25 g in weight; skin orange with a little russeting, thick; flesh yellow, juicy, of average flavor, and there are 3 or 4 seeds. Ripens in midseason, beginning in mid-April in Israel where it constitutes 10 to 20% of commercial plantings. Precocious and a good bearer; sets 20 to 30 fruits per cluster and requires drastic thinning, leaving about 6 fruits. Fruit is subject to sunburn. Stands harvesting and shipping well, keeps in good condition less than 2 weeks under refrigeration. This cultivar is self-fertile.

'Akko 13' or 'Acco 13' (of Japanese origin)–pear-shaped, 20 to 25 g in weight; dark-orange, with no russeting; flesh yellow, juicy, with acid, agreeable flavor; 2 or 3 seeds. Bears from end of March through April in Israel, regularly and abundantly; constitutes 50 to 70% of commercial plantings in Israel; of good handling and keeping quality; stands transportation for 2 weeks at 32ºF (O.OºC). Fruit is subject to sunburn. Needs cross-pollination.

'Asfar' (Lebanese, grown in India)–oval, smaller than 'Ahmar', with yellow skin and flesh, very juicy, of superior flavor, but very perishable.

'Blush' ('Red Blush') -Resembles 'Advance' but is very large. Was selected by C.P. Taft as being immune to blight, but was abandoned after 'Advance' proved to be highly blight-resistant.

'Champagne' (Japanese), often misidentified as 'Early Red'. Selected and introduced into cultivation in California by C. P. Taft around 1908. Elongated pear-shaped, often oblique; small to large (depending on where it is grown); skin pale-golden to deep-yellow, thick, tough, astringent; flesh white or yellow, soft, juicy, mild and subacid to sweet; of excellent flavor. There are 3 to 5 seeds. Midseason to late. Prolific; fruits borne in large clusters. Perishable; good for preserving. Tree has long, narrow, pointed leaves; is self -infertile.

'Early Red' (Japanese); originated by Taft in 1909. Obliquely pear-shaped; medium-large; skin orange-red with white dots, thick, tough, acid; flesh orange, very juicy, sweet, of fair to excellent flavor; has 2 or 3 seeds. Earliest in season, often appearing on California markets at the end of January or in the beginning of February. Borne in compact clusters.

'Eulalia' (a seedling of 'Advance' selected by M. Payan in California in 1905)–pear-shaped to obovate -pear-shaped; skin faintly downy, orange-yellow with red blush and pale gray dots, thick, tough; flesh pinkish or orange, melting, soft, very juicy; subacid in flavor. Seeds medium in size, numerous. Early in season.

'Fire Ball' (popular in India)–ovate to ovate-elliptic; small, with yellow, thick skin; flesh white to straw-colored, thick, crisp, smooth, of mild, subacid flavor. Seeds are large: average 2.90 per fruit. Midseason. Tree is a natural dwarf to 9.5 ft (2.84 in).

'Glenorie Superb' (grown in Western Australia)–round, large, dark-orange with yellow flesh which is juicy and sweet. Somewhat late in season. Inclined to bruise during harvesting.

'Golden Red' (grown in California)–flesh pale-orange, medium-thick, smooth, melting, of subacid, agreeable taste; few seeded. Midseason.

'Golden Yellow' (grown in India)–ovate-elliptic; of medium size; skin orange-yellow; flesh pale-orange, medium-thick, soft, smooth, with subacid, mild flavor. Seeds of medium size; average 4.83 per fruit.

'Golden Ziad' (#2-6) (grown in Egypt)–dark-yellow to light-orange; up to 1 1/2 in (3.96 cm) long; average number of seeds, 2.93-3.83 per fruit. Early. High-Yielding; 50 lbs (23.5 kg) per tree.

'Herd's Mammoth' (grown in Western Australia)–long and slightly tapering at the stem end; large; yellow to orange with white to cream-colored flesh. Ripens earlier than 'Victory'. Subject to black spot; not often planted.

'Improved Golden Yellow' (grown in India)–ovate-elliptic; skin orange-yellow; flesh orange-yellow, thick, crisp, smooth, with subacid to sweet, mild flavor. Seeds large; average 3.06 per fruit. Tree to 15 ft (4.49 in). Early.

'Improved Pale Yellow' (grown in India)–flesh pale-orange or cream-colored, firm or soft, smooth, of subacid, pleasant flavor, with medium number of seeds. Midseason.

'Kusunoki' (grown in Japan)–small; early.

'Large Agra' (grown in India)–ovate-round; of medium size; skin deep-yellow; flesh yellow or pale-orange, medium thick, smooth, firm, of pleasant flavor, fairly sweet. Seeds small; average 5.10 per fruit. Midseason. Tree a medium-dwarf–to 9 1/2 ft (2.83 in).

'Large Round' (grown in India)–ovate-round; of medium size; yellow of skin with cream-colored flesh, firm, coarse, subacid to sweet, mild. Seeds of medium size; average 4.80 per fruit. Midseason. Tree fairly tall–13 ft. (3.92 in).

'Maamora Golden Yellow' (#7-9) (grown in Egypt)–dark-yellow to light-orange; to 1 1/2 in (3.91 cm long); seeds average 2.40 to 4.03 per fruit; late in season. High-yielding–44 lbs (20 kg) per tree.

'Mammoth' (grown in Australia; mentioned in California in 1889)–flesh orange, medium thick, granular, coarse, of subacid, agreeable flavor. Midseason.

'Matchless' (grown in India) pear shaped; flesh medium-thick, pale-orange, smooth, soft, of mild, subacid flavor; medium number of seeds. Midseason.

'Mizuho' (grown in Japan)–rounded-oval; extra large (70-120 g); juicy, with agreeable, slightly acid though also sweet flavor, and with 5 or more seeds. Subject to fruit spots and sunburn.

'Mogi' (grown in Japan)–elliptical, light-yellow; small (40-50 g); Ripens in early spring. Tree is cold sensitive. Self-fertile. Constitutes 60% of the Japanese crop of loquats.

'Obusa' (a hybrid of 'Tanaka' and 'Kusonoki', developed and grown in Japan)–deep yellow, very large (80-100 g); of medium flavor; good keeping and shipping quality. Ripens earlier than Tanaka. Tree bears regularly and is resistant to insects and diseases, but fruit is subject to sunburn (purple stains on skin).

'Oliver' ('Olivier' X 'Tanaka'). In the past was considered the best loquat for southern Florida.

'Pale Yellow' (grown in India)–oblique -elliptic to round; light yellow, large; flesh white or cream-colored, thin, smooth, melting, of subacid to sweet flavor; seeds large; average 4.8 per fruit. Early. Tree is fairly tall–to 13 ft (4 in).

'Pineapple' (developed and introduced into cultivation in California by Taft in 1899)–round or sometimes pear-shaped; light-yellow with white flesh. Of good quality but inferior to 'Champagne'. Abandoned in California because of the weakness of the tree.

'Precoce de Itaquera' (erroneously called 'Tanaka'; grown in Brazil; believed to be a local selection of 'Mogi')–oval-pear-shaped; deep-orange; very small (25.3-29.1 g). Flesh is firm and acid-sweet. Very productive: 1,500 to 2,000 fruits per tree annually. Subject to sunburn (purple stains on skin) but less so than 'Mizuho'. Was for a long time the leading cultivar in the State of Sao Paulo but has lost ground to 'Mizuho' even though a pear-shaped fruit is preferred by consumers, because it does not keep or ship as well as the 'Mizuho', which now makes up 65% of the plantings and 'Precoce de Itaquera' 35%.

'Premier' (originated by Taft in California in 1899)–oval to oblong-pear-shaped; large; skin downy, orange-yellow to salmon-orange with large white dots; medium-thick, tough; flesh whitish, melting, juicy, subacid, of agreeable flavor; seeds average 4 or 5 per fruit. Late. Good for dooryards. Does not ship well, nor keep well.

'Safeda' (grown in India)–flesh is cream-colored, thick, smooth and melting, of subacid, excellent flavor; contains medium number of seeds. Early to midseason.

'Saint Michel' (unclassified; grown in Israel)–round but has the thin skin and white flesh of the Japanese group. Ripens late. Self-infertile.

'Swell's Enormity' (grown in Western Australia)–pear-shaped, very large; deep apricot-colored externally with flesh of the same color. Acid if harvested too early. Very late in season. Subject to sunburn in hot weather.

'Tanaka' (Chinese group; a seedling originated in Japan; young trees introduced by the United States Department of Agriculture in 1902; widely grown)–ovoid or round; large (70-80 g) in Japan; in some other areas small (30 g); skin orange or orange-yellow; flesh brownish-orange, medium thick, coarse, firm, juicy, sweet or subacid, of excellent taste. There may be 2 to 4 seeds; average 2.70 per fruit. Ripens late–beginning the first of May, which is too late for California because of susceptibility to sunburn. The tree is of medium size-nearly 10 ft (2.98 m); precocious; bears regularly; is self-fertile to a degree. Constitutes 10% of commercial crop in Israel; 35% of the crop in Japan. Highly cold-tolerant.

'Thales', also known as 'Gold Nugget' and 'Placentia', (Chinese group; very similar to 'Tanaka' and possibly a clone. Introduced from Japan and planted at Placentia, California, between 1880 and 1900)–oblong-obovate to round, large, skin orange-yellow with numerous white dots, tough; flesh, orange, thick, firm, juicy, of sweet, apricot-like flavor. There are 2 to 4 seeds. Late in season. Fruits borne only a few to a cluster; keep and ship well. Self-fertile.

'Thames Pride' (grown in India)–ovate-elliptic, of medium size or sometimes large; pale-orange or deep-yellow with cream colored or pale-orange, juicy, coarse, somewhat granular flesh of subacid flavor; moderately seedy; average 3.20 seeds per fruit. Early in season. Tree tall, to 13 1/2 ft (4.19 m). Bears heavily. This cultivar is grown and canned commercially.

'Tsrifin 8' (grown in Israel)–rounded pear-shaped; 25 to 30 g in weight; yellow-orange with some russeting. Of excellent quality with good acid and sugar content. Stands handling. shipping and storage well. Late–mid-April to mid-May. Precocious, bears regularly and abundantly but is subject to sunburn. Constitutes 10% of Israeli plantings.

'Victor' (originated by C.P. Taft in 1899)–oblong-pear-shaped; large; skin deep-yellow, medium-thick, tough. Flesh whitish, translucent, melting, very juicy, of sweet, mild flavor. There may be 3 to 5 seeds. Very late; too late for California. Good for canning.

'Victory' (the most popular cultivar in West Australia)–oval, large, yellow to orange, becoming amber on the sunny side. Flesh is white to cream-colored, juicy, sweet. Midseason to occasionally early.

'Wolfe', (S.E.S. #4) (a seedling of 'Advance' selected and named at the Agricultural Research and Education Center of the University of Florida in Homestead, and released in 1966)–obovoid to slightly pear-shaped; 1 3/4 to 2 in (4.5-5 cm) long and 1 to 1 1/4 in (2.5-3.2 cm) wide; yellow with fairly thick skin and pale-yellow, thick, firm, juicy flesh of excellent flavor, acid but also sweet when tree-ripe; has 1 to 5 seeds (usually 1 to 3). Tree reaches 25 ft (7.5 in) and bears well nearly every year,

Pollination

The loquat is normally pollinated by bees. Some cultivars such as 'Golden Yellow' are not self-fertile. 'Pale Yellow', 'Advance', and 'Tanaka' are partially self-fertile. In India, it has been observed that cross-pollination generally results in 10-17 % increased production over self-pollination. 'Tanaka' pollinated by 'Pale Yellow' has a lower yield than when self-pollinated, indicating a degree of cross-incompatibility. Whereas, when pollinated by 'Advance', the normal yield of 'Tanaka' is nearly doubled.

When cross-pollinating for the purpose of hybridizing, only flowers of the second flush should be used, as early and late flushes have abnormal stamens, very little viable pollen, and result in poor setting and undersized fruits.

Climate

The loquat is adapted to a subtropical to mild-temperate climate. In China it grows naturally at altitudes between 3,000 and 7,000 ft (914-2,100 m). In India, it grows at all levels up to 5, 000 ft (1,500 m). In Guatemala, the tree thrives and fruits well at elevations between 3,000 and 6,900 ft (900-1,200 m), but bears little or not at all at lower levels.

Well-established trees can tolerate a drop in temperature to 12º F (-11.11º C). In Japan, the killing temperature for the flower bud is 19.4º F (7º C); for the mature flower, 26.6º F (-3º C). At 25º F (-3.89º C), the seed is killed, causing the fruit to fall.

Loquats are grown on hillsides in Japan to have the benefit of good air flow. Extreme summer heat is detrimental to the crop, and dry, hot winds cause leaf scorch. Where the climate is too cool or excessively warm and moist, the tree is grown as an ornamental but will not bear fruit.

Soil

The tree grows well on a variety of soils of moderate fertility, from light sandy loam to heavy clay and even oolitic limestone, but needs good drainage.

Propagation

Generally, seeds are used for propagation only when the tree is grown for ornamental purposes or for use as rootstock. Loquat seedlings are preferred over apple, pear, quince or pyracantha rootstocks under most conditions. Quince and pyracantha may cause extreme dwarfing-to less than 8 ft (2.5 in). Quince rootstock tolerates heavier and wetter soils than loquat but is apt to put out numerous suckers. Loquat seeds remain viable for 6 months if stored in partly sealed glass jars under high humidity at room temperature, but the best temperature for storage is 40º F (5º C). They are washed and planted in flats or pots soon after removal from the fruit and the seedlings are transplanted when 6 to 7 in (15-17.5 cm) high to nursery rows. When the stem is 1/2 in (1.25 cm) thick at the base, the seedlings are ready to be top-worked. In India, inarching is commonly practiced but budding and grafting are more popular in most other areas. Shield-budding, using 3-month-old scions, is successful. Cleft-grafting has been a common practice in Florida. Veneer-grafting in April has proved to be a superior method in Pakistan. Cuttings are not easy to root. Air-layering may be only 20% successful, though 80 to 100% of the layers root in 6 weeks if treated with 3% NAA (2-naphthoxyacetic acid).

Trees that are vegetatively propagated will begin to bear fruit in 5 years or less, as compared to 8 to 10 years in seedling trees. Old seedling trees can be converted by cutting back severely and inserting budwood of a preferred cultivar.

Culture

The rainy season is best for planting loquats. When planted on rich soil, normal size trees should be set 25 to 30 ft (7.5-9 m) apart, allowing about 83 trees per acre (200 per ha). In Brazil, a spacing of 23 x 23 ft (7x7 m) is recommended on flat land, 26 x 20 ft (8x6 m) or 26 x 16.5 ft (8x5 m) on slopes. Dwarf trees are spaced at 13 x 6.5 ft (4x2 m) in Japan and this may allow 208 per acre (500 per ha). The tree is a heavy feeder. For good fruit production the trees require ample fertilization and irrigation. In the tropics, animal manure is often used. A good formula for applications of chemical fertilizer is: 1 lb (.45 kg) 6-6-6 NPK three times a year during the period of active growth for each tree 8 to 10 ft in height. The trees should be watered at the swelling of blossoms and 2 to 3 waterings should be given during harvest-time. Thinning of flowers and young fruits in the cluster, or the clipping off of the tip of the cluster, or of entire clusters of flowers and fruits, is sometimes done to enhance fruit size. This is carefully done by hand in Japan. With the 'Tanaka' cultivar, the Japanese leave only one fruit per cluster; with the 'Mogi', two. In Taiwan, thinning is done by spraying with NAA when the flowers are fully open.

In Taiwan, because of the hazard of strong typhoons, the loquat is grown as a mini-dwarf no more than 3 ft (0.9 m) high and wide, and branch tips may be tied to the ground because branches kept at a 451 angle flower heavily. Spraying with gibberellic acid (60 ppm) at full bloom enhances fruit set and increases fruit size and weight, total reducing sugars and ascorbic acid content, reduces fruit drop, number of seeds, and acidity. Spraying the same at 300 ppm results in small, seedless fruits. There should be judicious pruning after harvest, otherwise terminal shoots become too numerous and cause a decline in vigor which may result in biennial bearing. In Brazil, the clusters are bagged to eliminate sunburn (purple staining of the skin) to which both of the leading cultivars are susceptible.

Because of the shallow root system of the loquat, great care must be taken in mechanical cultivation not to damage the roots. The growing of dwarf trees greatly reduces the labor of flower-and fruit-thinning, bagging, and, later, harvesting and pruning.

Season

Generally, the loquat tree blooms in the fall and fruits in early spring. However, in tropical climates, the tree may flower 2 or 3 times a year beginning in July and set fruit mainly from the second flowering. In Florida, ripening begins in February; in California, usually in April; in Israel, the crop ripens from March to May. In Brazil, the harvesting extends from May to October.

Harvesting

Loquats reach maturity in 90 days from full flower opening. Determination of ripeness is not easy, but it is important because unripe fruits are excessively acid. Full development of color for each cultivar is the best guide.

The fruits are difficult to harvest because of the thick, tough stalk on each fruit which does not separate readily from the cluster, and the fruits must be picked with stalk attached to avoid tearing the skin. Clusters are cut from the branch with a sharp knife or with clippers. Whole clusters are not particularly attractive on the market, therefore the individual fruits are clipped from the cluster, the stalk is detached from each fruit and the fruits are graded for size and color to provide uniform packs. Great care is taken to avoid blemishes.

Major Japanese growers have monorail systems for conveying the picked fruits and equipment from their hillside plantations.

Yield

Dwarf loquats in Israel have produced 7 tons/ha at 3 years of age, 25 tons/ha at 7 years. Normal size trees in Brazil are expected to bear 110 lbs (50 kg) per tree, 4.17 tons per acre (10 tons/ha) when planted at a rate of 83 trees per acre (200 trees/ha). The 'Wolfe' cultivar in southern Florida has borne 100 lbs (45 kg) per tree at 5 years of age; 300 lbs (136 kg) when 15 to 20 years old.

Keeping Quality

Loquats generally will keep for 10 days at ordinary temperatures, and for 60 days in cool storage. After removal from storage, the shelf-life may be only 3 days. Treatment with the fungicide, benomyl, makes it possible to maintain loquats for one month at 60º F (15.56º C) with a minimum of decay. Other fungicides tried have proved much less effective. Cold storage of loquats in polyethylene bags alters the flavor of the fruit, promotes internal browning and the development of fungi.

Pests and Diseases

In Japan, scale insects, aphids, fruit flies and birds damage the fruits and may necessitate covering the clusters with cloth or paper bags. Laborers can attach 1,000 to 1,500 bags per day. An acre may require 62,500 bags (150,000/ha). A pole with a hook at the tip is employed to bring each branch within reach. The process is labor intensive. In Israel, wire netting is placed over trees to protect the crop from birds.

The Caribbean fruit fly *(Anastrepha suspensa)* has ruined the dooryard loquat crop for the past several years in Florida. The fruit flies, *A. striata* and *A. serpentina,* require control in Venezuela, the Mediterranean fruit fly, *Ceratitis capitata,* in Tunisia. Another fruit fly, *Dacus dorsalis, is* the major pest in India, forces the harvesting of mature fruits while they are still too hard to be penetrated, and the complete removal of all immature fruits at the same time so that they will not remain as hosts. The soil around the base of the tree must be plowed up and treated to kill the pupae. The second most important predator is the bark-eating caterpillar*, Indarbela quadrinotata.*

Minor pests include leaf-eating chafer beetles, *A doretus duvauceli, A. lasiopygus, A. horticola* and *A. versutus;* gray weevils, *Myllocerus lactivirens* and *M. discolor* which attack the margins of the leaves. The scale insects, *Coccus viridis, Eulecanium coryli, Parlatoria oleae, P. pseudopyri, Pulvinaria Psidii* and *Saissetia hemisphaerica* suck the sap from loquat leaves and branches. Carpenter bees, *Megochile anthracina,* cut holes in the leaves and take the tissue to line their mud nests. Aphids *(Aphis malvae)* suck sap from twigs and shoots and sooty mold develops on the honeydew which they excrete. Flowers are attacked by thrips *(Heliothrips sp.).* The caterpillars of the anar butterfly, *Virachola isocrates,* bore into the fruits and lay eggs on the fruits, flowers and leaves. In New Zealand, a leaf-roller caterpillar eats into the buds and flowers. In California, the main pests of loquat are the codlin moth *(Cydia pomonella),* the green apple aphis *(Aphis pomi)* and scales.

The roots of loquat trees in India are preyed on by nematodes–C*riconemoides xenophax, Helicotylenchus spp., Hemicriconemoides communis, Haplolaimus spp.* and *Xiphinema insigne.*

Diseases

Pear blight *(Bacillus amylovorus)* is the major enemy of the loquat in California and has killed many trees. *Phytophthora* is responsible for crown rot and *Pseudomonas eriobotryae* causes cankers in California. Scab may occur on the bark of the trunk and larger branches. A serious disease is collar rot and root rot caused by *Diplodia natalensis. D. eriobotrya* sometimes affects the leaves. The parasitic fungus, *Monochaetia indica,* induces leaf spot in India. Leaf spot is also caused by the soil-inhabiting fungus *Schlerotium rolfsii. Spilocaeae eriobotryae* causes black spot on fruits and leaves in Italy and South Western Australia. Fleck, caused by the fungus *Fabraea maculata is* recognized by red-brown spots with whitish centers on leaves, shoots and fruit. In Florida, leaf spot may result from infection by *Pestalotia sp.* The foliage of young plants in Brazilian nurseries is damaged by the fungus *Entomosporium maculatum.* Other fungus problems of the loquat include stem-brown disease caused by *Batryosphaeria dothidee;* die-back from *Macrophoma* sp., withertip from *Collectotrichum gloeosporioides,* and twig blight and canker from *Cytospora chrysospernw.* Post-harvest fruit rot is the result of infection by *Diplodia natalensis, Pestalotia sp.* or *Aspergillus niger.*

Sunburn, "purple spot", is responsible for much fruit loss in hot regions with long summers. Chemical sprays have been employed to hasten fruit maturity to avoid sunburn. Various types of bags have been tried in Brazil to protect the fruit from this blemish. The best are 2- and 3-ply newspaper bags.

Food Uses

The skin of the loquat is easily removed. Peeled and seeded fruits are eaten fresh, sometimes combined with sliced banana, orange sections and grated coconut. They are delicious simply stewed with a little sugar added. The fruits are also used in gelatin desserts or as pie-filling, or are chopped and cooked as a sauce. Loquats canned in sirup are exported from Taiwan. Some people prepare spiced loquats (with cloves, cinnamon, lemon and vinegar) in glass jars. The fruit is also made into jam and, when slightly underripe, has enough pectin to make jelly. The jelly was formerly manufactured commercially in California on a small scale.

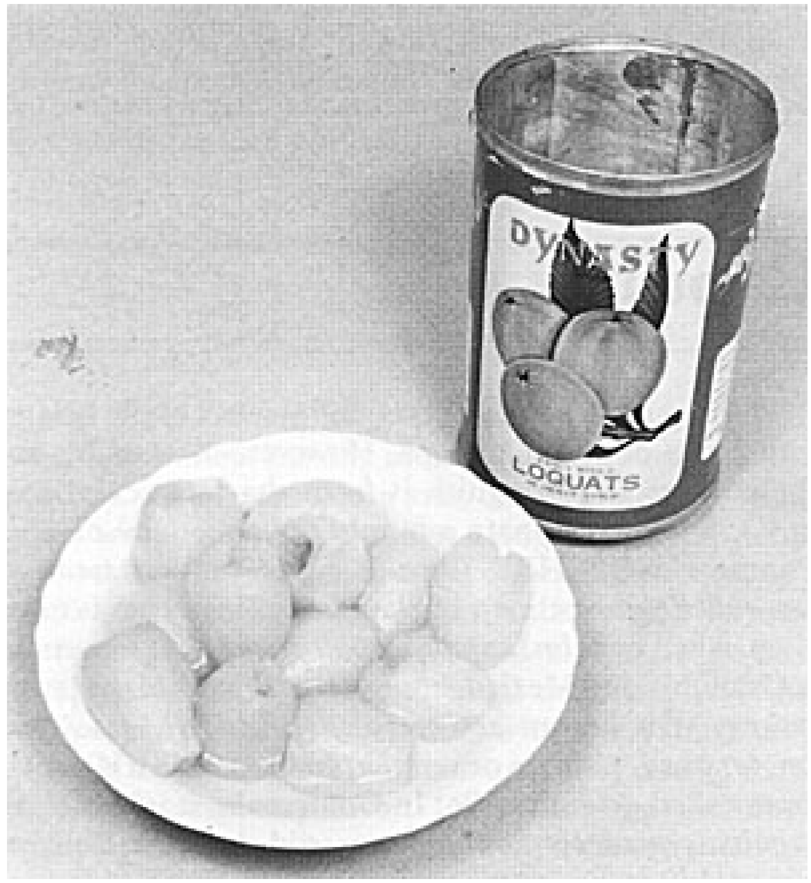


Fig. 29: Peeled, seeded loquats *(Eriobotrya japonica)* canned in sirup in Taiwan.

Food Value Per 100 g of Edible Portion*	
Calories	168
Protein	1.4 g
Fat	0.7 g
Carbohydrates	43.3 g
Calcium	70 mg
Phosphorus	126 mg
Iron	1.4 mg
Potassium	1,216 mg
Vitamin A	2,340 I.U.
Ascorbic Acid	3 mg

*Analyses reported by the Agricultural Research Service of the United States Department of Agriculture.

The fruit contains laevulose, sucrose and malic acid and lesser amounts of citric, tartaric and succinic acid. The pulp contains the carotenoids *B*-carotene (33%); *y*-carotene (6%); cryptoxanthin (22%), lutein, violaxanthin, neoxanthin (3-4% each). The peel is 5 times richer than the pulp in carotenoids which are similar to those in apricots.

Toxicity

A 5-year-old girl in Florida ate 4 unripe loquats, fell asleep and was difficult to awaken and seemed dazed. After about 2 hours, she was back to normal. There have been instances of poisoning in poultry from ingestion of loquat seeds. The seeds contain amygdalin (which is converted into HCN); also the lipids, sterol, β-sitosterol, triglyceride, sterolester, diglyceride and compound lipids; and fatty acids, mainly linoleic, palmitic, linolenic and oleic. There is amygdalin also in the fruit peel. The leaves possess a mixture of triterpenes, also tannin, vitamin B and ascorbic acid; in addition, there are traces of arsenic. Young leaves contain saponin. Some individuals suffer headache when too close to a loquat tree in bloom, The emanation from the flowers is sweet and penetrating.

Other Uses

Wood: The wood is pink, hard, close-grained, medium-heavy. It has been used instead of pear wood in making rulers and other drawing instruments.

Animal feed: The young branches have been lopped for fodder.

Perfume: In the 1950's, the flowers attracted the interest of the perfume industry in France and Spain and some experimental work was done in extraction of the essential oil from the flowers or leaves. The product was appealing but the yield was very small.

Medicinal Uses: The fruit is said to act as a sedative and is eaten to halt vomiting and thirst.

The flowers are regarded as having expectorant properties. An infusion of the leaves, or the dried, powdered leaves, may be taken to relieve diarrhea and depression and to counteract intoxication from consumption of alcoholic beverages. Leaf poultices are applied on swellings.

Morton, J. 1987. Capulin. p. 108–109. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Capulin

Prunus salicifolia

The capulin is a true cherry and doesn't really belong with fruits of warm regions. However, it must be included here to distinguish it from the Jamaica cherry (q.v.), for the two share a number of colloquial names. *Prunus salicifolia* HBK. (syns. P. *capuli* Cav.; P. *serotina* var. *salicifolia* Koehne), of the family Rosaceae, is most often called *capulin, capuli, capoli* or *capolin*, especially in Colombia and Mexico, but in certain parts of the latter country it is known as *cerezo, detsé, detzé, taunday, jonote, puan, palman or xengua.* In Colombia it is sometimes called *cerezo criollo.* In Guatemala, it is known as *capulin, cereza, cereza común*, or wild cherry; in Bolivia, it *is capuli;* in Eucador, *capuli* or black cherry.

Description

The tree is erect, reaching 40 to 50 ft (12-15 m) in height, with a short, stout trunk to 3 ft (0.9 m) in diameter. The deciduous, alternate, aromatic leaves are lanceolate to ovate-lanceolate, 2 3/8 to 7 in (6-18 cm) long, dark-green and glossy above, pale beneath; thin, finely toothed. New leaves are often rosy. Flowers, borne in slender, pendent racemes with 1 or more leaves at the base, are about 3/4 in (2 cm) wide with white petals and a conspicuous tuft of yellow stamens. The aromatic fruit is round, 3/8 to 3/4 in (1-2 cm) wide, with red or nearly black, rarely white or yellowish, smooth, thin, tender skin and pale-green, juicy pulp of sweet or acid, agreeable, but slightly astringent flavor. There is a single stone with a bitter kernel.

Origin and Distribution

The capulin is native and common throughout the Valley of Mexico from Sonora to Chiapas and Veracruz, and possibly also indigenous to western Guatemala. It has been cultivated since early times in these areas and other parts of Central America and in Colombia, Ecuador, Peru and

Bolivia, and is extensively and abundantly naturalized. The fruit is an important food, not only of the Indians, but of all the inhabitants, and it was at times a mainstay of the invading Spaniards. Great quantities appear in the native markets, especially of El Salvador, Guatemala and Ecuador. In Guatemala, seedlings of the capulin are utilized as rootstock on which commercial cultivars of the northern cherry are grafted. The capulin is little-known in eastern South America and elsewhere in the world. It was introduced into the cool medium elevations of the Philippines in 1924.

Climate

The tree requires a subtropical to subtemperate climate. It grows naturally at elevations between 4,000 and 11,000 ft (1,200-3,400 m).

Season

In Mexico, the tree blooms from January to March and the fruits ripen in July and August. In Guatemala, flowers appear from January to May and fruits from May to September. The fruiting season in El Salvador extends from December through April.

Food Uses

The ripe fruits are eaten raw or stewed; also are preserved whole or made into jam. In Mexico they are used as filling for special tamales. With skin and seeds removed, they are mixed with milk and served with vanilla and cinnamon as dessert. Sometimes the fruits are fermented to make an alcoholic beverage.

Food Value Per 100 g of Edible Portion*	
Moisture	76.8-80.8 g
Protein	0.105-0.185 g
Fat	0.26-0.37 g
Fiber	0.1-0.7 g
Ash	0.56-0.82 g
Calcium	17.2-25.1 mg
Phosphorus	16.9-24.4 mg
Iron	0.65-0.84 mg
Carotene	0.005-0.162 mg
Thiamine	0.016-0.031 mg
Riboflavin	0.018-0.028 mg
Niacin	0.640-1.14 mg
Ascorbic Acid	22.2 32.8 mg

*According to analyses made in Guatemala and Ecuador.

Other Uses

Seeds: The seeds contain 30-38% of a yellow, semidrying oil suitable for use in soap and paints.

Flowers: The flowers are much visited by honeybees.

Wood: The sapwood is yellow with touches of red. The heartwood is reddish-brown, fine-grained, very hard, strong, durable. It is used for furniture, interior paneling, cabinets, turnery and general carpentry. Old roots are valued for carving tobacco pipes, figurines, et cetera.

Medicinal Uses: A sirup made of the fruits is taken to alleviate respiratory troubles. The leaf decoction is given as a febrifuge and to halt diarrhea and dysentery; also applied in poultices to relieve inflammation. A leaf infusion is prescribed in Yucatan as a sedative in colic and neuralgia and as an antispasmodic. The pounded bark is employed in an eyewash.

The leaves contain essential oil, fat, resin, tannin, amygdalin, glucose, a brown pigment and mineral salts. The bark contains starch, brown pigment, amygdalin, gallic acid, fat, calcium, potassium and iron. All of these parts must be utilized cautiously because the bark, leaves or seeds in contact with water can release HCN.

Morton, J. 1987. Mysore Raspberry. p. 109–110. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mysore Raspberry

Rubus neveus

Many species of *Rubus* (family Rosaceae), especially from the warm regions of the world, have been tried in southern Florida. Only one has been truly successful here, the Mysore raspberry, *R. niveus* Thunb., (syns. *R. lasiocarpus* Hook. f. in part; *R. albescens* Roxb.; *R. mysorensis* Heyne), also called Ceylon, hill or Mahabaleshwar, raspberry in India and *pilai* in the Philippines.

Description

The plant is a large scrambling shrub growing 10 to 15 ft (3-4.5 m) high, with cylindrical, flexible stems downy when young, later purple, coated with a white bloom. It is thoroughly set with sharp, hooked thorns. The leaves, 4 to 8 in (10-20 cm) long, are composed of 5 to 9 elliptic-ovate leaflets 1 to 2 1/2 in (2.5-6.25 cm) long, coarsely toothed, dark-green above and, on the underside, white-hairy with small, sharp spines along the rachis, petiole and midrib. Pink or red-purple, 5-petalled flowers, 1/2 in (1.25 cm) across, occur in lax axillary and terminal clusters. The fruit is rounded-conical, flat at the base; compound, made up of individual drupelets; red when unripe, purple-black when ripe, with a very fine bloom; 1/2 to 3/4 in (1.25-2 cm) in diameter, juicy and of sweet, rich black-raspberry flavor. The clusters may contain as many as 2 dozen or even more. The seeds are small and not objectionable.

Origin and Distribution


Plate XII: MYSORE RASPBERRY, *Rubus niveus*

The species is native to Burma and India, particularly the lower Himalayas, from Punjab to Assam, the Deccan peninsula, and the Western Ghats; and is common in the evergreen forests of Mahabaleshwar. The more hairy var. *horsfieldii* Focke extends south through Malaya to Indonesia and Bontoc and Benguet in the Philippines. From India, the Mysore raspberry was introduced into Kenya, East Africa, and has been grown in the mountains there for many years. Seeds from Kenya were obtained by F. B. Harrington of Natal, South Africa, in 1947. In 1948, he supplied seeds to the University of Florida's Agricultural Research and Education Center, Homestead. The resulting seedlings were planted out in 1949 and fruited so well the following winter that plants were distributed to many experimenters throughout south and central Florida. By 1952, many nurseries were offering the plants for sale and had difficulty filling the demand. By 1955, a major supermarket in Lake Worth was selling the fruits by the pint. In 1955, the University of Puerto Rico received planting material from Florida and established plantings in the central-western mountains of that island.

In Florida, some interest was still alive in 1965, but early enthusiasm waned as homeowners neglected their raspberry bushes, growth became too rampant, picking more and more difficult among the tangle of thorny canes, and birds competed eagerly for the crop. Many plantings were destroyed, and few remain.

Climate

This raspberry has a remarkable climatic range in Asia, from the relatively warm altitude of 1,500 ft (450 m) to the temperate environment at 10,000 ft (3,000 m). In Florida, brief drops in temperature to 35º F (1.67º C) have done the plants no harm but 20º F (-1.67º C) has killed young, tender growth, and prolonged freezing weather has killed the plants to the ground or outright.

Soil

In Florida, the plant flourishes on limestone or acid sand. In Puerto Rico it is grown on lateritic Alonso clay with a pH of 5.0. Good drainage is essential.

Propagation

The Mysore raspberry is often grown from seed but germination is slow and irregular (from 3 weeks to several months), and the seedlings are subject to damping-off. Germination can be expedited by pre-treatment with concentrated sulphuric acid. Stem cuttings root well, but the preferred method of propagation is by tip-layering. They develop plentiful roots in 3 to 4 weeks.

Culture

Florida gardeners place the plants 2 1/2 to 4 ft (0.75-1.2 m)apart in rows 6 to 8 ft (1.8-2.4 m) apart supported by 2 or 3 strands of wire attached to end-posts. In Puerto Rico, the plants are set out in hills spaced 6 to 8 ft (1.8-2.4 m) apart each way. If taller than 18 in (45 cm), they are cut back, surrounded by 2 or 3 stakes 6 ft (1.8 m) high linked by crosswires. As the canes grow, they are loosely tied to the stakes and wires. A mulch is desirable to retain Moisture and control weeds.

During the first year, in Puerto Rico, the plants are given 1 to 2 oz (28-56 g) each of ammonium sulfate quarterly. Thereafter, a 9-10-5 fertilizer formula is applied quarterly, 4 to 6 oz (113-170 g) per plant.

On Florida limestone, the recommended fertilizer consisting of 4-8-4 or 4-7-5 NPK with 3 to 4% magnesium and 30 to 40% organic nitrogen is applied every 2 to 3 weeks. And it is considered highly desirable that a mixture of zinc, copper and manganese be sprayed on the underside of the leaves 3 to 4 times per year.

Irrigation is necessary in dry seasons. Old canes should be cut to the ground at the end of the fruiting period and there should be severe pruning and thinning out in the late fall to force new growth for a winter-spring crop.

Season

The Mysore raspberry tends to bloom and fruit throughout the year but summer fruits are of poor size and quality. Therefore, the seasonal pruning has the additional purpose of preventing spring and summer flowering and allowing the first blooms to appear in December. Thus managed, the fruits are borne continuously from about February to May or June.

Harvesting

The fruits should be harvested only when they are not wet from dew or rain and when they are fully ripe and separate easily from the receptacle which remains on the plant. Gathering should be done at least 2 or 3 times a week to avoid losses by falling and spoilage. The fruits are highly perishable and should be consumed or processed as soon as possible.

Yield

In full sun, the crop is light. Where the plants receive some light shade in the afternoon, the yield is heavy. A single plant may yield 2,400 to 3,000 fruits over a 4-month period. A plot of 8 test plants in Florida produced 50 lbs (22.5 kg) in one season.

Pests and Diseases

The 2-spotted mite, *Tetranychus bimaculatus,* congregates on the underside of the leaves of shade-grown seedlings, turning them yellow. Occasionally, flower buds and fruits are attacked by the green stink bug, *Nezara viridula, also* called pumpkin or squash bug.

Anthracnose *(Elsinoe veneta)* causes spotting and scabbing of the canes toward the end of the fruiting season. Affected canes should be cut off and destroyed to prevent further infection.

Damping-off of seedlings can be avoided by planting seeds in a mixture of peat moss and vermiculite, or in sphagnum moss.

Food Uses

The fruits are enjoyed fresh, alone or served with sugar and cream or ice cream. They are excellent for making pie, tarts, jam and jelly. The fresh fruits can be quick-frozen for future use.

Morton, J. 1987. Red Ceylon Peach. p. 111–112. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Red Ceylon Peach

Prunus persica

The peach, *Prunus Persica* Batsch, is not ordinarily included among tropical or subtropical fruits. It is grown mainly in temperate regions of the world, including North America from the mild-temperate areas of Nova Scotia and the Ontario peninsula close to the Great Lakes, to north-central Florida, and across the Gulf States to California.

The earliest settlers in the South grew peaches, especially the highly-esteemed 'Spanish Blood'. Commercial culture began in the southern states with the introduction of other types and, by 1900, peach culture was receiving serious attention in many parts of the country. There are 5 races of the peach differing widely in their characteristics. The United States Department of Agriculture introduced many cultivars of the South China race, typified by the 'Peen-to', a flat type well adapted to moderately warm climates. The peach tree has a chilling requirement of a certain number of hours at 45° F (7.22° C) from the time of leaf-fall to the emerging of new buds. This period varies with the race and cultivar from 30 to 1,000 hours. Late in the 1880's, the 'Red Ceylon', which requires no more than 50 hours of chilling, became well-established in southern Florida. In 1904, this cultivar was planted at the agricultural experiment station at Santiago de Las Vegas, Cuba, and was soon being grown all around the Havana area because it was the only peach found suitable to that tropical climate and the local soils.

Description

The tree is dwarf, slender and willowy, with deciduous, alternate, slender, pointed leaves; bears pink, 5-petalled flowers on bare branches in January and February, sometimes March, and fruits heavily in April and May. The fruit is oval with a protruding knob at the apex, 2 3/4 in (7 cm) long and 2 3/8 in (6 cm) wide; velvety, green with deep-red blush when ripe. The flesh is mainly white but a rich strawberry-red in the center; tender, juicy, and of excellent, sweet-acid flavor having a slight suggestion of bitter-almond. The stone is free, corrugated and very hard; small in proportion to the size of the fruit. Despite its unattractiveness externally and small dimensions, the 'Red

Ceylon' is much-appreciated on close acquaintance. It is peeled, sliced and enjoyed fresh or stewed and can be used for various culinary purposes. The sliced fruit can be frozen in sirup and relished out-of-season as topping on cake or ice cream. In fact, one becomes so partial to this peach that the ordinary commercial peaches, though far more beautiful, seem somewhat rubbery and much less flavorful by comparison.

Fig. 30: The supple branches of the 'Red Ceylon Peach' (Prunus persica) bend to the ground when laden with fruit.

Other Cultivars

Two other subtropical cultivars have been successfully grown in southern Florida:

'Saharanpur'–a selection from seedlings received in 1969 from the Horticultural Research Institute, Saharanpur, India. The fruit is very similar to that of 'Red Ceylon' except that it lacks the fine red coloration in the center. The seedlings received from India were probably of the selection **'Shabati'** reported by Dr. L. B. Singh as having been released in 1950 and widely distributed all over India where winter chilling requirement of 30 to 40 hours could be guaranteed.

'Okinawa'–a fruit of superior form but of inferior quality. This cultivar has been valued mainly as a rootstock because of its greater nematode-resistance.

Culture

The 'Red Ceylon' peach has been commonly propagated by seed or by grafting. The seeds may take several months to germinate unless cracked which will induce sprouting in 10 to 90 days. The tree grows rapidly and bears in 2 years from seed. It is relatively nematode-resistant and requires little care, but should receive plenty of water for good production.

Status

In the 1940's and 1950's the 'Red Ceylon' peach was being deservedly promoted as a useful fruit for home gardens. It is impractical for marketing because of the protruding tip which bruises and then spoils readily. Seedlings and grafted plants were being sold by nurseries. Unfortunately, with the advent of the Caribbean fruit fly in 1965, and its rapid spread in southern Florida, interest in peach-growing dwindled, for the peach is a major host of this pest. Marie Neal wrote that, in Hawaii, a type of peach with small fruits having whitish flesh was formerly grown from the lowlands to an altitude of 3,000 ft (900 m), but its cultivation was discouraged because of the prevalence of the Mediterranean fruit fly.

The 'Red Ceylon' and the 'Okinawa' have been used as rootstocks for peaches in central Florida, though such tender rootstocks may make the grafted tree inclined to cold-sensitivity. In 1957, a hybrid between the 'Red Ceylon' and the 'Southland' peach was developed at the University of Florida's Agricultural Experiment Station in Gainesville.

Plate XIII: RED CEYLON PEACH, *Prunus persica*

In the past 2 decades there have been continuous efforts to develop low-chilling cultivars for central Florida and also hardier types as a crop replacement for the orange in the northern part of the "Citrus Belt" where severe damage to orange trees occurred in the winter of 1962-1963 and 200,000 bearing trees were killed by freezes in December 1983 and January 1985.

Dr. Ralph Sharpe has been a leader in peach-breeding in this state for many years. Through his research and that of his colleagues, Florida now has a substantial peach industry. The low-chilling, semi -cling-stone **'Floridaprince',** requiring only 150 hours below 45º F (7.22º C), was released to nurseries in late 1985.

Morton, J. 1987. Sansapote. p. 113–114. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sansapote

Licania platypus

A fruit held in rather low esteem, the sansapote, *Licania platypus* Fritsch (syn. *Moquilea platypus* Hemsl.), of the family Chrysobalanaceae, is often called *sonzapote*, *sunzapote*, *sungano*, *zapote cabelludo, sapote* or *sangre* in Costa Rica and El Salvador; *sonzapote* in Nicaragua; *zapote amarillo, zapote borracho, zapote cabello, zapote de mico, zapote de mono, mesonsapote, mezonzapote*, *cabeza de mico*, or *caca de niño* in Mexico; *sonza, sunza, zunza, chaute jolobob in* Guatemala; *urraco* in Honduras; *chupa* in Colombia; monkey apple in Belize.

Description

The handsome tree is erect, stately, reaching 100 to 160 ft (30-50 m) in height; has a rounded crown of thick branches, heavily foliaged, and dark purplish or brown bark dotted with tiny white or reddish-white lenticels. It is sometimes slightly buttressed. The deciduous leaves are alternate, occasionally spiraled, elliptic- to narrow-lanceolate, pointed at both ends; 4 to 12 in (10-30 cm) long, 1 1/4 to 3 1/2 in (3-9 cm) wide, with thick midrib, indented above and prominent beneath. New foliage is bronze or red-purple and very showy. The abundant, fragrant flowers, in broad terminal, branched panicles 4 to 14 in (10-35 cm) long, are small and densely hairy with recurved petals and numerous protruding stamens. Only 1 to 3 fruits develop from each particle. The obovoid or pyriform. fruit, 5 to 8 in (13-20 cm) long, 4 to 5 1/2 in (10-14 cm) wide, has a thin, dark-brown or reddish, warty rind covered with white lenticels. The flesh, somewhat pumpkin-scented, is yellow or orange-yellow, soft, fibrous, dry or juicy and of subacid or sweet flavor. Usually there is a single rounded or ovate-oblong, flattened seed, 2 3/8 to 4 in (6-10 cm) long.

Fig 31: The sansapote, photographed by the U.S. Department of Agriculture plant explorers, Cook, Collins and Doyle, at Nicoya, Costa Rica, in 1903. Published in Henry Pittier's *New or Noteworthy Plants from Colombia and Central America #3* (Contribution of the U.S. National Herbarium Vol. 13, Part 12), the Smithsonian Institution; 1912.

Origin and Distribution

The sansapote grows wild in dense forests from southern Mexico to Panama, on both coasts, and also in northern Colombia. It is much planted as an ornamental and shade tree throughout Central America. It was introduced into the Philippines in the early 1900's and into Hawaii only about 25 years ago. In the spring of 1913, the United States Department of Agriculture received seeds from the Department of Agriculture in San José, Costa Rica (S.P.I. #34915). In November of the same year, seeds of a small-fruited type from the Pacific Coast and a large-fruited type from the Atlantic slope were received from the same source (S.P.I. #36590). Another introduction was made from Colombia in 1916 (S.P.I. #42991).

Few of the trees planted in southern Florida have survived. Several young specimens have died at the Fairchild Tropical Garden. One at the Subtropical Horticulture Research Station, Miami, has bloomed several times after rains but has not fruited. William Whitman obtained seeds from the Ministry of Agriculture, El Salvador, in 1957. One tree grew well, suffered severe hurricane damage in 1964, recovered, bloomed in late 1969 and, in the summer of 1970, produced a dozen fruits; over 100 in 1971. The fruits are not highly regarded in Central America but are sold in native markets. Tapirs and peccaries feast on those that are left on the ground.

Climate

This is a tropical species limited to low elevations–not more than 2,000 ft (600 m) above sea-level.

Season

According to Pennington, the tree blooms from July to September in Mexico and the fruits ripen from August to December. Perhaps he means of the following year. In Costa Rica and Honduras the fruit is said to take a year to develop to maturity. In Florida, one tree bloomed in November and the first fruits ripened 9 months later and the season extended from summer to fall.

Food Uses

The fruit is eaten raw when better fruits are not available. According to Standley, it has the reputation of being unwholesome, causing fever and other illnesses.

Food Value Per 100 g of Edible Portion*

Moisture	64.6-67.4 g
Protein	0.230-0.291 g
Fat	0.26-0.49 g
Fiber	0.9-2.5 g
Ash	0.96-1.61 mg
Calcium	10.5-33.2 mg
Phosphorus	24.5-29.1 mg
Iron	0.52-1.70 mg
Carotene	0.157-0.273 mg
Thiamine	0.005-0.16 mg
Riboflavin	0.013-0.027 mg
Niacin	1.466-1.530 mg
Ascorbic Acid	11.0-35.6 mg

*According to analyses made in Costa Rica and El Salvador.

Other Uses

The sapwood is pale-yellow or light yellowish-brown; the heartwood is purplish-brown or reddish, fine-grained, very heavy and strong, suitable for fine furniture and cabinetwork, but it is not durable in contact with the ground. It is little-known inasmuch as the trees are valued and seldom felled. Related species provide timber for construction and charcoal. The seeds of *L. rigida* Benth. yield oiticica oil, much like tung oil.

Morton, J. 1987. Tamarind. p. 115–121. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Tamarind

Tamarindus indica

Of all the fruit trees of the tropics, none is more widely distributed nor more appreciated as an ornamental than the tamarind, *Tamarindus indica* L. (syns. *T. occidentalis* Gaertn.; *T. officinalis* Hook.), of the family Leguminosae. Most of its colloquial names are variations on the common English term. In Spanish and Portuguese, it is *tamarindo;* in French, *tamarin*, *tamarinier*, *tamarinier des Indes*, or *tamarindier;* in Dutch and German, *tamarinde;* in Italian, *tamarandizio;* in Papiamiento of the Lesser Antilles, *tamarijn*. In the Virgin Islands, it is sometimes called *taman;* in the Philippines, *sampalok* or various other dialectal names; in Malaya, *asam jawa;* in India, it is tamarind or *ambli*, *imli*, *chinch*, etc.; in Cambodia, it is *ampil* or *khoua me;* in Laos, *mak kham;* in Thailand, *ma-kharm;* in Vietnam, *me*. The name "tamarind" with a qualifying adjective is often applied to other members of the family Leguminosae having somewhat similar foliage.

Description

Plate XIV: TAMARIND, *Tamarindus indica*

The tamarind, a slow-growing, long-lived, massive tree reaches, under favorable conditions, a height of 80 or even 100 ft (24-30 m), and may attain a spread of 40 ft (12 m) and a trunk circumference of 25 ft (7.5 m). It is highly wind-resistant, with strong, supple branches, gracefully drooping at the ends, and has dark-gray, rough, fissured bark. The mass of bright-green, fine, feathery foliage is composed of pinnate leaves, 3 to 6 in (7.5-15 cm) in length, each having 10 to 20 pairs of oblong leaflets 1/2 to 1 in (1.25-2.5 cm) long and 1/5 to 1/4 in (5-6 mm) wide, which fold at night. The leaves are normally evergreen but may be shed briefly in very dry areas during the hot season. Inconspicuous, inch-wide flowers, borne in small racemes, are 5-petalled (2 reduced to bristles), yellow with orange or red streaks. The flowerbuds are distinctly pink due to the outer color of the 4 sepals which are shed when the flower opens.

The fruits, flattish, beanlike, irregularly curved and bulged pods, are borne in great abundance along the new branches and usually vary from 2 to 7 in long and from 3/4 to 1 1/4 in (2-3.2 cm) in diameter. Exceptionally large tamarinds have been found on individual trees. The pods may be cinnamon-brown or grayish-brown externally and, at first, are tender-skinned with green, highly acid flesh and soft, whitish, under-developed seeds. As they mature, the pods fill out somewhat and the juicy, acidulous pulp turns brown or reddish-brown. Thereafter, the skin becomes a brittle, easily-cracked shell and the pulp dehydrates naturally to a sticky paste enclosed by a few coarse strands of fiber extending lengthwise from the stalk. The 1 to 12 fully formed seeds are hard, glossy-brown, squarish in form, 1/8 to 1/2 in (1.1-1.25 cm) in diameter, and each is enclosed in a parchmentlike membrane.

Origin and Distribution

Native to tropical Africa, the tree grows wild throughout the Sudan and was so long ago introduced into and adopted in India that it has often been reported as indigenous there also, and it was apparently from this Asiatic country that it reached the Persians and the Arabs who called it *"tamar hindi"* (Indian date, from the date-like appearance of the dried pulp), giving rise to both its common and generic names. Unfortunately, the specific name, *"indica"*, also perpetuates the illusion of Indian origin. The fruit was well known to the ancient Egyptians and to the Greeks in the 4th Century B.C.

The tree has long been naturalized in the East Indies and the islands of the Pacific. One of the first tamarind trees in Hawaii was planted in 1797. The tamarind was certainly introduced into tropical America, Bermuda, the Bahamas, and the West Indies much earlier. In all tropical and near-tropical areas, including South Florida, it is grown as a shade and fruit tree, along roadsides and in dooryards and parks. Mexico has over 10,000 acres (4,440 ha) of tamarinds, mostly in the states of Chiapas, Colima, Guerrero, Jalisco, Oaxaca and Veracruz. In the lower Motagua Valley of Guatemala, there are so many large tamarind trees in one area that it is called "El Tamarindal". There are commercial plantings in Belize and other Central American countries and in northern Brazil. In India there are extensive tamarind orchards producing 275,500 tons (250,000 MT) annually. The pulp is marketed in northern Malaya and to some extent wherever the tree is found even if there are no plantations.

Varieties

In some regions the type with reddish flesh is distinguished from the ordinary brown-fleshed type and regarded as superior in quality. There are types of tamarinds that are sweeter than most. One in Thailand is known as **'Makham waan'.** One distributed by the United States Department of Agriculture's Subtropical Horticulture Research Unit, Miami, is known as **'Manila Sweet'.**

Climate

Very young trees should be protected from cold but older trees are surprisingly hardy. Wilson Popenoe wrote that a large tree was killed on the west coast of Florida (about 7.5º lat. N) by a freeze in 1884. However, no cold damage was noted in South Florida following the low temperatures of the winter of 1957-1958 which had severe effects on many mango, avocado, lychee and lime trees. Dr. Henry Nehrling reported that a tamarind tree in his garden at Gotha, Florida, though damaged by freezes, always sprouted out again from the roots. In northwestern India, the tree grows well but the fruits do not ripen. Dry weather is important during the period of fruit development. In South Malaya, where there are frequent rains at this time, the tamarind does not bear.

Soil

The tree tolerates a great diversity of soil types, from deep alluvial soil to rocky land and porous, oolitic limestone. It withstands salt spray and can be planted fairly close to the seashore.

Propagation

Tamarind seeds remain viable for months, will germinate in a week after planting. In the past, propagation has been customarily by seed sown in position, with thorny branches protecting the young seedlings. However, today, young trees are usually grown in nurseries. And there is intensified interest in vegetative propagation of selected varieties because of the commercial potential of tamarind products. The tree can be grown easily from cuttings, or by shield-budding, side-veneer grafting, or air-layering.

Culture

Nursery-grown trees are usually transplanted during the early rainy season. If kept until the second rainy season, the plants must be cut back and the taproot trimmed. Spacing may be 33 to 65 ft (10-20 m) between trees each way, depending on the fertility of the soil. With sufficient water and regular weeding, the seedlings will reach 2 ft (60 cm) the first year and 4 ft (120 cm) by the second year.

In Madagascar, seedlings have begun to bear in the 4th year; in Mexico, usually in the 5th year; but in India, there may be a delay of 10 to 14 years before fruiting. The tree bears abundantly up to an age of 50-60 years or sometimes longer, then productivity declines, though it may live another 150 years.

Season

Mexican studies reveal that the fruits begin to dehydrate 203 days after fruit-set, losing approximately 1/2 moisture up to the stage of full ripeness, about 245 days from fruit-set. In Florida, Central America, and the West Indies, the flowers appear in summer, the green fruits are found in December and January and ripening takes place from April through June. In Hawaii the fruits ripen in late summer and fall.

Harvesting

Tamarinds may be left on the tree for as long as 6 months after maturity so that the moisture content will be reduced to 20% or lower. Fruits for immediate processing are often harvested by pulling the pod away from the stalk which is left with the long, longitudinal fibers attached. In India, harvesters may merely shake the branches to cause mature fruits to fall and they leave the remainder to fall naturally when ripe. Pickers are not allowed to knock the fruits off with poles as this would damage developing leaves and flowers. To keep the fruit intact for marketing fresh, the stalks must be clipped from the branches so as not to damage the shell,

Yield

A mature tree may annually produce 330 to 500 lbs (150-225 kg) of fruits, of which the pulp may constitute 30 to 55%, the shells and fiber, 11 to 30 %, and the seeds, 33 to 40%.

Keeping Quality

To preserve tamarinds for future use, they may be merely shelled, layered with sugar in boxes or pressed into tight balls and covered with cloth and kept in a cool, dry place. For shipment to processors, tamarinds may be shelled, layered with sugar in barrels and covered with boiling sirup. East Indians shell the fruits and sprinkle them lightly with salt as a preservative. In Java, the salted pulp is rolled into balls, steamed and sun-dried, then exposed to dew for a week before being packed in stone jars. In India, the pulp, with or without seeds and fibers may be mixed with salt (10%), pounded into blocks, wrapped in palmleaf matting, and packed in burlap sacks for marketing. To store for long periods, the blocks of pulp may be first steamed or sun-dried for several days.

Pests and Diseases

One of the major pests of the tamarind tree in India is the Oriental yellow scale, *Aonidiella orientalis.* Tamarind scale, *A. tamarindi*, and black, or olive, scale, *Saissetia oleae*, are also partial to tamarind but of less importance. Butani (1970) lists 8 other scale species that may be found on the tree, the young and adults sucking the sap of buds and flowers and accordingly reducing the crop.

The mealybug, *Planococcus lilacinus, is* a leading pest of tamarind in India, causing leaf-fall and sometimes shedding of young fruits. Another mealybug, *Nipaecoccus viridis, is* less of a menace except in South India where it is common on many fruit trees and ornamental plants. *Chionaspis acuminata-atricolor* and *Aspidiotus* spp., suck the sap of twigs and branches and the latter also feeds on young fruits. White grubs of *Holotrichia insularis* may feed on the roots of young seedlings. The nematodes, *Xiphinema citri* and *Longidorus elongatus* may affect the roots of older trees. Other predators attacking the leaves or flowers include the caterpillars, *Thosea aperiens, Thalarsodes quadraria, Stauropus alternus,* and *Laspeyresia palamedes;* the black citrus aphid, *Toxoptera aurantii,* the whitefly, *Acaudaleyrodes rachispora;* thrips, *Ramaswamia hiella subnudula, Scirtothrips dorsalis,* and *Haplothrips ceylonicus;* and cow bugs, *Oxyrhachis tarandus, Otinotus onerotus,* and *Laptoentrus obliquis.*

Fruit borers include larvae of the cigarette beetle, *Lasioderma serricorne,* also of *Virachola isocrates, Dichocrocis punctiferalis, Tribolium castaneum, Phycita orthoclina, Cryptophlebia (Argyroploca) illepide, Oecadarchis sp., Holocera pulverea, Assara albicostalis, Araecerus suturalis, Aephitobius laevigiatus,* and *Aphomia gularis.* The latter infests ripening pods on the tree and persists in the stored fruits, as do the tamarind beetle, *Pachymerus (Coryoborus) gonogra,* and tamarind seed borer, *Calandra (Sitophilus) linearis.* The rice weevil, *Sitophilus oryzae,* the rice moth, *Corcyra cepholonica,* and the fig moth, *Ephestia cautella,* infest the fruits in storage. The lesser grain borer, *Rhyzopertha dominica* bores into stored seeds.

In India, a bacterial leaf-spot may occur. Sooty mold is caused by *Meliola tamarindi.* Rots attacking the tree include saprot, *Xylaria euglossa,* brownish saprot, *Polyporus calcuttensis,* and white rot, *Trametes floccosa.* The separated pulp has good keeping quality but is subject to various molds in refrigerated storage.

Food Uses

The food uses of the tamarind are many. The tender, immature, very sour pods are cooked as seasoning with rice, fish and meats in India. The fully-grown, but still unripe fruits, called "swells" in the Bahamas, are roasted in coals until they burst and the skin is then peeled back and the sizzling pulp dipped in wood ashes and eaten. The fully ripe, fresh fruit is relished out-of-hand by children and adults, alike. The dehydrated fruits are easily recognized when picking by their comparatively light weight, hollow sound when tapped and the cracking of the shell under gentle pressure. The shell lifts readily from the pulp and the lengthwise fibers are removed by holding the stem with one hand and slipping the pulp downward with the other. The pulp is made into a variety of products. It is an

Fig 32: Acid-sweet pulp of the tamarind *(Tamarindus indica) is* blended with sugar as a confection, or preserved as jam or nectar. It enhances chutney and some well-known sauces.

important ingredient in chutneys, curries and sauces, including some brands of Worcestershire and barbecue sauce, and in a special Indian seafood pickle called "tamarind fish". Sugared tamarind pulp is often prepared as a confection. For this purpose, it is desirable to separate the pulp from the seeds without using water. If ripe, fresh, undehydrated tamarinds are available, this may be done by pressing the shelled and defibered fruits through a colander while adding powdered sugar to the point where the pulp no longer sticks to the fingers. The seeded pulp is then shaped into balls and coated with powdered sugar. If the tamarinds are dehydrated, it is less laborious to layer the shelled fruits with granulated sugar in a stone crock and bake in a moderately warm oven for about 4 hours until the sugar is melted, then the mass is rubbed through a sieve, mixed with sugar to a stiff paste, and formed into patties. This sweetmeat is commonly found on the market in Jamaica, Cuba and the Dominican Republic. In Panama, the pulp may be sold in corn husks, palmleaf fiber baskets, or in plastic bags.

Fig. 33: Bahamian children hold mature but still green tamarinds in hot ashes until they sizzle, then dip the tip in the ashes and eat them. The high calcium content contributes to good teeth.

Tamarind ade has long been a popular drink in the Tropics and it is now bottled in carbonated form in Guatemala, Mexico, Puerto Rico and elsewhere. Formulas for the commercial production of spiced tamarind beverages have been developed by technologists in India. The simplest home method of preparing the ade is to shell the fruits, place 3 or 4 in a bottle of water, let stand for a short time, add a tablespoonful of sugar and shake vigorously. For a richer beverage, a quantity of shelled tamarinds may be covered with a hot sugar sirup and allowed to stand several days (with or without the addition of seasonings such as cloves, cinnamon, allspice, ginger, pepper or lime slices) and finally diluted as desired with ice water and strained.

In Brazil, a quantity of shelled fruits may be covered with cold water and allowed to stand 10 to 12 hours, the seeds are strained out, and a cup of sugar is added for every 2 cups of pulp; the mixture is boiled for 15 to 20 minutes and then put up in glass jars topped with paraffin. In another method, shelled tamarinds with an equal quantity of sugar may be covered with water and boiled for a few minutes until stirring shows that the pulp has loosened from the seeds, then pressed through a sieve. The strained pulp, much like apple butter in appearance, can be stored under refrigeration for use in cold drinks or as a sauce for meats and poultry, plain cakes or puddings. A foamy "tamarind shake" is made by stirring this sauce into an equal amount of dark-brown sugar and then adding a tablespoonful of the mixture to 8 ounces of a plain carbonated beverage and whipping it in an electric blender.

If twice as much water as tamarinds is used in cooking, the strained product will be a sirup rather than a sauce. Sometimes a little soda is added. Tamarind sirup is bottled for domestic use and export in Puerto Rico. In Mayaguez, street vendors sell cones of shaved ice saturated with tamarind sirup. Tamarind pulp can be made into a tart jelly, and tamarind jam is canned commercially in Costa Rica. Tamarind sherbet and ice cream are popular and refreshing. In making fruit preserves, tamarind is sometimes combined with guava, papaya or banana. Sometimes the fruit is made into wine.

Inasmuch as shelling by hand is laborious and requires 8 man-hours to produce 100 lbs (45 kg) of shelled fruits, food technologists at the University of Puerto Rico have developed a method of pulp extraction for industrial use. They found that shelling by mechanical means alone is impossible because of the high pectin and low moisture content of the pulp. Therefore, inspected and washed pods are passed through a shell-breaking grater, then fed into stainless steel tanks equipped with agitators. Water is added at the ratio of 1:1 1/2 or 1:2 pulp/water, and the fruits are agitated for 5 to 7 minutes. The resulting mash is then passed through a screen while nylon brushes separate the shells and seeds. Next the pulp is paddled through a finer screen, pasteurized, and canned.

Young leaves and very young seedlings and flowers are cooked and eaten as greens and in curries in India. In Zimbabwe, the leaves are added to soup and the flowers are an ingredient in salads.

Tamarind seeds have been used in a limited way as emergency food. They are roasted, soaked to remove the seedcoat, then boiled or fried, or ground to a flour or starch. Roasted seeds are ground and used as a substitute for, or adulterant of, coffee. In Thailand they are sold for this purpose. In the past, the great bulk of seeds available as a by-product of processing tamarinds, has gone to waste. In 1942, two Indian scientists, T. P. Ghose and S. Krishna, announced that the decorticated kernels contained 46 to 48% of a gel-forming substance. Dr. G. R. Savur of the Pectin Manufacturing Company, Bombay, patented a process for the production of a purified product, called "Jellose", "polyose", or "pectin", which has been found superior to fruit pectin in the manufacture of jellies, jams, and marmalades. It can be used in fruit preserving with or without acids and gelatinizes with sugar concentrates even in cold water or milk. It is recommended as a stabilizer in ice cream, mayonnaise and cheese and as an ingredient or agent in a number of pharmaceutical products.

Food Value Per 100 g of Edible Portion

	*Pulp (ripe) **	*Leaves (young)*	*Flowers*
Calories	115		
Moisture	28.2-52 g	70.5 g	80 g
Protein	3.10 g	5.8 g	0.45 g
Fat	0.1 g	2.1 g	1.54 g
Fiber	5.6 g	1.9 g	1.5 g
Carbohydrates	67.4 g	18.2 g	
Invert Sugars	30-41 g		
(70% glucose; 30% fructose)			
Ash	2.9 g	1.5 g	0.72 g
Calcium	35-170 mg	101 mg	35.5 mg
Magnesium		71 mg	
Phosphorus	54-110 mg	140 mg	45.6 mg

Iron	1.3-10.9 mg	5.2 mg	1.5 mg
Copper		2.09 mg	
Chlorine		94 mg	
Sulfur		63 mg	
Sodium	24 mg		
Potassium	375 mg		
Vitamin A	15 I.U.	250 mcg	0.31 mg
Thiamine	0.16 mg	0.24 mg	0.072 mg
Riboflavin	0.07 mg	0.17 mg	0.148 mg
Niacin	0.6-0.7 mg	4.1 mg	1.14 mg
Ascorbic Acid	0.7-3.0 mg	3.0 mg	13.8 mg
Oxalic Acid		196 mg	
Tartaric Acid	8-23.8 mg		
Oxalic Acid	trace only		

*The pulp is considered a promising source of tartaric acid, alcohol (12% yield) and pectin (2 1/2% yield). The red pulp of some types contains the pigment, chrysanthemin.

Seeds contain approximately 63% starch, 14-18% albuminoids, and 4.5-6.5% of a semi-drying oil.

Food Value

Analyses of the pulp are many and varied. Roughly, they show the pulp to be rich in calcium, phosphorus, iron, thiamine and riboflavin and a good source of niacin. Ascorbic acid content is low except in the peel of young green fruits.

Other Uses

Fruit pulp: in West Africa, an infusion of the whole pods is added to the dye when coloring goat hides. The fruit pulp may be used as a fixative with turmeric or annatto in dyeing and has served to coagulate rubber latex. The pulp, mixed with sea water, cleans silver, copper and brass.

Leaves: The leaves are eaten by cattle and goats, and furnish fodder for silkworms–*Anaphe sp.* in India, *Hypsoides vuilletii* in West Africa. The fine silk is considered superior for embroidery.

Tamarind leaves and flowers are useful as mordants in dyeing. A yellow dye derived from the leaves colors wool red and turns indigo-dyed silk to green. Tamarind leaves in boiling water are employed to bleach the leaves of the buri palm *(Corypha elata* Roxb.) to prepare them for hat-making. The foliage is a common mulch for tobacco plantings.

Flowers: The flowers are rated as a good source of nectar for honeybees in South India. The honey is golden-yellow and slightly acid in flavor.

Seeds: The powder made from tamarind kernels has been adopted by the Indian textile industry as 300% more efficient and more economical than cornstarch for sizing and finishing cotton, jute and spun viscose, as well as having other technical advantages. It is commonly used for dressing homemade blankets. Other industrial uses include employment in color printing of textiles, paper sizing, leather treating, the manufacture of a structural plastic, a glue for wood, a stabilizer in bricks, a binder in sawdust briquettes, and a thickener in some explosives. It is exported to Japan, the United States, Canada and the United Kingdom.

Tamarind seeds yield an amber oil useful as an illuminant and as a varnish especially preferred for painting dolls and idols. The oil is said to be palatable and of culinary quality. The tannin-rich seedcoat (testa) is under investigation as having some utility as an adhesive for plywoods and in dyeing and tanning, though it is of inferior quality and gives a red hue to leather.

Wood: The sapwood of the tamarind tree is pale-yellow. The heartwood is rather small, dark purplish-brown, very hard, heavy, strong, durable and insect-resistant. It bends well and takes a good polish and, while hard to work, it is highly prized for furniture, panelling, wheels, axles, gears for mills, ploughs, planking for sides of boats, wells, mallets, knife and tool handles, rice pounders, mortars and pestles. It has at times been sold as "Madeira mahogany". Wide boards are rare, despite the trunk dimensions of old trees, since they tend to become hollow-centered. The wood is valued for fuel, especially for brick kilns, for it gives off an intense heat, and it also yields a charcoal for the manufacture of gun-powder. In Malaysia, even though the trees are seldom felled, they are frequently topped to obtain firewood. The wood ashes are employed in tanning and in de-hairing goatskins. Young stems and also slender roots of the tamarind tree are fashioned into walking-sticks.

Twigs and barks: Tamarind twigs are sometimes used as "chewsticks" and the bark of the tree as a masticatory, alone or in place of lime with betelnut. The bark contains up to 7% tannin and is often employed in tanning hides and in dyeing, and is burned to make an ink. Bark from young trees yields a low-quality fiber used for twine and string. Galls on the young branches are used in tanning.

Lac: The tamarind tree is a host for the lac insect, *Kerria lacca*, that deposits a resin on the twigs. The lac may be harvested and sold as stick-lac for the production of lacquers and varnish. If it is not seen as a useful byproduct, tamarind growers trim off the resinous twigs and discard them.

Medicinal Uses: Medicinal uses of the tamarind are uncountable. The pulp has been official in the British and American and most other pharmacopoeias and some 200,000 lbs (90,000 kg) of the shelled fruits have been annually imported into the United States for the drug trade, primarily from the Lesser Antilles and Mexico. The European supply has come largely from Calcutta, Egypt and the Greater Antilles. Tamarind preparations are universally recognized as refrigerants in fevers and as laxatives and carminatives. Alone, or in combination with lime juice, honey, milk, dates, spices or camphor, the pulp is considered effective as a digestive, even for elephants, and as a remedy for biliousness and bile disorders, and as an antiscorbutic. In native practice, the pulp is applied on inflammations, is used in a gargle for sore throat and, mixed with salt, as a liniment for rheumatism. It is, further, administered to alleviate sunstroke, *Datura* poisoning, and alcoholic intoxication. In Southeast Asia, the fruit is prescribed to counteract the ill effects of overdoses of false chaulmoogra, *Hydnocarpus anthelmintica* Pierre, given in leprosy. The pulp is said to aid the restoration of sensation in cases of paralysis. In Colombia, an ointment made of tamarind pulp, butter, and other ingredients is used to rid domestic animals of vermin.

Tamarind leaves and flowers, dried or boiled, are used as poultices for swollen joints, sprains and boils. Lotions and extracts made from them are used in treating conjunctivitis, as antiseptics, as vermifuges, treatments for dysentery, jaundice, erysipelas and hemorrhoids and various other ailments. The fruit shells are burned and reduced to an alkaline ash which enters into medicinal formulas. The bark of the tree is regarded as an effective astringent, tonic and febrifuge. Fried with salt and pulverized to an ash, it is given as a remedy for indigestion and colic. A decoction is used in cases of gingivitis and asthma and eye inflammations; and lotions and poultices made from the bark are applied on open sores and caterpillar rashes. The powdered seeds are made into a paste for drawing boils and, with or without cumin seeds and palm sugar, are prescribed for chronic diarrhea and dysentery. The seedcoat, too, is astringent, and it, also, is specified for the latter disorders. An infusion of the roots is believed to have curative value in chest complaints and is an ingredient in prescriptions for leprosy.

The leaves and roots contain the glycosides: vitexin, isovitexin, orientin and isoorientin. The bark yields the alkaloid, hordenine.

Superstitions

Few plants will survive beneath a tamarind tree and there is a superstition that it is harmful to sleep or to tie a horse beneath one, probably because of the corrosive effect that fallen leaves have on fabrics in damp weather. Some African tribes venerate the tamarind tree as sacred. To certain Burmese, the tree represents the dwelling-place of the rain god and some hold the belief that the tree raises the temperature in its immediate vicinity. Hindus may marry a tamarind tree to a mango tree before eating the fruits of the latter. In Nyasaland, tamarind bark soaked with corn is given to domestic fowl in the belief that, if they stray or are stolen, it will cause them to return home. In Malaya, a little tamarind and coconut milk is placed in the mouth of an infant at birth, and the bark and fruit are given to elephants to make them wise.

Morton, J. 1987. Carob. p. 65–69. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Carob

Ceratonia siliqua

Non-fleshy and bean-like, the carob would not be generally regarded as a fruit, in the food-use sense, except for its sweetness. To many people it is familiar only by name as "St. John's Bread", in allusion to the "locusts" which, according to the Bible, sustained St. John the Baptist in the desert, and the "husks" which tempted the hungry Prodigal Son, though "no man gave unto him." The word "locust" was originally applied to the carob tree; later to migratory and other grasshoppers; and the name is attached to a number of other leguminous trees with pinnate leaves and oblong pods *(Gleditsia, Hymenaea, Parkia, Robinia)*. The carob tree is called *carrubo* in *Sicily, carrubio* in Italy, *algarrobo* in Guatemala, *alfarrobeira* in Brazil.

Description

The tree reaches 50 to 55 ft (15-17 m) in height and at an age of 18 years may have a trunk 33 in (85 cm) in circumference. The evergreen leaves are pinnate with 6 to 10 opposite leaflets, oval, rounded at the apex, dark-green, leathery, 1 to 2 1/2 in (2.5-6.25 cm) long. The tiny red flowers are in short, slender racernes borne in clusters along the branches–male, female or hermaphrodite on


Fig. 34: A rarity in southern Florida, this carob tree on the campus of the University of Miami was 15 years old when photographed in 1954. It is still bearing small fruits every year without cross-pollination.

separate trees. The pod is light- to dark-brown, oblong, flattened, straight or slightly curved, with a thickened margin; 4 to 12 in (10-30 cm) long, 3/4 to 1 in (1-2.5 cm) wide, glossy, tough and fibrous. It is filled with soft, semi-translucent, pale-brown pulp, scant or plentiful, and 10 to 13 flattened, very hard seeds which are loose in their cells and rattle when the pod is fully ripe and dry. The unripe pod is green, moist and very astringent; the ripe pod sweet when chewed (avoiding the seeds) but the odor of the broken pod is faintly like Limburger cheese because of its 1.3% isobutyric acid content.

Origin and Distribution

Alphonse de Candolle said that the carob "grew wild in the Levant, probably on the southern coast of Anatolia and in Syria, perhaps also in Cyrenaica. Its cultivation began within historic time. The Greeks diffused it in Greece and Italy, but it was afterwards more highly esteemed by the Arabs, who propagated it as far as Morocco and Spain. In all these countries the tree has become naturalized here and there in a less productive form . . . ".

In Spain and Portugal it survives only on their Atlantic coasts. Throughout the Mediterranean region, it is grown only in the warmest areas near the coast, and the neighboring islands–Cyprus, Crete, Sicily, Sardinia and Majorca. Producers in the Bari region of Italy on the Adriatic coast have long exported the pods to Russia and central Europe. Prince Belmonte in the Province of Salerno, Italy, was a leading influence in the 19th century in the use of the carob as an ornamental and avenue tree and in the planting of thousands for reforestation of the slopes of the Appenines.

Spanish missionaries introduced the carob into Mexico and southern California. In 1856, 8,000 seedlings, from seed brought in from Spain by the United States Patent Office, were distributed in the southern states. More seeds came from Israel in 1859. Many carobs were planted in Texas, Arizona, California and a few in Florida as ornamental and street trees. Seeds privately imported from Dalmatia were planted in California in 1873.

In the Mediterranean region, peasants have virtually lived on the pods in times of famine, but the tree is valued mostly as providing great amounts of pods as feed for livestock, as it is also in the State of Campinas, Brazil. Imported pods used to be regularly sold by street vendors in the Italian section of lower New York City for chewing. In the early 1920's, there was much promotion of carob culture in California, especially allied with the development of arid lands, and there was a flurry of activity in producing "health food" products from imported pods. Some of these products are still sold today, especially as substitutes for chocolate. Dr. J. Eliot Coit, of Vista, California, led in the study of the carob and wrote extensively on its potential improvement as a crop and its utilization.

In 1949, Dr. Walter Rittenhouse provided funds for the establishment of a 30-year test plot in northern San Diego County, where 400 local nursery seedlings and many trees grafted with Mediterranean budwood were planted and evaluated. Fruits from several thousand ornamental carob trees in California and Arizona were collected in an effort to identify superior types for human food use. Budwood of the most promising clones was supplied to horticulturists in Tunisia, Israel, Australia, South Africa, Hawaii, Mexico, Brazil and Chile.

Varieties

From more than 80 clones, 7 selections made by Coit were set out at the Citrus Research Center of the University of California for preservation. The 7 are, briefly:

'Amele'-an old commercial variety from Italy; S.P.I. #19437. Female. Pods light-brown, straight or slightly curved, 5 1/2 to 6 1/4 in (14-16 cm) long, 3/4 to 1 in (2-2.5 cm) wide; 53.8% sugar content under irrigation near Indio. Flavor good. Season: September at Indio; October at Vista.

'Casuda'-a very old cultivar from Spain. Female. Pod brown, mostly straight; 4 3/4 in (12 cm) long; 3/5 in (1.5 cm) wide; 51.7 % sugar at Vista; 56.7 % under irrigation at Indio. Flavor fair. Season: September at Indio; October at Vista.

'Clifford'-seedling street tree in Riverside. Hermaphrodite. Pod light-brown, slightly curved, 5 1/8 in (13 cm) long, 3/4 in (2 cm) wide; 52.9% sugar content. Flavor fair. Season: early October; bears regularly and heavily.

'Sfax'-from Menzel bou Zelfa, Tunisia; S.P.I. #187063. Female. Pod red-brown, straight or slightly curved; 6 in (15 cm) long, 3/4 in (2 cm) wide; 56.6% sugar at Vista, 45.6% at Indio. Excellent flavor. Season: August at Indio, September at Vista. A regular, medium-heavy bearer.

'Santa Fe'-seedling from Santa Fe Springs, California. Hermaphrodite; self-fertile. Pod light-brown, slightly curved, often twisted; 7 to 7 7/8 in (18-20 cm) long, 3/4 in (2 cm) wide; 47.5% sugar at Vista. Excellent flavor. Season: October. Bears regular, good crops. Good for coastal foothills. Not suited to irrigated culture at Indio.

'Tantillo'-from Sicily; S.P.I. #233580. Hermaphrodite. Pod dark-brown, mostly straight; 5 1/8 to 6 in (13-15 cm) long, 3/4 in (2 cm) wide. Of fair flavor. Season: mid-September to mid-October. Bears heavily and regularly.

'Tylliria'-from Cyprus; their chief export variety; S.P.I. # 189008. Female. Pod dark mahogany-brown, slightly curved, 6 in (15 cm) long, 3/4 to 1 in (2-2.5 cm) wide; 47.4% sugar at Vista; 50.9% at Indio; 48.8% in Cyprus. Good flavor. Season: mid-August to mid-September at Indio; October at Vista. Adapted to coastal foothills. (As reported from Cyprus, seed content is 7.6 to 10.6%; pod contains 51 % sugar and the seeds 49% gum).

These 7 superseded some older cultivars, including 'Bolser', 'Conejo', 'Gabriel', 'Horne', and 'Molino'; all hermaphroditic.

Other common cultivars in Cyprus are:

'Koundourka'-a tree with weeping branches; mature pods generally less than 6 1/2 in (17 cm) long; they split readily; have 14.7% seeds with a high (58%) gum content.

'Koumbota'-a large-growing tree with "knotty" pods with low seed content. Pods contain 53% sugar; seeds, 53% gum.

Grafted types are classed as 'Imera'. The name 'Apostolika' is a general term for seedlings of fair quality. Wild types as a group are called 'Agria'.

Pollination

In a planting of female trees, one male should be included for every 25 or 30 females. In southern Europe, branches from male trees are grafted onto some of the females in an orchard instead of interplanting male trees.

Climate

The carob is slightly hardier than the sweet orange. Young trees suffer frost damage. Mature tees can endure a temperature drop to 20º F (-6.67º C). Frost during the blooming period will reduce or prevent fruit-set. The tree does best in a Mediterranean-type climate with cool, not cold, winters, mild to warm springs, and warm to hot summers with little or no rain. Temperatures in carob-growing regions of Israel may reach 104º to 122º F (40º-50º C) in summer. Ideal annual precipitation is 30 in (75 cm), but widely spaced trees will thrive with only 6 to 15 in (15-37.5 cm) without irrigation in mild climates. The pods should not be exposed to rain or heavy dew after they have turned brown and developed a high sugar content. Wet pods ferment quickly.

Soil

The tree flourishes in widely divergent soils, from rocky hillsides to deep sand or heavy loam, but must have good drainage. In Nicosia, Cyprus, a large plantation was developed by dynamiting planting holes in caprock underlaid with limestone (pH 9). The carob is not tolerant of acid or wet soils; it is extremely drought-tolerant.

Propagation

Fresh seeds germinate quickly and may be sown directly in the field. Dried, hard seeds need to be scarified or chipped and then soaked in water or dilute sulfuric or hydrochloric acid solutions until they swell. In Cyprus, seeds are planted in sand and kept wet for 6 weeks or more, periodically sifting out those that have swollen to 3 times normal size. Germination rate may be only 25%. The swollen seeds are traditionally planted in flats and when they produce the second set of leaves they are transferred to small pots. When 12 in (30 cm) tall, they are transplanted to large containers or nursery rows. A recently developed technique is to plant the seeds in 2 halves of clay drainpipes bound together or in plastic tubes packed in deep wooden boxes to accommodate the long taproot. In perhaps a year, the tubes are split and the seedlings are planted in the field in holes made with a post-hole digger. Budding is done when the stem is at least 3/8 in (1 cm) thick.

The shield-budding system is employed, or sometimes a blend of budding and grafting, in February and March in Cyprus, in April, May and June in California and Mexico. Male trees or those that bear poorly are top-worked to productive cultivars.

Culture

The carob grows slowly during the first year. Stem-elongation in young plants has been expedited by application of gibberellin (50 mg/liter monthly, or 25 mg/liter semi-monthly) for 5 months. It is necessary to cut back the taproot 6 months before transferring to the field if the plant is not grown by the tube/post-hole method. Large trees cannot be successfully transplanted.

A good spacing is 30 ft (9 in) apart each way. Most carob growers consider fertilizing unnecessary but the government of Cyprus subsidizes fertilization–so much per tree. Irrigation must be provided in very dry seasons if the tree is grown for its fruits. Budded trees begin to bear in the 6th year from planting. A carob tree may remain productive for 80 to 100 years.

Harvesting

The pods must be harvested before winter rains. They are shaken down by means of a long pole with a terminal hook to grasp the branches. Those that don't fall readily are knocked off with the pole. The pods are caught on canvas sheets laid on the ground. Then they are sun-dried for 1 or 2 days until the moisture content is reduced to 8% or below and then go through a kibbling process–crushing and grading into 4 categories: cubed, medium-kibbled, meal, and seed kernels.

Yield

At 6 years of age, a budded tree in California should yield about 5 lbs (2.25 kg). At 12 years, the crop should be 100 lbs (45 kg). Productivity increases steadily up to 25 or 30 years when the yield may average 200 lbs (90 kg). In Israel individual trees have produced 450 to 550 lbs (204-227 kg) 18 years after grafting. Some ancient trees in the Mediterranean area are reported to have borne 3,000 lbs (1,360 kg) in a season.

Pests and Diseases

In the Mediterranean area, the major pest is the carob moth, *Myelois ceratoniae*. It lays eggs on the flowers or newly-formed pods and the larvae bore into the pods and ruin them. The larvae of a midge, *Asphondylia gennadii,* cause stunting of the pods. Some of the best cultivars are resistant to these pests.

In Cyprus, the tree is subject to several scale insects: *Aspidiotus ceratoniae, Lecanium sp., Lepidosaphes sp.* and the red scale, *Aonidiella aurantii.* A beetle, *Cerambyx velutinus,* may bore holes in the trunk. Rats climb the trees, hide among the branches, gnaw the bark until the branches die. Such branches are pruned out twice a year. The only pests reported as attacking carob trees in California are scale insects, including the red scale. Ground squirrels feed on plants under 2 years of age. Pocket gophers are very fond of carob roots, and rabbits and deer graze on the young trees.

Diseases are few. In Cyprus, deformation of young pods may be caused by the fungus *Oidium ceratoniae. Cercospora ceratoniae* occasionally induces leaf-spotting.

Food Uses

Apart from being chewed as a sweetmeat, carob pods are processed to a cocoa -like flour which is added to cold or heated milk for drinking. It has been combined with wheat flour in making bread or pancakes. A flour made by beating the seeded pods is high in fiber and has been utilized in breakfast foods. The finer flour is also made into confections, especially candy bars. The pods, coarsely ground and boiled in water yield a thick, honey-like sirup, or molasses.

Plate XV: CAROB, *Ceratonia siliqua*

The seeds constitute 10 to 20% of the pod. They yield a tragacanth-like gum (manogalactan), called in the trade "Tragasol", which is an important commercial stabilizer and thickener in bakery goods, ice cream, salad dressings, sauces, cheese, salami, bologna, canned meats and fish, jelly, mustard, and other food products. The seed residue after gum extraction can be made into a starch- and sugar-free flour of 60% protein content for diabetics.

In Germany, the roasted seeds have served as a substitute for coffee. In Spain, they have been mixed with coffee.

It has been demonstrated that the extracted sugars of the pod (sucrose, glucose, fructose and maltose in the ratio 5:1:1:0:7) can be utilized to produce fungal protein. Infusions of the pulp are fermented into alcoholic beverages.

Food Value Per 100 g of Carob Flour

Calories	180
Moisture	11.2 g
Protein	4.5 g
Fat	1.4 g
Carbohydrates*	80.7 g
Fiber	7.7 g
Ash	2.2 g
Calcium	352 mg
Phosphorus	81 mg

*Sugar content may be as high as 72%.

The pods contain up to 1.5% tannins which interfere with the body's utilization of protein.

Other Uses

Pods: The pods are relished by horses, cattle, pigs, goats and rabbits. Whole pods are broken up in a hammermill in order to crush the seeds as well. Because of the tannin content, carob pods should constitute no more than 10% of total feed, other-wise they will depress growth rate. They cannot be fed to chickens. The flour is often utilized in dog biscuits. Great quantities of pods have been imported into the United States for flavoring uncured tobacco.

Seeds: The seed gum is much employed in the manufacture of cosmetics, pharmaceutical products, detergents, paint, ink, shoe polish, adhesives, sizing for textiles, photographic paper, insecticides and match heads. It is also utilized in tanning. Where rubber latex is produced, the gum is added to cause the solids to rise to the surface. It is also used for bonding paper pulp and thickening silkscreen pastes, and some derivatives are added to drilling mud. It has many other actual or potential applications. A flour made from the seeds serves as cattle feed.

Wood: The heartwood is hard and close-grained. It is prized for turnery and cabinetwork. As a fuel it burns slowly and makes excellent charcoal. It yields algarrobin, which gives textiles a light-brown hue.

Morton, J. 1987. Carambola. p. 125–128. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Carambola

Averrhoa carambola

A curious, attractive fruit of the Oxalidaceae, the carambola, *Averrhoa carambola* L., has traveled sufficiently to have acquired a number of regional names in addition to the popular Spanish appelation which belies its Far Eastern origin. In the Orient, it is usually called *balimbing, belimbing,* or *belimbing manis* ("sweet belimbing"), to distinguish it from the bilimbi or *belimbing asam, A. bilimbi* L. In Ceylon and India, the carambola has the alternate names of *kamaranga, kamruk,* or other variants of the native *kamrakh.* In Vietnam, it is called *khe, khe ta,* or similar terms; in Kampuchea, *spu*; in Laos, *nak fuang,* or the French name, *carambolier;* in Thailand, *ma fueang*. Malayans may refer to it as *belimbing batu, belimbing besi, belimbing pessegi, belimbing sayur, belimbing saji, kambola, caramba,* or as "star fruit". Australians use the descriptive term, five corner; in Guam, it is *bilimbines;* to the Chinese, it is *yang-táo.* Early English travelers called it Chinese, or Coromandel gooseberry, or cucumber tree. In Guyana, it is five fingers; in the Dominican Republic, it is *vinagrillo;* in Haiti, *zibline;* in some of the French Antilles, *cornichon;* in El Salvador, *pepino de la India;* in Surinam, *blimbing legi* or *fransman-birambi;* Costa Rica, *tiriguro;* in Brazil, *camerunga* or *caramboleiro,* or *limas de Cayena;* in Mexico, *carambolera* or *caramboler* or *árbol de pepino;* in Trinidad, it may be called coolie tamarind. Venezuelans call it *tamarindo chino* or *tamarindo dulce.*

Description

Plate XVI: CARAMBOLA, *Averrhoa carambola*

The carambola tree is slow-growing, short-trunked with a much-branched, bushy, broad, rounded crown and reaches 20 to 30 ft (6-9 m) in height. Its deciduous leaves, spirally arranged, are alternate, imparipinnate, 6 to 10 in(15-20 cm) long, with 5 to 11 nearly opposite leaflets, ovate or ovate-oblong, 1 1/2 to 3 1/2 in (3.8-9 cm) long; soft, medium-green, and smooth on the upper surface, finely hairy and whitish on the underside. The leaflets are sensitive to light and more or less inclined to fold together at night or when the tree is shaken or abruptly shocked. Small clusters of red-stalked, lilac, purple-streaked, downy flowers, about 1/4 in (6 mm) wide, are borne on the twigs in the axils of the leaves. The showy, oblong, longitudinally 5- to 6-angled fruits, 2 1/2 to 6 in (6.35-15 cm) long and up to 3 1/2 (9 cm) wide, have thin, waxy, orange-yellow skin and juicy, crisp, yellow flesh when fully ripe. Slices cut in cross-section have the form of a star. The fruit has a more or less pronounced oxalic acid odor and the flavor ranges from very sour to mildly sweetish. The so-called "sweet" types rarely contain more than 4% sugar. There may be up to 12 flat, thin, brown seeds 1/4 to 1/2 in (6-12.5 mm) long or none at all.

Origin and Distribution

The carambola is believed to have originated in Ceylon and the Moluccas but it has been cultivated in southeast Asia and Malaysia for many centuries. It is commonly grown in the provinces of Fukien, Kuangtung and Kuangsi in southern China, in Taiwan and India. It is rather popular in the Philippines and Queensland, Australia, and moderately so in some of the South Pacific islands, particularly Tahiti, New Caledonia and Netherlands New Guinea, and in Guam and Hawaii.

There are some specimens of the tree in special collections in the Caribbean islands, Central America, tropical South America, and also in West Tropical Africa and Zanzibar. Several trees have been growing since 1935 at the Rehovoth Research Station in Israel. In many areas, it is grown more as an ornamental than for its fruits.

It was introduced into southern Florida before 1887 and was viewed mainly as a curiosity until recent years when some small groves have been established and the fruits have been used as "conversation pieces" to decorate gift shipments of citrus fruits, and also, in clear-plastic-wrapped trays, have been appearing in the produce sections of some supermarkets. One fruit-grower and shipper now has 50 acres (20 ha) planted but suggests that other prospective growers be cautious as the market may remain limited. Shipments go mainly to Vancouver, Quebec, Cleveland, and Disneyworld. Small amounts are sold locally.

Varieties

There are 2 distinct classes of carambola–the smaller, very sour type, richly flavored, with more oxalic acid; the larger, so-called "sweet" type, mild-flavored, rather bland, with less oxalic acid.

In 1935, seeds from Hawaii were planted at the University of Florida's Agricultural Research and Education Center in Homestead. A selection from the resulting seedlings was vegetatively propagated during the 1940's and 1950's and, in late 1965, was officially released under the name **'Golden Star'** and distributed to growers. The fruit is large, deeply winged, decorative, and mildly subacid to sweet. Furthermore, this cultivar shows the least minor-element deficiency in alkaline soil, and even isolated trees bear well and regularly without cross-pollination.

Several cultivars from Taiwan are being grown at the United States Department of Agriculture's Subtropical Horticulture Research Unit in Miami, including 'Mih Tao' (P. I. No. 272065) introduced in 1963, also 'Dah Pon' and 'Tean Ma' and others identified only by numbers, and Fwang Tung' brought from Thailand by Dr. R J. Knight in 1973. There are certain "lines" of carambola, such as 'Newcomb', 'Thayer' and 'Arkin' being grown commercially in southern Florida. Some cultivars and seedlings bear flowers with short styles, others only flowers with long styles, a factor which affects self- and cross-pollination.

Climate

The carambola should be classed as tropical and sub-tropical because mature trees can tolerate freezing temperatures for short periods and sustain little damage at 27º F (-2.78º C). In Florida, the tree survives in sheltered sites as far north as St. Petersburg on the west coast and Daytona Beach on the east. It thrives up to an elevation of 4,000 ft (1,200 m) in India. In an interior valley of Israel, all trees succumbed to the prevailing hot, dry winds. The carambola needs moisture for best performance and ideally rainfall should be fairly evenly distributed all year. In Australia, it is claimed that fruit quality and flavor are best where annual rainfall is 70 in (180 cm) or somewhat more.

Soil

Not too particular as to soil, the carambola does well on sand, heavy clay or limestone, but will grow faster and bear more heavily in rich loam. It is often chlorotic on limestone. It needs good drainage; cannot stand flooding.

Propagation

The carambola is widely grown from seed though viability lasts only a few days. Only plump, fully developed seeds should be planted. In damp peat moss, they will germinate in one week in summer, require 14 to 18 days in winter. The seedlings are transplanted to containers of light sandy loam and held until time to set out. They are very tender and need good care. Seedlings are highly variable. Air-layering has been practiced and advocated. However, root formation is slow and later performance is not wholly satisfactory. Inarching is successful in India, shield-budding in the Philippines and the Forkert method in Java. Trees can be top-worked by bark-grafting, a popular technique in Java. For mass production, side-veneer grafting of mature, purplish wood, onto carambola seedlings gives best results for most workers. The rootstocks should be at least 1 year old and 3/8 to 5/7 in (1-1.5 cm) thick. One Florida farmer prefers cleft-grafting of green budwood and has 90% success. Grafted trees will fruit in 10 months from the time of planting out. Mature trees can be top-worked by bark-grafting.

Culture

The tree needs full sun. A spacing of 20 ft (6 m) has been advocated but if the trees are on good soil no less than 30 ft (9 m) should be considered. At the Research Center in Homestead, trees 8 to 10 ft (2.4-3 m) high respond well to 1 lb (0.5 kg) applications of N, P, K, Mg in the ratio of 6-6-6-3 given 3 to 4 times per year. If chlorosis occurs, it can be corrected by added iron, zinc and manganese. Some advisers recommend minor-element spraying 4 times during the year if the trees are on limestone soils. Moderate irrigation is highly desirable during dry seasons. Heavy rains during blooming season interfere with pollination and fruit production. Interplanting of different strains is usually necessary to provide cross-pollination and obtain the highest yields.

Harvesting and Yield

In India, carambolas are available in September and October and again in December and January. In Malaya, they are produced all the year. In Florida, scattered fruits are found through the year but the main crop usually matures from late summer to early winter. Some trees have fruited heavily in November and December, and again in March and April. There may even be three crops. Weather conditions account for much of the seasonal variability.

The fruits naturally fall to the ground when fully ripe. For marketing and shipping they should be hand-picked while pale-green with just a touch of yellow.

Trees that receive adequate horticultural attention have yielded 100 to 250 or even 300 lbs (45-113-136 kg) of fruit.

Keeping Quality

Carambolas have been shipped successfully without refrigeration from Florida to northern cities in avocado lugs lined and topped with excelsior. The fruits are packed solidly, stem-end down, at a 45º angle, the flanges of one fruit fitting into the "V" grooves of another. Of course, they cannot endure rough handling.

In storage trials at Winter Haven, Florida, carambolas picked when showing the first signs of yellowing kept in good condition for 4 weeks at 50º F (10º C); 3 weeks at 60º F (15.56º C); 2 weeks at 70º F (21.1º C). Waxing extends storage life and preserves the vitamin value.

Pests and Diseases

The carambola is relatively pest-free except for fruit flies. In Malaya, fruit flies (especially *Dacus dorsalis*) are so troublesome on carambolas that growers have to wrap the fruits on the tree with paper. Experimental trapping, with methyl eugenol as an attractant, has reduced fruit damage by 20%. In Florida, a small stinkbug causes superficial blemishes and a black beetle attacks overripe fruits. Reniform nematodes may cause tree decline.

Anthracnose caused by *Colletotrichum gloeosporioides* may be a problem in Florida, and leaf spot may arise from attack by *Phomopsis* sp., *Phyllosticta* sp. or *Cercospora averrhoae. Cercospora* leaf spot is reported also from Malaya, Ceylon, China and may occur in the Philippines as well. A substance resembling sooty mold makes many fruits unmarketable in summer.

Food Uses

Ripe carambolas are eaten out-of-hand, sliced and served in salads, or used as garnish on avocado or seafood. They are also cooked in puddings, tarts, stews and curries. In Malaya, they are often stewed with sugar and cloves, alone or combined with apples. The Chinese cook carambolas with fish. Thais boil the sliced green fruit with shrimp. Slightly underripe fruits are salted, pickled or made into jam or other preserves. In mainland China and in Taiwan, carambolas are sliced lengthwise and canned in sirup for export. In Queensland, the sweeter type is cooked green as a vegetable. Cross-sections may be covered with honey, allowed to stand overnight, and then cooked briefly and, put into sterilized jars. Some cooks add raisins to give the product more character. A relish may be made of chopped unripe fruits combined with horseradish, celery, vinegar, seasonings and spices. Indian experimenters boiled horizontal slices with 3/4 of their weight in sugar until very thick, with a Brix of 68º. They found that the skin became very tough, the flavor was not distinctive, and the jam was rated as only fair. Sour fruits, pricked to permit absorption of sugar and cooked in sirup, at first 33º Brix, later 72º, made an acceptable candied product though the skin was still tough. The ripe fruits are sometimes dried in Jamaica.

Carambola juice is served as a cooling beverage. In Hawaii, the juice of sour fruits is mixed with gelatin, sugar, lemon juice and boiling water to make sherbet. Filipinos often use the juice as a seasoning. The juice is bottled in India, either with added citric acid (1% by weight) and 0.05 % potassium metabisulphite, or merely sterilizing the filled bottles for 1/2 hr in boiling water.

To make jelly, it is necessary to use unripe "sweet" types or ripe sour types and to add commercial pectin or some other fruit rich in pectin such as green papaya, together with lemon or lime juice.

The flowers are acid and are added to salads in Java; also, they are made into preserves in India. The leaves have been eaten as a substitute for sorrel.

Food Value

Ripening and storage studies were conducted at the Florida Citrus Experiment Station at Lake Alfred in 1966. They found quite a difference in the acid make-up of mature green and mature yellow carambolas. Fresh mature green fruits of 'Golden Star' were found to have a total acid content of 12.51 mg/g consisting of 5 mg oxalic, 4.37 tartaric, 1.32 citric, 1.21 malic, 0.39 α-ketoglutaric, 0.22 succinic, and a trace of fumaric. Mature yellow fruits had a total acid content of 13 mg/g, made up of 9.58 mg oxalic, 0.91 tartaric, 2.20 α-ketoglutaric, 0.31 fumaric.

In 1975, 16 carambola selections and 2 named cultivars were assayed at the United States Citrus and Subtropical Products Laboratory, Winter Haven, Florida. Preliminary taste tests ranked 'No. 17, 'No. 37', 'No. 42' and 'Tean Ma' as preferred. In a later test, 'Dah Pon' was ranked above 'Tean Ma'. 'No. 17' (º Brix 9.9) was described as "sweet, good and apple-like". 'No. 37' (º Brix 6.7), as "sour and sweet". 'No. 42' (º Brix 8.3), as "sour, tart and apple-like". 'Dah Pon' (º Brix 8.0), as "good and mild". 'Tean Ma (º Brix 7.2), as "sweet, good and mild". Analyses showed that these 5 were among those with relatively high ascorbic acid content–'No. 17, 30 mg; 'Dah Pon', 30 mg; 'No. 37', 37 mg; 'No. 42', 37 mg; and 'Tean Ma', 41 mg. 'No. 40' had 43 mg and 'No. 11', 50 mg, whereas 'M-23007' had only 14 mg and 'No. 10' only 17 mg.

Oxalic acid content of the 18 selections and cultivars ranged from 0.039 mg to 0.679 mg and 4 of the preferred carambolas were in the lower range as follows: 'No. 17', 0.167; 'Dah Pon', 0.184; 'Tean Ma', 0.202; 'No. 42', 0.276 mg, but 'No. 37', with 0.461 was 3rd from the highest of all.

Puerto Rican technologists found the oxalic acid content of ripe carambolas to average 0.5 g per 100 ml of juice, the acid being mostly in the free state. They likened the juice to rhubarb juice and advised that physicians be informed of this because there are individuals who may be adversely affected by ingestion of even small amounts of oxalic acid or oxalates. Other investigators have presumed the oxalic acid in fully ripe carambolas to be precipitated as calcium oxalate or in solution as neutral salts. The health risk needs further study.

Food Value Per 100 g of Edible Portion*	
Calories	35.7
Moisture	89.0-91.0 g
Protein	0.38 g
Fat	0.08 g
Carbohydrates	9.38 g
Fiber	0.80-0.90 g
Ash	0.26-0.40 g
Calcium	4.4-6.O mg
Phosphorus	15.5-21.0 mg
Iron	0.32-1.65 mg
Carotene	0.003-0.552 mg
Thiamine	0.03-0.038 mg
Riboflavin	0.019-0.03 mg
Niacin	0.294-0.38 mg
Ascorbic Acid*	26.0-53.1 mg

* According to analyses made in Cuba and Honduras.

Amino Acids: (shown in Cuban analyses)

Tryptophan	3.0 mg
Methionine	2 mg
Lysine	26 mg

Other amino acids reported by the Florida Citrus Experiment Station at Lake Alfred and expressed in micromoles per g in mature green fruits (higher) and mature yellow fruits (lower), respectively, are:

Asparagine	0.82-0.64
Threonine	0.92-0.79
Serine	3.88-2.00
Glutamic Acid	2.41-1.80
Proline	0.23-0.09
Glycine	0.20-0.10
Alanine	5.40-1.26
Valine	0.17-0.11
Isoleucine	0.03-trace
Leucine	trace
Phenylalanine	trace
Gamma Amino Bytyric Acid	0.77-0.55
Ornithine	0.11-0.13
Histidine	trace

**Analyses in India showed 10.40 mg ascorbic acid in the juice of a "sweet" variety; 15.4 mg in juice of a sour variety. Ascorbic acid content of both waxed and unwaxed fruits stored at 50º F (10º C) has been reported as 20 mg/100 ml of juice. Waxed fruits stored for 17 days at 60º F (15.56º C) had 11 mg/100 ml of juice. Unwaxed fruits had lost ascorbic acid.

Other Uses

The acid types of carambola have been used to clean and polish metal, especially brass, as they dissolve tarnish and rust. The juice will also bleach rust stains from white cloth. Unripe fruits are used in place of a conventional mordant in dyeing.

Wood: Carambola wood is white, becoming reddish with age; close-grained, medium-hard. It has been utilized for construction and furniture.

Medicinal Uses: In India, the ripe fruit is administered to halt hemorrhages and to relieve bleeding hemorrhoids; and the dried fruit or the juice may be taken to counteract fevers. A conserve of the fruit is said to allay biliousness and diarrhea and to relieve a "hangover" from excessive indulgence in alcohol. A salve made of the fruit is employed to relieve eye afflictions. In Brazil, the carambola is recommended as a diuretic in kidney and bladder complaints, and is believed to have a beneficial effect in the treatment of eczema. In *Chinese Materia Medica* it is stated, "Its action is to quench thirst, to increase the salivary secretion, and hence to allay fever."

A decoction of combined fruit and leaves is drunk to overcome vomiting. Leaves are bound on the temples to soothe headache. Crushed leaves and shoots are poulticed on the eruptions of chicken-pox, also on ringworm.

The flowers are given as a vermifuge. In southeast Asia, the flowers are rubbed on the dermatitis caused by lacquer derived from *Rhus verniciflua* Stokes.

Burkill says that a preparation of the inner bark, with sandalwood and *Alyxia sp., is* applied on prickly heat. The roots, with sugar, are considered an antidote for poison. Hydrocyanic acid has been detected in the leaves, stems and roots.

A decoction of the crushed seeds acts as a galactagogue and ernmenagogue and is mildly intoxicating. The powdered seeds serve as a sedative in cases of asthma and colic.

Morton, J. 1987. Bilimbi. p. 128–129 In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Bilimbi

Averrhoa bilimbi

The bilimbi, *Averrhoa bilimbi,* L., (Oxalidaceae), is closely allied to the carambola but quite different in appearance, manner of fruiting, flavor and uses. The only strictly English names are "cucumber tree" and "tree sorrel", bestowed by the British in colonial times. "Bilimbi" is the common name in India and has become widely used. In Malaya, it is called *belimbing asam, belimbing buloh, b'ling*, or *billing-billing.* In Indonesia, it is *belimbing besu, balimbing, blimbing,* or *blimbing wuluh;* in Thailand, it is *taling pling,* or *kaling pring.*

In Haiti, it is called *blimblin;* in Jamaica, *bimbling plum;* in Cuba, it is *grosella china;* in El Salvador and Nicaragua, *mimbro;* in Costa Rica, *mimbro* or *tiriguro;* in Venezuela, *vinagrillo;* in Surinam and Guyana, *birambi;* in Argentina, *pepino de Indias.* To the French it is *carambolier bilimbi,* or *cornichon des Indes.* Filipinos generally call it *kamias* but there are about a dozen other native names.

Description

The tree is attractive, long-lived, reaches 16 to 33 ft (5-10 m) in height; has a short trunk soon dividing into a number of upright branches. The leaves, very similar to those of the Otaheite gooseberry and mainly clustered at the branch tips, are alternate, imparipirmate; 12 to 24 in (30-60 cm) long, with 11 to 37 alternate or subopposite leaflets, ovate or oblong, with rounded base and pointed tip; downy; medium-green on the upper surface, pale on the underside; 3/4 to 4 in (2-10 cm) long, 1/2 to 1 1/8 in (1.2-1.25 cm) wide.

Small, fragrant, 5-petalled flowers, yellowish-green or purplish marked with dark-purple, are borne in small, hairy panicles emerging directly from the trunk and oldest, thickest branches and some twigs, as do the clusters of curious fruits. The bilimbi is ellipsoid, obovoid or nearly cylindrical, faintly 5-sided, 1 1/2 to 4 in (4-10 cm) long; capped by a thin, star-shaped calyx at the stem-end and tipped with 5 hair-like floral remnants at the apex. The fruit is crisp when unripe, turns from bright-green to yellowish-green, ivory or nearly white when ripe and falls to the ground. The outer skin is glossy, very thin, soft and tender, and the flesh green, jelly-like, juicy and extremely acid. There may be a few (perhaps 6 or 7) flattened, disc-like seeds about 1/4 in (6 mm) wide, smooth and brown.

Plate XVII: BILIMBI, *Averrhoa bilimbi*

Origin and Distribution

Perhaps a native of the Moluccas, the bilimbi is cultivated throughout Indonesia; is cultivated and semi-wild everywhere in the Philippines; is much grown in Ceylon and Burma. It is very common in Thailand, Malaya and Singapore; frequent in gardens across the plains of India, and has run wild in all the warmest areas of that country. It is much planted in Zanzibar. Introduced into Queensland about 1896, it was readily adopted and commercially distributed to growers.

In 1793, the bilimbi was carried from the island of Timor to Jamaica and, after some years, was planted in Cuba and Puerto Rico, Trinidad, the lowlands of Central America, Venezuela, Colombia, Ecuador, Surinam, Guyana and Brazil, and even in northern Argentina, and it is very popular among the Asiatic residents of those countries as it must be in Hawaii. Still it is grown only as an occasional curiosity in southern Florida.

Varieties

Bilimbis are all much the same wherever they are grown, but P.J. Wester reported that a form with sweet fruits had been discovered in the Philippines.

Climate

The bilimbi is a tropical species, more sensitive to cold than the carambola, especially when very young. In Florida, it needs protection from cold and wind. Ideally, rainfall should be rather evenly distributed throughout most of the year but there should be a 2- to 3-month dry season. The bilimbi is not found in the wettest zones of Malaya. The tree makes slow growth in shady or semi-shady situations. It should be in full sun.

Soil

While the bilimbi does best in rich, moist, but well-drained soil, it grows and fruits quite well on sand or limestone.

Propagation

Most efforts at grafting and budding have not been rewarding, though Wester had success in shield-budding, utilizing non-petioled, ripe, brown budwood cut 1 1/2 to 2 in (3.8-5 cm) long. Air-layering has been practiced in Indonesia for many years. However, the tree is more widely grown from seed.

Bilimbi trees are vigorous and receive no special horticultural attention. It has been suggested that they would respond well to whatever cultural treatment gives good results with the carambola.

Season, Harvesting and Keeping Quality

In India as in Florida, the tree begins to flower about February and then blooms and fruits more or less continuously until December. The fruits are picked by hand, singly or in clusters. They need gentle handling because of the thin skin. They cannot be kept on hand for more than a few days.

Pests and Diseases

No pests or diseases have been reported specifically for the bilimbi.

Food Uses

The bilimbi is generally regarded as too acid for eating raw, but in Costa Rica, the green, uncooked fruits are prepared as a relish which is served with rice and beans. Sometimes it is an accompaniment for fish and meat. Ripe fruits are frequently added to curries in the Far East. They yield 44.2% juice having a pH of 4.47, and the juice is popular for making cooling beverages on the order of lemonade.

Mainly, the bilimbi is used in place of mango to make chutney, and it is much preserved. To reduce acidity, it may be first pricked and soaked in water overnight, or soaked in salted water for a shorter time; then it is boiled with much sugar to make a jam or an acid jelly. The latter, in Malaya, is added to stewed fruits that are oversweet. Half-ripe fruits are salted, set out in the sun, and pickled in brine and can be thus kept for 3 months. A quicker pickle is made by putting the fruits and salt into boiling water. This product can be kept only 4 to 5 days.

The flowers are sometimes preserved with sugar.

Food Value Per 100 g of Edible Portion*

Moisture	94.2-94.7 g
Protein	0.61 g
Fiber	0.6g
Ash	0.31-0.40 g

Calcium	3.4 mg
Phosphorus	11.1 mg
Iron	1.01 mg
Carotene	0.035 mg
Thiamine	0.010 mg
Riboflavin	0.026 mg
Niacin	0.302 mg
Ascorbic Acid	15.5 mg

*According to analyses of fruits studied in Nicaragua and the Philippines.

Other Uses

Fruit: Very acid bilimbis are employed to clean the blade of a *kris* (dagger), and they serve as mordants in the preparation of an orange dye for silk fabrics. Bilimbi juice, because of its oxalic acid content, is useful for bleaching stains from the hands and rust from white cloth, and also tarnish from brass.

Wood: The wood is white, soft but tough, even-grained, and weighs 35 lbs/cu ft. It is seldom available for carpentry.

Medicinal Uses: In the Philippines, the leaves are applied as a paste or poulticed on itches, swellings of mumps and rheumatism, and on skin eruptions. Elsewhere, they are applied on bites of poisonous creatures. Malayans take the leaves fresh or fermented as a treatment for venereal disease. A leaf infusion is a remedy for coughs and is taken after childbirth as a tonic. A leaf decoction is taken to relieve rectal inflammation. A flower infusion is said to be effective against coughs and thrush.

In Java, the fruits combined with pepper are eaten to cause sweating when people are feeling "under the weather". A paste of pickled bilimbis is smeared all over the body to hasten recovery after a fever. The fruit conserve is administered as a treatment for coughs, beri-beri and biliousness. A sirup prepared from the fruit is taken as a cure for fever and inflammation and to stop rectal bleeding and alleviate internal hemorrhoids.

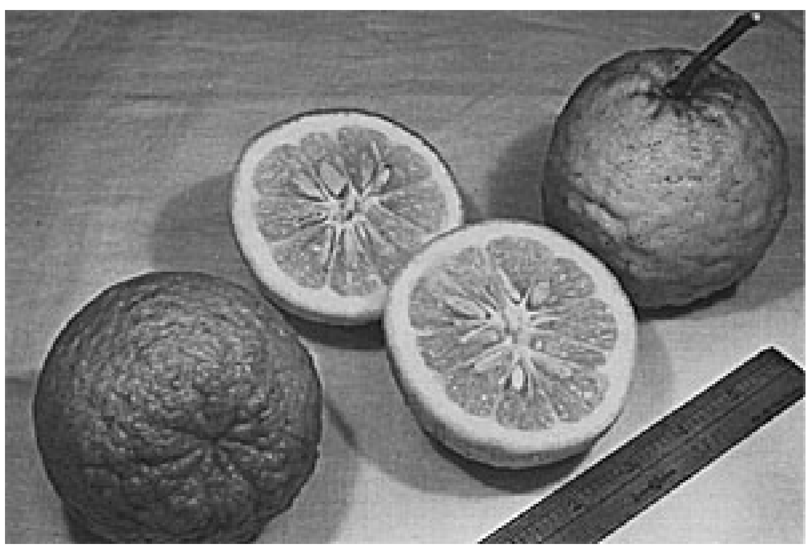
Morton, J. 1987. Sour Orange. p. 130–133. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sour Orange

Citrus aurantium

A species of multiple uses, the sour orange *(Citrus aurantium,* L.), is also known as bitter, bigarade, or Seville orange. In Spanish-speaking areas it may be called *naranja ácida, naranja agria,* or *naranja amarga.* In Arabia, it is *naranji;* in Italy, *melangolo;* in India, *khatta;* in Samoa, *moli,* in Guam, soap orange.

Description



The tree ranges in height from less than 10 ft (3 m) to 30 ft (9 m), is more erect and has a more compact crown than the sweet orange; has smooth, brown bark, green twigs, angular when young, and flexible, not very sharp, thorns from 1 in to 3 1/8 in (2.5-8 cm) long. The evergreen leaves (technically single leaflets of compound leaves), are aromatic, alternate, on broad-winged petioles much longer than those of the sweet orange; usually ovate with a short point at the apex; 2 1/2 to 5 1/2 in (6.5-13.75 cm) long, 1 1/2 to 4 in (3.75-10 cm) wide; minutely toothed; dark-green above, pale beneath, and dotted with tiny oil glands. The highly fragrant flowers, borne singly or in small clusters in the leaf axils, are about 1 1/2 in (3.75 cm) wide, with 5 white, slender, straplike, recurved, widely-separated petals surrounding a tuft of up to 24 yellow stamens. From 5 to 12% of the flowers are male.

Fig. 35: The sour orange *(Citrus aurantium)*has a rough, fairly thick skin, very sour juice.

The fruit is round, oblate or oblong-oval, 2 3/4 to 3 1/8 in (7-8 cm) wide, rough-surfaced, with a fairly thick, aromatic, bitter peel becoming bright reddish-orange on maturity and having minute, sunken oil glands. There are 10 to 12 segments with bitter walls containing strongly acid pulp and from a few to numerous seeds. The center becomes hollow when the fruit is full-grown.

Origin and Distribution

The sour orange is native to southeastern Asia. Natives of the South Sea Islands, especially Fiji, Samoa, and Guam, believe the tree to have been brought to their shores in prehistoric times. Arabs are thought to have carried it to Arabia in the 9th Century. It was reported to be growing in Sicily in 1002 A.D., and it was cultivated around Seville, Spain, at the end of the 12th Century. For 500 years, it was the only orange in Europe and it was the first orange to reach the New World. It was naturalized in Mexico by 1568 and in Brazil by 1587, and not long after it was running wild in the Cape Verde Islands, Bermuda, Jamaica, Puerto Rico and Barbados. Sir Walter Raleigh took sour orange seeds to England; they were planted in Surrey and the trees began bearing regular crops in 1595, but were killed by cold in 1739.

Spaniards introduced the sour orange into St. Augustine, Florida. It was quickly adopted by the early settlers and local Indians and, by 1763, sour oranges were being exported from St. Augustine to England. Sour orange trees can still be found in Everglades hammocks on the sites of former Indian dwellings. The first sweet orange budwood was grafted onto sour orange trees in pioneer dooryards and, from that time on, the sour orange became more widely grown as a rootstock in all citrus-producing areas of the world than for its fruit or other features. Today, the sour orange is found growing wild even in southern Georgia and from Mexico to Argentina.

It is grown in orchards or groves only in the Orient and the various other parts of the world where its special products are of commercial importance, including southern Europe and offshore islands, North Africa, the Middle East, Madras, India, West Tropical Africa, Haiti, the Dominican Republic, Brazil and Paraguay.

Varieties

There are various well-established forms of the sour orange. In the period 1818-1822, 23 varieties were described and illustrated in Europe. A prominent subspecies is the Bergamot orange, C. *aurantium,* var. *bergamia* Wight & Arn., grown in the Mediterranean area since the 16th Century but commercially only in Italy. Trees grown in California and Florida under this name are actually the 'Bouquet' variety of sour orange (see below). The flowers of the Bergamot are small, sweetly fragrant; the fruits round or pear-shaped, with strongly aromatic peel and acid pulp.

The myrtle-leaved orange (C. *aurantium,* var. *myrtifolia),* is a compact shrub or tree with small leaves and no thorns. It was found as a bud mutation on trunks of old sour orange trees in Florida. It is propagated and grown only on the French and Italian Riviera for its small fruits which are preserved in brine and exported for candying.

Apart from these special types, there are several groups of sour oranges, within which there are placed certain cultivars:

1) *Normal group* (large, seedy fruits)

'African', 'Brazilian', 'Rubidoux', 'Standard', 'Oklawaha' and 'Trabut'. 'Oklawaha' originated in the United States. It has large fruits rich in pectin and is prized for marmalade.

2) Aberrant group

'Daidai', or 'Taitai', popular in Japan and China. Its fruits are large with very thick peel, very acid pulp, and many seeds. The tree is somewhat dwarf and almost thornless; immune to citrus canker in the Philippines. It is prized for its flower buds which are dried and mixed with tea for their scent.

'Goleta' has medium-large fruits with juicy, medium-sour pulp and very few seeds. The tree is of medium size and almost thornless.

'Bouquet' has small, deep-orange fruits, acid, with few seeds. The tree is less than 10 ft (3 in) high and is grown as an ornamental.

3) *Bittersweet group* includes any sweet-acid forms of the sour orange introduced by Spaniards and formerly found growing in the Indian River region of Florida. These oranges are often seen in a naturalized state in the West Indies. The peel is orange-red, the pulp is darker in hue than that of the normal sour orange.

'Paraguay' was introduced from Paraguay in 1911. The fruit is of medium size, with sweet pulp, moderately seedy. The tree is large, thorny and hardy.

Among other forms of sour orange, there is in India a type called 'Karna', 'Khatta' or 'Id Nimbu', identified as *C. aurantium* var. *khatta* (or *C. karna* Raf.) but suspected of being a hybrid of sour orange and lemon. The fruits are typical sour oranges but the flowers are red-tinted like those of the lemon.

Two cultivars are grown as rootstocks for the sweet orange in China:

'Vermilion Globe' has oblate fruits containing 30 to 40 seeds. The tree has long, narrow, pointed leaves.

'Leather-head' has small, oblate, rough fruits with 20 seeds. The tree has elliptic, blunt leaves.

Cultivars grown especially for the production of Neroli oil in France and elsewhere, have flowers in large, more concentrated clusters than the ordinary types of sour orange. One of these, 'Riche Défouille', has unusual, wingless leaves.

Climate

The sour orange flourishes in subtropical, near-tropical climates, yet it can stand several degrees of frost for short periods. Generally it has considerable tolerance of adverse conditions. But the Bergamot orange is very sensitive to wind and extremes of drought or moisture.

Soil

Unlike its sweet relative, the sour orange does well on low, rich soils with a high water table and is adapted to a wide range of soil conditions.

Propagation

Sour orange trees volunteer readily from self-sown seeds. As generally grown for rootstock for sweet oranges, they are raised in nurseries for 1 or 2 years and then budded. Growth of the seedlings, especially in diameter, has been expedited by weekly applications of gibberellic acid to the stems, making it possible to bud them much earlier.

Culture

In the proper climatic and soil conditions, the sour orange is self-maintaining and receives only a modicum of cultural attention. It has an extraordinary ability to survive with no care at all. Some trees in Spain are said to be over 600 years old and one tree in a tub at Versailles, which, of course, must be carefully tended, was reportedly planted in the year 1421.

Pests and Diseases

The sour orange is subject to most of the pests that attack the sweet orange. In addition to its susceptibility to the disease called tristeza, the tree is liable to other viruses -crinkly leaf, gummy bark, psorosis, and xyloporosis. The Division of Plant Industry of the Florida State Department of Agriculture has recorded the following fungal problems as sometimes seen: leaf spot (*AIternaria citri*, *Cercospora penzigii*, *Mycophaerella horii*, *Cladosporium oxysporum*, and *Phyllosticta hesperidearum);* greasy spot *(Cercospora citri-grisea);* tar spot (C. *gigantea);* leprosis *(Cladosporium herbarum);* mushroom root rot *(Clitocybe tabescens);* anthracnose *(Colletotrichum gloeosporioides);* thread blight *(Corticium koleroga* and C. *stevensii);* gummosis and dieback *(Diaporthe citri);* foot rot and root rot *(Fusarium oxysporum, Macrophomia phaseolina, Phytophthora* spp.); heart rot and wood rot *(Fomes applanatus, Ganoderma sessilis, Xylaria polymorpha),* and others.

Food Uses

The normal types of sour orange are usually too sour to be enjoyed out-of-hand. In Mexico, however, sour oranges are cut in half, salted, coated with a paste of hot chili peppers, and eaten.

The greatest use of sour oranges as food is in the form of marmalade and for this purpose they have no equal. The fruits are largely exported to England and Scotland for making marmalade. Sour oranges are used primarily for marmalade in South Africa.

Fig. 36: Dried peel of the locally-grown sour orange yields the essential oil that flavors "Curacao liqueur".

The juice is valued for ade and as a flavoring on fish and, in Spain, on meat during cooking. In

Yucatan, it is employed like vinegar. In Egypt and elsewhere, it has been fermented to make wine.

"Bitter orange oil", expressed from the peel, is in demand for flavoring candy, ice cream, baked goods, gelatins and puddings, chewing gum, soft drinks, liqueurs and pharmaceutical products, especially if the water-or alcohol-insoluble terpenes and sesquiterpenes are removed. The oil is produced in Sicily, Spain, West Africa, the West Indies, Brazil, Mexico and Taiwan.

The essential oil derived from the dried peel of immature fruit, particularly from the selected types -'Jacmel' in Jamaica and the much more aromatic 'Curacao orange' (var. *curassaviensis)-gives* a distinctive flavor to certain liqueurs.

"Neroli oil", or "Neroli Bigarade Oil", distilled from the flowers of the sour orange, has limited use in flavoring candy, soft-drinks and liqueurs, ice cream, baked goods and chewing gum.

'Petitgrain oil', without terpenes, is used to enhance the fruit flavors (peach, apricot, gooseberry, black currant, etc.) in food products, candy, ginger ale, and various condiments.

'Orange leaf absolute' enters into soft-drinks, ice cream, baked goods and candy.

The ripe peel of the sour orange contains 2.4 to 2.8%, and the green peel up to 14%, neohesperidin dihydrochalcone which is 20 times sweeter than saccharin and 200 times sweeter than cyclamate. Potential use as a sweetener may be hampered by the limited supply of peel.

Food Value Per 100 g of Edible Portion

	Fruit (raw)	*Fruit (raw, with only superficial layer of peel removed)**
Calories	37-66	
Moisture	83-89.2 g	77.8-83.1 g
Protein	0.6-1.0 g	0.154-0.167 g
Fat	trace-0.1 g	0.05-0.07 g
Carbohydrates	9.7-15.2 g	?
Fiber	0.4 g	1.8-2.2 g
Ash	0.5 g	0.57-0.69 g
Calcium	18-50 mg	64.3-81.9 mg
Iron	0.2 mg	0.22-0.85 mg
Phosphorus	12 mg	19.6-20.4 mg
Vitamin A	290 mcg or 200 I.U.	0.055-0.07 mg
Thiamine	100 mcg	0.048-0.059 mg
Riboflavin	40 mcg	0.030-0.040 mg
Niacin	0.3 mg	0.282-0.400 mg
Ascorbic Acid	45-90 mg	55.2-103.5 mg
*Sampled in Guatemala and El Salvador.		

Other Uses

Soap substitute: Throughout the Pacific Island, the crushed fruit and the macerated leaves, both of which make lather in water, are used as soap for washing clothes and shampooing the hair. Safford described the common scene in Guam of women standing in a river with wooden trays on which they rub clothing with sour orange pulp, then scrub it with a corncob. He wrote: "Often the entire surface of the river where the current is sluggish is covered with decaying oranges." On the islands of Zanzibar and Pemba, the fruits are used for scouring floors and brass.

Perfumery: All parts of the sour orange are more aromatic than those of the sweet orange. The flowers are indispensable to the perfume industry and are famous not only for the distilled Neroli oil but also for "orange flower absolute" obtained by fat or solvent extraction. During favorable weather in southern France, 2,200 lbs (1,000 kg) of flowers will yield 36 to 53 oz (1,000-1,500 g) of oil.

Neroli oil consists of 35% terpenes (mainly dipentene, pinene and camphene), 30% *1*-linalool, and 4% geraniol and nerol, 2% *d*-terpineol, 6% *d*-nerolidol, traces of decyclic aldehyde, 7% *1*-linalyl acetate, 4% neryl and geranyl acetates, traces of esters of phenylacetic acid and benzoic acid, as much as 0.1% methyl anthranilate, and traces of jasmone, farnesol, and palmitic acid. Orange flower water is usually a by-product of oil production.

Petitgrain oil is distilled from the leaves, twigs and immature fruits, especially from the Bergamot orange. Both Petitgrain and the oil of the ripe peel are of great importance in formulating scents for perfumes and cosmetics. Petitgrain oil is indispensable in fancy eau-de-cologne. The seed oil is employed in soaps.

Honey: The flowers yield nectar for honeybees.

Wood: The wood is handsome, whitish to pale-yellow, very hard, fine-grained, much like boxwood. It is valued for cabinetwork and turnery. In Cuba it is fashioned into baseball bats.

Medicinal Uses: Sour orange juice is antiseptic, anti-bilious and hemostatic. Africans apply the cut-open orange on ulcers and yaws and areas of the body afflicted with rheumatism. In Italy, Mexico and Latin America generally, decoctions of the leaves are given for their sudorific, antispasmodic, stimulant, tonic and stomachic action. The flowers, prepared as a sirup, act as a sedative in nervous disorders and induce sleep. An infusion of the bitter bark is taken as a tonic, stimulant, febrifuge and vermifuge.

The fresh young leaves contain as much as 300 mg of ascorbic acid per 100 g. The mature leaf contains 1-stachyhydrine.

Morton, J. 1987. Orange. p. 134–142. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Orange

Citrus sinensis

One of the most widely favored of the world's fruits, the orange, sweet orange, or round orange, was for many years known as *Citrus aurantium* var. *sinensis* L. and considered to be a form of the sour orange (q.v.). It is still not universally agreed to be a distinct species, C. *sinensis* Osbeck, but it is usually treated as though it were. One of its first recorded regional names was the Persian *narang*, from which were derived the Spanish name, *naranja*, and the Portuguese, *laranja*. In some Caribbean and Latin American areas, the fruit is called *naranja de China*, *China dulce*, or simply *China* (pronounced *cheena)*.

Description

The orange tree, reaching 25 ft (7.5 m) or, with great age, up to 50 ft (15 m), has a rounded crown of slender branches. The twigs are twisted and angled when young and may bear slender, semi-flexible, bluntish spines in the leaf axils. There may be faint or conspicuous wings on the petioles of the aromatic, evergreen, alternate, elliptic to ovate, sometimes faintly toothed "leaves"–technically solitary leaflets of compound leaves. These are 2 1/2 to 6 in (6.5-15 cm) long, 1 to 3 3/4 in (2.5-9.5 cm) wide. Borne singly or in clusters of 2 to 6, the sweetly fragrant white flowers, about 2 in (5 cm) wide, have a saucer-shaped, 5-pointed calyx and 5 oblong, white petals, and 20 to 25 stamens with conspicuous yellow anthers. The fruit is globose, subglobose, oblate or somewhat oval, 2 1/2 to 3 3/4 in (6.5-9.5 cm) wide. Dotted with minute glands containing an essential oil, the outer rind (epicarp) is orange or yellow when ripe, the inner rind (mesocarp) is white, spongy and non-aromatic. The pulp (endocarp), yellow, orange or more or less red, consists of tightly packed membranous juice sacs enclosed in 10 to 14 wedge-shaped compartments which are readily separated as individual segments. In each segment there may be 2 to 4 irregular seeds, white externally and internally, though some types of oranges are seedless. The sweet orange differs physically from the sour orange in having a solid center.

Origin and Distribution

The orange is unknown in the wild state; is assumed to have originated in southern China, northeastern India, and perhaps southeastern Asia (formerly Indochina). It was carried to the Mediterranean area possibly by Italian traders after 1450 or by Portuguese navigators around 1500. Up to that era, citrus fruits were valued by Europeans mainly for medicinal purposes, but the orange was quickly adopted as a luscious fruit and wealthy persons grew it in private conservatories, called orangeries. By 1646 it had been much publicized and was well known.

Spaniards undoubtedly introduced the sweet orange into South America and Mexico in the mid-1500's, and probably the French took it to Louisiana. It was from New Orleans that seeds were obtained and distributed in Florida about 1872 and many orange groves were established by grafting the sweet orange onto sour orange rootstocks. Arizona received the orange tree with the founding of missions between 1707 and 1710. The orange was brought to San Diego, California, by those who built the first mission there in 1769. An orchard was planted at the San Gabriel Mission around 1804. A commercial orchard was established in 1841 on a site that is now a part of Los Angeles. In 1781, a surgeon and naturalist on the ship, Discovery, collected orange seeds in South Africa, grew seedlings on board and presented them to tribal chiefs in the Hawaiian Islands on arrival in 1792. In time, the orange became commonly grown throughout Hawaii, but was virtually abandoned after the advent of the Mediterranean fruit fly and the fruit is now imported from the United States mainland.

The orange has become the most commonly grown tree fruit in the world. It is an important crop in the Far East, the Union of South Africa, Australia, throughout the Mediterranean area, and subtropical areas of South America and the Caribbean. The United States leads in world production, with Florida, alone, having an annual yield of more than 200 million boxes, except when freezes occur which may reduce the crop by 20 or even 40%. California, Texas and Arizona follow in that order, with much lower production in Louisiana, Mississippi, Alabama and Georgia. Other major producers are Brazil, Spain, Japan, Mexico, Italy, India, Argentina and Egypt. In Brazil, oranges are grown everywhere in the coastal plain and in the highlands but most extensively in the States of Sao Paulo and Rio de Janeiro, where orange culture rose sharply in the years immediately following World War II and is still advancing. Mexico's citrus industry is located largely in the 4 southern states of Nuevo Leon, Tamaulipas, San Luis Potosi and Veracruz. The orange crop is over one million MT and Nuevo Leon has 20 modern packing plants, mostly with fumigation facilities. Large quantities of fresh oranges and orange juice concentrate are exported to the United States and small shipments go to East Germany, Canada and Argentina. However, overproduction has glutted domestic markets and brought down prices and returns to the farmer to such an extent that plantings have declined and growers are switching to grapefruit. Cuba's crop has become nearly 1/3 as large as that of Florida. Lesser quantities are produced in Puerto Rico, Central America (especially Guatemala), some of the Pacific Islands, New Zealand, and West Africa, where the fruit does not acquire an appealing color but is popular for its quality and sweetness. Many named cultivars have been introduced and grown in the Philippines since 1912, but the fruitis generally of low qualitybecause of the warm climate.

Varieties

Most of the oranges grown in California are of 2 cultivars: the 'Washington Navel' and the 'Valencia'. Florida's commercial cultivars are mainly: (early) 'Hamlin'; (mid-season) 'Pineapple'; (late) 'Valencia'.

The 'Washington Navel' (formerly known as 'Bahia') originated, perhaps as a mutant in Bahia, Brazil, before 1820. It was introduced into Florida in 1835 and several other times prior to 1870. In 1873, budded trees reached California where the fruit matures at the Christmas season. It is large but with a thick, easily removed rind; not very juicy; of excellent flavor, and seedless or nearly so. Ease of peeling and separation of segments makes this the most popular orange in the world for eating out-of-hand or in salads. Limonene content of the juice results in bitterness when pasteurized and therefore this cultivar is undesirable for processing. The tree needs a relatively cool climate and should not be grown below an elevation of 3,300 ft (1,000 in) in tropical countries. Today it is commercially grown, not only in Brazil and California, but also in Paraguay, Spain, South Africa, Australia and Japan.

'Trovita', a non-navel seedling raised in 1914-1915 at the Citrus Experiment Station in California and released in 1935, is milder in flavor and has a few seeds, but may be earlier in season, and it has been considered promising in hot, dry regions unsuitable for 'Washington Navel'. There are several other named variations such as 'Robertson Navel', 'Summer Navel', 'Texas Navel', and the externally attractive 'Thompson Navel' which was grown in California for a time but dropped because of its poor quality. Various mutants, more suitable for warmer climates, have been selected and named in Florida, including 'Dream', 'Pell', 'Summerfield', 'Surprise'–the latter being more productive than 'Washington Navel' in Florida but still not grown to any extent. 'Bahiamina' is a small version of the 'Washington Navel' developed in Brazil in the late 1940's. It follows 'Pera' and 'Natal' sweet oranges in importance in tropical Bahia.

'Valencia', or 'Valencia Late', is the most important cultivar in California, Texas and South Africa. It has been the leader in Florida until recently. In 1984, 40% of the oranges being planted in Florida were 'Valencia', 60% were 'Hamlin'. The 'Valencia' may have originated in China and it was presumably taken to Europe by Portuguese or Spanish voyagers. The well-known English nurseryman, Thomas Rivers, supplied plants from the Azores to Florida in 1870 and to California in 1876. In Florida, it was quickly appreciated and cultivated, at first labeled 'Brown' and later renamed 'Hart's Tardiff, 'Hart' and 'Hart Late' until it was recognized as identical to the 'Valencia' in California. It was not propagated for sale in California until 1916 and was slow to be adopted commercially. It is smaller than the 'Washington Navel', with a thinner, tighter rind; is far juicier and richer in flavor; nearly seedless except in Chile where the dry climate apparently allows better pollination and development of many more seeds -up to 980 in 44 lbs (20 kg). It needs a warm climate. In fact, it is the most satisfactory orange for the tropics, even though it may not develop full color in warm regions. In Colombia, the quality is good from sea-level to 5,000 ft (1,600 m). It bears two crops a year, overlapping and giving it the great advantage of a late and long season lasting until midsummer. The fruits on the trees in spring will regreen, lose their orange color and turn green at the stem end, but the quality is not affected. They were formerly dyed to improve market appearance but since the 1955 Food & Drug Administration ban on the synthetic dyes used on oranges, they have been colored by exposure to ethylene gas in storage. The gas removes the chlorophyll layer, revealing the orange color beneath. Degreening does not occur in California where 'Valencia' oranges from one growing area or another are marketed from late spring through fall.

'Lue Gim Gong' was claimed to be a hybrid of 'Valencia' and 'Mediterranean Sweet' made by a Chinese grower in 1886. 'Lue Gim Gong' was awarded the Wilder Silver Medal by the American Pomological Society in 1911 but, later on, his hybrid was judged to be a nucellar seedling of 'Valencia'. Propagated and distributed by Glen St. Mary Nurseries in 1912, this cultivar closely resembles 'Valencia', matures and is marketed with its parent without distinction. It is best cited as the 'Lue Gim Gong Strain' of 'Valencia'. 'Mediterranean Sweet' was introduced into Florida from Europe in 1875, was briefly popular, but is no longer grown.

Certain strains of 'Valencia' are classed as summer oranges because the fruits can be left on the trees longer without dehydrating. One is known as 'Pope', 'Pope Summer', or 'Glen Summer'. It was found in a grove of 'Pineapple' oranges near Lakeland about 1916, was propagated in 1935, and trademarked in 1938. On sour orange or sweet orange rootstocks in hammock soils, the fruit matures in April but is still in good condition on the tree in July and August.

'Rhode Red Valencia' was discovered in 1955 in a grove near Sebring, Florida, by Paul Rhode, Sr., of Winter Haven. Some budwood was put on sour orange stock which caused dwarfing and some on rough lemon which produced large, vigorous, productive trees. In 1974, 5 trees were accepted into the Citrus Budwood Registration Program but there was no budwood free of exocortis and xyloporosis viruses. The fruit equals 'Valencia' insoluble solids, excels 'Valencia' in volume of juice, is less acid, has slightly less ascorbic acid, but has a far more colorful juice due to its high content of cryptoxanthin, a precursor of vitamin A which remains nearly stable during processing.

In Cuba, 'Campbell Valencia' (a 1942 seedling similar to 'Valencia'), 'Frost Valencia' (a 1915 nucellar seedling of 'Valencia'), and 'Olinda Valencia' (a virus-free nucellar seedling of 'Valencia' discovered in California in 1939), each on 2 different rootstocks–sour orange and Cleopatra mandarin–were test-planted in 1973 and evaluated in 1982. 'Olinda Valencia' on sour orange excelled in quality and in productivity.

'Hamlin', discovered in 1879 near Glenwood, Florida, in a grove later owned by A.G. Hamlin, is small, smooth, not highly colored, seedless and juicy but the juice is pale. The fruit is of poor-to-medium quality but the tree is high-yielding and cold-tolerant. The fruit is harvested from October to December and this cultivar is now the leading early orange in Florida. On pineland and hammock soil it is budded on sour orange which gives a high solids content. On sand, it does best on rough lemon rootstock.

'Homosassa', a selected Florida seedling named in 1877, is of rich orange color, of medium size, and excellent flavor, It was formerly one of the most valued midseason oranges in Florida but it is too seedy to maintain that position. It is no longer planted except perhaps in Texas and Louisiana.

'Shamouti' ('Jaffa'; 'Khalili'; 'Khalili White')–originated as a limb sport on a 'Beledi' tree near Jaffa, Israel, in 1844; introduced into Florida about 1883; oval, medium-large; peel entirely orange when ripe; leathery, thick, easy to remove; pulp very juicy, of good quality. Constitutes 75% of the Lebanese and Israeli crops; is one of the 2 main cultivars in Syria; was formerly an important, midseason, cold-tolerant, cultivar in Florida and was grown in all other orange-growing regions of the United States. However, the tree tends to alternate-bearing, the fruit does not hold for long on the tree and is subject to the fungus, *Alternaria citri*, and it is no longer planted in this country.

'Parson Brown' wasdiscovered in a grove owned by Parson Brown in Wester, Florida; was purchased, propagated and distributed by J.L. Carney between 1870 and 1878. It is rough-skinned, with pale juice; moderately seedy; of low-to-medium quality. It was formerly popular in Florida because of its earliness and long season (October through December), but has been largely replaced by 'Hamlin'. It is grown in Texas, Arizona and Louisiana but is not profitable in California where it matures at the same time as 'Washington Navel'. It does not develop acceptable quality in the tropics.

'Pineapple' is a seedling found in a grove near Citra, Florida. It was propagated in 1876 or 1877 under the name of 'Hickory'. It is pineapple-scented, smooth, highly colored, especially after cold spells; of rich, appealing flavor, and medium-seedy. It is the favorite midseason orange in Florida, its tendency to preharvest drop having been overcome by nutrition and spray programs. If the crop is allowed to remain too long on the tree, it may induce alternate-bearing. It is grown to some extent in Texas, rarely in California; succeeds on sour orange rootstock in low hammock land, on rough lemon in light sand. Seedless mutants of 'Pineapple' have been produced by seed irradiation. This cultivar does fairly well in tropical climates though not as well as 'Valencia'.

'Queen' is a seedling of unknown origin which was found in a grove near Bartow, Florida. Because it survived the freeze of 1894-95, it was propagated in 1900 under the name 'King' which was later changed to 'Queen'. It is much like 'Pineapple', has fewer seeds, higher soluble solids, persists on the tree better in dry spells; is high-yielding and somewhat more cold-tolerant than 'Pineapple'.

'Blood Oranges' are commonly cultivated in the Mediterranean area, especially in Italy, and also in Pakistan. They are grown very little in Florida where the red coloration rarely develops except during periods of cold weather. In California they are grown only as novelties. Among the well-known cultivars in this group are 'Egyptian', which tends to develop a small navel; 'Maltese', 'Ruby', and 'St. Michael'.

Pollination

Orange blossoms yield very little pollen and orange growers do not practice artificial pollination.

However, there is evidence of self-incompatibility and need for cross-pollination in the TANGOR and TANGELO (qq.v.).

Climate

The orange is subtropical, not tropical. During the growing period, the temperature should range from 55º to 100º F (12.78º-37.78º C). In the winter dormancy, the ideal temperature range is 35º to 50º F (1.67º-10º C). Mature, dormant trees have survived 10 hours at temperatures below 25º F (-3.89º C) but fruit is damaged by freezing–30º to 26º F (-1.11º-3.33º C). Young trees may be killed outright by even brief frosts. Hardiness, however, varies with the cultivar and rootstock, Seedling orange trees of bearing age are capable of enduring more cold than budded cultivars. Prolonged cold is more injurious than short periods of freezing temperatures. In Florida, many efforts have been made to protect orange trees from winter cold, which is most damaging if preceded or accompanied by drought.

In the early days, slatted shadehouses were erected over young groves. Windbreaks have been planted on the northeast exposure. Old automobile tires have been burned in piles throughout groves. A commercially produced heater has been fueled and lit in the coldest predawn hours. Helicopters have been flown back and forth to cause movement of air, and, more recently, wind machines have been installed. Most recent, and most effective are overhead sprinklers which give maximum protection from cold damage.

Favorable annual precipitation varies from 5 to 20 in (12.5-50 cm), though oranges are frequently grown in areas receiving 40 to 60 in (100-150 cm) of rain. Benthall says that in the damp climate of Lower Bengal, the fruits lack juice and are usually very sour. California's generally dry climate contributes to more intense color in the orange peel than is seen in humid areas. Success in orange culture depends a great deal on the selection of cultivars tolerant of the weather conditions where they are to be grown.

Soil

The best soil for orange-growing in Florida is known as Lakeland fine sand, well-drained, and often identified as high hammock or high pineland soil. There must be adequate depth for good root development. Shallow soils of high water-holding ability are avoided. In Egypt, it has been found that where the water table is too high–30 in (78 cm) or less below the surface of the soil–root growth, vegetative vigor and fruit yield of orange trees are greatly reduced. In the alkaline soil of South Florida, neglected orange trees develop chlorosis and gradually decline. Many old groves planted in the southern part of the state to avoid cold have been totally lost. In California, the best soils for orange groves are deep loams. It is important to select the appropriate rootstock for particular soil conditions.

Propagation

While the orange will often come true from seed because of nucellar embryos, the common means of assuring the reproduction of cultivars of known quality is by budding onto appropriate rootstocks. It is believed that budding was practiced by Europeans during the 16th and 17th Centuries, but, with the realization that seedling trees were more vigorous and productive, Italian and Spanish orange growers went back to planting seeds. Fortunately, budded orange trees from Europe had been imported into Florida in 1824 and budwood from these and of others later brought in from England was utilized in topworking existing sour and sweet orange seedlings. It was soon apparent that the budded trees came into bearing earlier than seedlings, were less thorny, and matured uniformly. The sweet orange lost popularity as a rootstock because of its susceptibility to foot rot. Sour orange, resistant to foot rot, became the preferred rootstock in low hammock and flatwoods soils with high water table until the discovery of the virus disease, tristeza, in Florida orange groves in 1952. This caused many to switch from the susceptible sour orange to 'Cleopatra mandarin'. Unfortunately, trees on 'Cleopatra' stock are reduced in size, they have lower yields than those on sour orange, and acidity of the fruit is elevated.

As citrus-growing stretched southward into high pineland, rough lemon *(Citrus jambhiri)* rootstock gained favor and was found to induce more rapid and vigorous growth and earlier bearing, counterbalancing its sensitivity to cold and tendency toward foot rot. Rough lemon became the dominant rootstock in Florida until it was found to be extremely susceptible to blight and was abandoned. Sour orange has been reinstated in recent years because tristeza has been more or less dormant since the 1940's and sour orange is now the prevailing stock for 50% of the orange and grapefruit trees in the state. In second place is the 'Carrizo citrange', resistant to tristeza but subject to exocortis and also to blight though less so than rough lemon. 'Carrizo' is somewhat resistant to the burrowing nematode and gives a little higher yield than the similar rootstocks. Growers are advised to quickly replace blight-affected orange trees on rough lemon with new plants on 'Carrizo' held ready for this purpose. Because exocortis can now be detected quickly, it has become possible to utilize 'Carrizo' as a rootstock for hundreds of thousands of orange trees in Florida.

About 90% of commercial orange groves in Queensland are on rough lemon rootstock, as are 90% of the citrus trees in Jamaica. In Egypt, rough lemon rootstock has been found short-lived on heavy soils. In that country, early budding was done on citron *(Citrus medica* L.) but that stock was abandoned when sour orange was found much more desirable on the prevailing loamy-clay. Second to the sour orange rootstock is the Egyptian lime, locally considered native and used mainly on lighter soils.

In the tropical citrus-growing region of Bahia, Brazil, Rangpur lime (C. X *limonia* Osbeck) has been the dominant rootstock–95 % in orchards and 100% in nurseries–but experiments in the past few years have shown that rough lemon and Cleopatra mandarin give better results. Also, 'Cleopatra' has good resistance to citrus decline, whereas Rangpur is susceptible to Phytophthora root rot and exocortis.

Some oranges are budded onto the so-called trifoliate orange *(Poncirus trifoliata* Raf.) which tends to reduce the growth but is cold-tolerant and able to flourish on low, wet soils. It does poorly in light sand. Rootstocks capable of dwarfing orange trees may become necessary if close spacing is to be considered more advantageous. Trifoliate orange cultivar 'English Small' has successfully dwarfed 'Valencia'. 'Rusk' and 'Carrizo' ('Troyer') citranges (P. *trifoliata X C. sinensis)* show promise for semi-dwarfing of 'Valencia'. However, all of these are very susceptible to the exocortis virus. Alternative root-stocks include 'Swingle citrumelo' (P. *trifoliata X C. paradisi)*–cold-hardy, resistant to tristeza, exocortis, xyloporosis, and the citrus nematode but not the burrowing nematode–and the 'Volkamer lemon' (C. *volkameriana)* which behaves much like rough lemon but gives very high yields of fruit of slightly better quality.

In India, the sweet lime (C. *limettioides* Tanaka) was found to be the best rootstock for their 'Mosambi' orange in wet zones with high maximum temperatures.

Cuban horticulturists are currently experimenting with various *Citrus* species as potential rootstocks to replace sour orange.

In Florida, nurseries of seedling rootstocks must be approved by the Department of Agriculture, Division of Plant Industry. The seeds must not be more than 3 to 4 weeks old unless they have been washed, dried, then mixed with sand and kept in a cool place, or put into a plastic bag and refrigerated for a few weeks at about 40º F (4.4º C). Seeds of *P. trifoliata* are planted in the fall but sour orange and 'Cleopatra mandarin' are planted in spring. Seeds are set in rows 3 to 4 ft (0.9-1.2 m) apart and will germinate in 3 weeks. When the stems reach 1/2 in (1.25 cm) in diameter, the seedlings are ready for budding. The budding technique most commonly used in Florida is shield-budding by the inverted T method, inserting the bud 2 to 3 in (5-7.5 cm) above ground level. California propagators favor the upright T. Usually the trees are ready for transplanting after one growing season. Mature trees that have been frozen back, or that are to be converted to more suitable cultivars, may be top-worked by cleft-grafting, crown grafting, or budding of the sprouts that arise after the tree is cut off close to the ground.

It must be kept in mind that the rootstock influences not only the rate of growth, disease resistance and productivity of the cultivar but also the physical and chemical attributes of the crop. For example, 'Valencia' oranges on sour orange stock have been found to have more dry matter in the peel, pulp and juice than those on rough lemon. 'Washington Navel' oranges on rough lemon stock have had low levels of potassium in the peel, pulp and juice; and, on 'Cleopatra mandarin' stock, even lower in the pulp and juice. Trifoliate orange rootstock produces high levels of potassium throughout the fruit. In south-eastern Queensland, Australia, nearly half of the oranges for processing are grown in the Near North Coast area. There, trials of 'Valencia' on rough lemon revealed that fruit quality was inferior to that in Florida; there was bitterness in the juice and only a small percentage of the fruits met the minimum standards for processing as frozen orange juice concentrate. General quality, flavor and ascorbic acid content were considerably higher on sweet orange rootstock. Trifoliate orange gave second-best results. Rootstocks affect the chemistry of the peel oil, especially the aldehyde content, and the oil content of the peel is influenced by selection of budwood. Dr. Walter T. Swingle, one of the early and renowned plant explorers of the United States Department of Agriculture, was an authority on Citrus and vitally interested in rootstocks. He was convinced that they were the key to the successful future of the citrus industry.

Culture

A spacing of 25 x 25 ft (7.5x7.5 m) was standard in the past. However, many orange groves today are being close-planted and hedged to facilitate both manual and wide enough to accommodate mobile machinery for fertilizing, spraying, pruning and harvesting. There are arguments against close-spacing; mainly that, as the trees grow and become more crowded, productivity declines; also that close-spacing requires expensive pruning. However, data gathered on yields of the 'Pineapple' orange on rough lemon rootstock at Lake Alfred, Florida, over an 11-year trial, showed total yields for the period as: 2,380 boxes per acre (5,880/ha) at 25 x 20 ft (7.5x6 m)–87 trees per acre (215/ha); 3,496 boxes per acre (8,639/ha) at 20 x 15 ft (6x4.5 m)–145 trees per acre (358/ha); 4,484 boxes per acre (11,079/ha) at 15 x 10 ft (4.5-3 m)–290 trees per acre (716/ha). Other examples are given under **Yield.**

The young trees must be carefully tended and kept weed-free for the first 2 or 3 years in the field. Citrus trees have special nutritional requirements. The soil should be tested to determine the best balance of major and minor elements to be added. In general, orange trees need to be fertilized with N P K very soon after harvesting. The balance of major nutrients has to be considered in relation to the ultimate use of the crop. For example, extra nitrogen increases the peel oil content of oranges, while extra potassium decreases it. In California, 1 lb (0.45 kg) of nitrogen per tree per year has been found sufficient to maintain high productivity. Indian scientists, after a 4-year study, concluded that sweet oranges of the best quality were produced by applications of nitrogen at the rate of 2 lbs (0.9 kg) per year for 8-year-old trees. Orange trees are watched for signs of deficiencies which may be counteracted by foliar spraying. Leaf analysis reveals what is lacking or being applied in excess.

Efforts in northern India to control spring fruit drop with growth regulators have not been successful but pre-harvest drop has been greatly reduced. Gibberellic acid at 100 to 1,000 ppm, whether applied at full bloom or small fruit stage, has significantly increased the number of 'Washington Navel' fruits harvested.

Irrigation: Irrigation of orange trees is carefully managed. Ordinarily, it is omitted in the fall in order to avoid the production of tender new growth that would be damaged in winter cold spells. It may be very desirable in the spring dry season to prevent wilting. Excessive irrigation lowers the solids content of the fruit. The deeper the soil, the better the root system and the greater the ability to withstand drought. Soils at least 4 ft (1.2 m) deep can be given 1 1/2 in (6.25 cm) of water as needed, whereas soils only 1 1/2 ft (45 cm) deep should receive no more than 1 in (2.5 cm) of water at a time but more frequently.

Pruning: Orange trees are self-forming and do not need to be shaped by early pruning. Removal of water sprouts from young and older trees is important. Branches that are lower than 1 ft (30 cm) from the ground should be taken off. Deadwood from any cause–adverse soil conditions, pests or diseases, nutritional deficiencies, or cold injury–should be cut out and cut surfaces over 1 in (2.5 cm) in diameter should be sealed with pruning compound. Orange trees that are close-planted and hedged are being mechanically pruned by special equipment. Cuban experimenters claim that this procedure is beneficial in increasing the number of new shoots and that it decreases pest and disease problems.

In Israel, the old practice of girdling has been revived. If done in winter, it will enhance the sprouting of buds in the spring. Summer girdling increases the size of the fruits.

Harvesting

In the early days of the orange industry, harvesters climbed ladders and pulled the fruits off by hand, putting them into pails or shoulder-sacks which they later emptied into 90-lb (40.8 kg) field boxes. From 1900 to 1940, they used clippers. With the erstwhile shortage and increased cost of field labor, various changes and improvements have been made in harvesting methods. Pulling is again practiced, especially with fruits destined for processing. In the United States, Federal regulations and the individual state Department of Agriculture and state Citrus Commission control the stage of maturity at which the fruits may be picked and the grading of the fruits for marketing and shipping.

In anticipation of drastic increases in the cost of conventional harvesting, various methods of wholly or partly mechanized harvesting have been explored, including limb and tree shakers and air jets. Devices developed are not being widely utilized as yet because of the investments necessary for their acquisition and the current availability of manual labor. Manual picking is less laborious now that oranges for processing can be allowed to fall on the ground instead of being placed in sacks which have to be carried down ladders. The efficiency of hand-harvesting has been enhanced also by the use of fiberglass ladders and abscission agents which make it possible to pluck the fruit with less force and consequently greater speed. Good workers who have harvested oranges at the rate of 6.5 boxes per hour are now able to pick 9.1 boxes per hour. The effectiveness of the abscission agent depends largely on the lapsed time after spray-application and the prevailing temperature and relative humidity during that period.

Yield

On the average, a 'Washington Navel' orange tree may bear approximately 100 fruits in a season. Horticulturists at the University of Puerto Rico have selected Navel orange clones and budded them onto orange seedlings for test plantings. Of 5 that were numbered 4, 5, 6, 7 and 8, numbers 5 and 7 surpassed the others in productivity, number 7 yielding 293 fruits per tree. These two clones are considered worthy of propagation and naming. It is said that very old, large orange trees in the Mediterranean area may bear 3,000 to 5,000 oranges each year.

Growers everywhere are testing high-density as a means of gaining higher yields. In Australia, 'Valencia' orange trees 6 years old, planted 1,011 to 2,023 trees per acre (2,500-5,000/ha), yielded 24 tons/acre (60 tons/ha). 'St. Ives Valencia' trees on P. trifoliata rootstock and inoculated in the nursery with mildly dwarfing exocortis, were planted in 1973 at densities ranging from 270 to 2,023 trees per acre (667-5,000 trees/ha). Those at 506 trees/ acre (1,250/ha) yielded 55 tons/acre (135 tons/ha). Those at 1,214 to 2,023 trees/acre (3,000-5,000/ha) yielded 105 tons/acre (260 tons/ha) until after the 4th crop, when productivity began to decline.

Keeping Quality

Oranges can be stored for 3 months at 52º F (11.11º C); up to 5 months at 36º to 39º F (2.22º-3.89º C). Deterioration in market quality is primarily due to transpiration-loss of moisture in the peel and pulp. After 2 months of storage at 68º F (20º C) and, relative humidity of 60 to 80 %, 'Valencia' oranges have been found to have lost 9.5% of the moisture in the peel but only 2.1% of that in the pulp. The peel becomes 50% thinner, the pulp 10%. Later, the peel is very thin, dry and brittle while the pulp is still juicy. Coating the fruits with a polyethylene/wax emulsion doubles the storage life.

Pests

Oranges and other citrus fruits are commonly affected by citrus rust mites causing external blemishing and, in extreme infestations, smaller fruits, pre-mature falling and even shedding of leaves. Citrus red mites (purple mites) and Texas citrus mites, common in summer, disfigure the surface of the fruit and the foliage mainly in the winter and during droughts. Parasitic fungi (*Hirsutella thompsonii* and *Triplosporium floridana*) help to eradicate rust mites and the Texas citrus mite.

Several scale insects prey on citrus trees. The most harmful enemy is citrus snow scale infesting the woody portions of the tree. Purple scale and glover scale suck sap from the branches, twigs, leaves and fruit. Florida red scale and yellow scale induce shedding of fruit and foliage. Chaff scale may be found on the fruit, foliage and bark and produces green spots on the fruit. Cottony cushion scale often infests young trees. Maintaining populations of the Vedalia lady beetle in nurseries and groves is a fairly effective means of controlling this scale. Parasitic wasps (*Aphytis* spp.) are able to control Citrus snow scale, purple scale and Florida red scale.

California red scale (*Aonidiella aurantii*) is fairly well controlled by insect parasites in desert orchards but chemical treatment is necessary in the San Joaquin Valley when pheromone trapping of males reveals infestations. Pheromone trapping has virtually eliminated this scale in commercial groves in Arizona.

Mealybugs, prevalent in spring and early summer, form white masses underneath and between fruits in the early stages of development and may cause shedding, and their excretion of honeydew provides a base for the fungal manifestation termed sooty mold. The whitefly in its immature stage congregates on the lower side of the leaves, sucking the sap, and also excreting honeydew leading to sooty mold. Immature whiteflies are preyed upon by the parasitic fungi, *Aschersonia* spp. and *Aegerita* sp., which are frequently mistaken for harmful pests. The citrus blackfly, *Aleurocanthus woglumi*, deposits eggs in spiral formations on the underside of the leaves. It is a serious pest in many of the citrus regions of the world. In January 1976, an inspection program was launched in Florida with the expectation that spraying could eventually be replaced with biological control utilizing the blackfly parasites, *Amitus hesperidum* and *Prospaltella opulenta*. By 1978, the parasites were credited with a 97% reduction in the blackfly population.

Aphids (plant lice) cause leaves to curl and become crinkled. The brown citrus aphid, *Toxoptera citricidus*, is the main vector of the tristeza virus. The orange dog is a large brown-and-white caterpillar, the larva of a black-and-yellow, swallowtailed butterfly. These pests damage the trees in summer and autumn.

In 1953, it was discovered that the burrowing nematode, *Radopholus similis*, was the cause of spreading decline in Florida and extraordinary measures costing over 21 million dollars in the next 22 years were taken to remove infested trees, treat the soil and create buffer zones to prevent spread into other groves.

Fruit flies are a constant threat to oranges and massive steps have been taken against the spread of the Mediterranean fruit fly whenever it has appeared in Florida or California. The Caribbean fruit fly is common in Florida and oranges from this state were, until 1980, fumigated with ethylene dibromide before export. When this chemical was reported to have caused cancer in experimental animals, it was banned for export or domestic use. Instead, cold treatment for 17 days at 34º F (1.1º C) has been required. Quality of 'Valencia' oranges has remained stable for only 1 week at 40º F (4.4º C) following cold treatment; has deteriorated in a further 2 weeks at 70º F (21.1º C).

Diseases

Orange and other citrus trees are subject to a great number of fungal diseases affecting the roots, the trunk and branches, the foliage and the fruits. Greasy spot, caused by *Cercospora citri-grisea, is* seen, 2 to 9 months after severe infection, as yellow-brown, blistery, oily, brown or black spots on the foliage. Severe defoliation may follow. The fungus, *Diaporthe citri, is* responsible for gummosis, melanose, dieback and stem-end rot. The fungus, *Elsinoe australis,* causes sweet orange scab which is frequently seen on oranges in South America and in Sicily and New Caledonia. *Phytophthora megasperma, P. palmivora* and P. *Parasitica* are common causes of foot rot.

There are also viruses and viroids usually named for the syndromes they cause–crinkly leaf; gummy bark; exocortis (scaly butt) transmitted by budwood and by tools; psorosis, xyloporosis (cachexia), transmitted only by budwood. Tristeza has been a major problem in Florida in the past and still is in Brazil. Since 1953, Florida has maintained a Citrus Budwood Registration program for the production of virus-tested citrus trees. Under this program, the Etrog citron was adopted as a test plant for identifying exocortis virus in one year's time, and techniques have been developed for identifying tristeza in a few hours instead of months.

In 1984, an outbreak of citrus canker *(Xanthomonas campestris* pr. *citri* or *Phytomonas citri)* in four whole-sale citrus nurseries in Florida caused widespread alarm and forced the burning of thousands of nursery plants and a search for plants that had been sold by those nurseries, in efforts to prevent the spread of this menace. The virus causes lesions on fruits, stems, and, unlike other diseases, on both sides of the leaves; induces leaf fall and premature fruit drop and, in severe cases, the death of the tree. Canker is common in various countries including India, the Philippines, the Middle East, parts of Africa and in Brazil and Argentina. The highly virulent Oriental Strain A was introduced into Florida in 1910 and was eradicated in Florida and the Gulf States by 1933. In anticipation of reintroduction, pathologists have gone abroad to study the disease. By January 1986, Strain E had been reported in 17 nurseries and over 15 million young trees had been destroyed. Eradication programs were intensified when Oriental Strain A reappeared on Florida's west coast in midsummer, and 5 million more trees had to be burned.

Blight, or young tree decline (YTD), is the leading cause of losses of orange trees-up to a half-million per year-in Florida, especially 'Valencia' on rough lemon, but any cultivars on any rootstocks. Sour orange rootstock seems somewhat more resistant than the others. Blight was thought to be the result of nutritional deficiencies or physiological or soil problems. But root-grafting of healthy trees onto affected trees has shown the disease to be infectious.

Experiments at Lake Alfred have shown that substantial recovery from YTD, can be achieved by early treatment of an affected tree with 20 gals (7 6 liters) of a 1 1/2% solution of sodium erythorbate or erythorbic acid applied to the soil, and 10 gals (38 liters) applied as a foliar spray, plus soil application of 5 to 7 1/2 lbs (2.2-3.3 kg) of calcium chloride or calcium nitrate–about 6 ft (1.8 m) out from the base of the trunk. Foliar sprays of urea–5 lbs (2.2 kg) per 100 gals (380 liters)–with a wetter-sticker are given to encourage new growth.

Californian scientists have traced decline of the 'Navel' orange to incompatibility with trifoliate orange rootstock (especially 'Rubidoux'; rarely 'Rich 16-6'). Malformation at the union, evident in about 20 years, fully developed in 25, takes two forms–tongue-and-groove, and shelf-and-shoulder distortions.

Often, abnormal aspects of leaves, occasioned by mineral deficiencies, may be mistaken for signs of disease, Exanthema is the result of copper deficiency. Mottle-leaf indicates zinc deficiency. Yellow spot signals lack of molybdenum. On the other hand, star melanose is brought about by late copper spraying. Inspection by trained entomologists and/or plant pathologists is usually necessary to determine the actual cause, or causes, of disfigurations or decline. Citrus quarantine laws are very strict with a view to preventing the introduction and spread of pests and diseases, and failure to comply with these laws can have disastrous consequences.

Food Uses

In the past, oranges were primarily eaten fresh, out-of-hand, and many are so consumed in warm climates. In Cuba, oranges are peeled by an old-fashioned apple peeler mounted on the pushcart of fruit vendors. Today, pre-peeled oranges in plastic bags are sold to motorists by Latin American street vendors in Miami. The hand-labor of peeling oranges has limited the production of sliced oranges for use by restaurants and orange-salad packers. However, a peeling machine developed by John Webb in Clear-water, Florida, is peeling 80 oranges a minute and this device, together with his successful sectioning machine, is expected to greatly expand the commercial use of fresh oranges.

In the home, oranges are commonly peeled, segmented and utilized in fruit cups, salads, gelatins and numerous other desserts, and as garnishes on cakes, meats and poultry dishes. They were also squeezed daily in the kitchen for juice but housewives are becoming less and less inclined to do this. In South America, a dozen whole, peeled oranges are boiled in 3 pints (1.41 liters) of slightly sweetened water for 20 minutes and then strained and the liquid is poured over small squares of toast and slices of lemon and served as soup.

In the past few decades, the commercial extraction of orange juice and its marketing in waxed cartons or cans has become a major industry, though now surpassed on a grand scale by the production of frozen orange concentrate to be diluted with water and served as juice. Dehydrated orange juice (orange juice powder), developed in 1963, is sold for use in food manufacturing, adding flavor, color and nutritive elements to bakery goods and many other products. Whole oranges are sliced, dried and pulverized, and the powder is added to baked goods as flavoring.

Orange slices and orange peel are candied as confections. Grated peel is much used as a flavoring and the essential oil, expressed from the outer layer of the peel, is employed commercially as a food, soft-drink and candy flavor and for other purposes. Pectin for use in fruit preserves and otherwise, is derived from the white inner layer of the peel. Finisher pulp, consisting mostly of the juice sacs after the extraction of orange juice, has become a major by-product. Dried to a moisture content of less than 10%, it has many uses as an emulsifier and binder in the food and beverage industries.

Orange wine was at one time made in Florida from fruits too affected by cold spells to be marketed. It is presently produced on a small scale in South Africa. Orange wine and brandy are made in Brazil from fruits which have been processed for peel oil and then crushed.

Food Value

The chemistry of the orange is affected by many factors. On the average, 'Valencia', 'Washington Navel', and other commercial oranges have been found to possess the values shown on the next page.

Food Value Per 100 g of Edible Portion

	Fruit (fresh)	Juice (fresh)*	Juice (canned, unsweetened, undiluted)	Frozen concentrate (unsweetened, undiluted)	Juice (dehydrated)	Orange Peel (raw)**
Calories	47-51	40-48	223	158	380	
Moisture	86.0 g	87.2-89.6 g	42.0 g	58.2 g	1.0 g	72.5%
Protein	0.7-1.3 g	0.5-1.0 g	4.1 g	2.3 g	5.0 g	1.5 g
Fat	0.1-0.3 g	0.1-0.3 g	1.3 g	0.2 g	1.7 g	0.2 g
Carbohydrates	12.0-12.7 g	9.3-11.3 g	50.7 g	38.0 g	88.9 g	25.0 g
Fiber	0.5 g	0.1 g	0.5 g	0.2 g	0.8 g	
Ash	0.5-0.7 g	0.4 g	1.9 g	1.3 g	3.4 g	0.8 mg
Calcium	40-43 mg	10-11 mg	51 mg	33 mg	84 mg	161 mg
Phosphorus	17-22 mg	15-19 mg	86 mg	55 mg	134 mg	21 mg
Iron	0.2-0.8 mg	0.2-0.3 mg	1.3 mg	0.4 mg	1.7 mg	0.8 mg
Sodium	1.0 mg	1.0 mg	5 mg	2 mg	8.0 mg	3.0 mg
Potassium	190-200 mg	190-208 mg	942 mg	657 mg	1,728 mg	212 mg
Vitamin A	200 I.U.	200 I.U.	960 I.U.	710 I.U.	1,680 I.U.	420 I.U.
Thiamine	0.10 mg	0.09 mg	0.39 mg	0.30 mg	0.67 mg	0.12 mg
Riboflavin	0.04 mg	0.03 mg	0.12 mg	0.05 mg	0.21 mg	0.09 mg
Niacin	0.4 mg	0.4 mg	1.7 mg	1.2 mg	2.9 mg	0.9 mg
Ascorbic Acid	45-61 mg	37-61 mg	229 mg	158 mg	359 mg	136 mg

*Volatile properties include: ethyl, *iso*amyl and phenylethyl alcohols; acetone; acetaldehyde; formic acid; esters of formic, acetic and caprylic acids; geraniol and terpineol. The juice also contains β-sitosteryl-*D*-glucoside and β-sitosterol.

Orange Peel Oil *d*-limonene (90%); citral; citranellal; methyl ester of anthranilic acid; decyclic aldehyde; linalool; ***d*-*l*-terpineol; nonyl alcohol; methyl anthranilate; and traces of caprilic acid esters.

Toxicity

Persons in close proximity to orange trees in bloom may have adverse respiratory reactions. Sawdust of the wood of orange trees, formerly used for polishing jewelry, has caused asthma. Excessive contact with the volatile oils in orange peel can produce dermatitis. People who suck oranges often suffer skin irritation around the mouth. Those who peel quantities of oranges may have rash and blisters between the fingers. If they touch their faces, they are apt to have facial symptoms as well. In southern Florida, a young woman shook an orange tree in order to cause the fruit to fall. An hour later, she broke out in hives, presumably from exposure to a spray of citrus oils from the ruptured peduncles, stem-end peel, and broken leaf petioles. A similar reaction has occurred from shaking down the fruits of a lime tree in Miami. Sensitive individuals may have respiratory reactions in proximity to the volatile emanations from broken orange peel.

Other Uses

Pulp: Citrus pulp (3/4 being a by-product of orange juice extraction) is highly valued as pelleted stockfeed with a protein content of 6.58 to 7.03%, and it is also being marketed as cat litter. It is a source of edible yeast, non-potable alcohol, ascorbic acid, and hesperidin.

Peel: In addition to its food uses, orange peel oil is a prized scent in perfume and soaps. Because of its 90-95% limonene content, it has a lethal effect on houseflies, fleas and fireants. Its potential as an insecticide is under investigation. It is being used in engine cleaners and in waterless hand-cleaners in heavy machinery repair shops. It is commercially produced mainly in California and Florida, followed distantly by Italy, Israel, Jamaica, South Africa, Brazil and Greece, in that order. Terpenes extracted from the outer layer of the peel are important in resins and in formulating paints for ships. Australians have reported that a shipment of platypuses sent to the United States in the 1950s was fed mass-produced worms raised on orange peel.

Seeds: Oil derived from orange and other citrus seeds is employed as a cooking oil and in soap and plastics. The high-protein seed residue is suitable for human food and an ingredient in cattlefeed, and the hulls enter into fertilizer mixtures.

Flowers and foliage: The essential oils distilled from orange flowers and foliage are important in perfume manufacturing. Some Petitgrain oil is distilled from the leaves, flowers, twigs, and small, whole, unripe fruits.

Nectar: The nectar flow is more abundant than that from any other source in the United States and is actually a nuisance to grove workers in California, more moderate in Florida. It is eagerly sought by honeybees and the delicious, light-colored honey is widely favored, though it darkens and granulates within a few months. Citrus honey constitutes 25% of all honey produced in California each year. There are efforts to time pest-control spraying to avoid adverse effects on honeybees during the period of nectar-gathering.

Wood: The wood is yellowish, close-grained and hard but prone to attack by drywood termites. It has been valued for furniture, cabinetwork, turnery and engraver's blocks. Branches are fashioned into walking-sticks. Orange wood is the source of orange sticks used by manicurists to push back the cuticle.

Medicinal Uses: Oranges are eaten to allay fever and catarrh. The roasted pulp is prepared as a poultice for skin diseases. The fresh peel is rubbed on acne. In the mid-1950s, the health benefits of eating peeled, whole oranges was much publicized because of its protopectin, bioflavonoids and inositol (related to vitamin B). The orange contains a significant amount of the vitamin-like glucoside, hesperidin, 75-80% of it in the albedo, rag and pulp. This principle, also rutin, and other bioflavonoids were for a while much advocated for treating capillary fragility, hemorrhages and other physiological problems, but they are no longer approved for such use in the United States.

An infusion of the immature fruit is taken to relieve stomach and intestinal complaints. The flowers are employed medicinally by the Chinese people living in Malaya. Orange flower water, made in Italy and France as a cologne, is bitter and considered antispasmodic and sedative. A decoction of the dried leaves and flowers is given in Italy as an antispasmodic, cardiac sedative, antiemetic, digestive and remedy for flatulence. The inner bark, macerated and infused in wine, is taken as a tonic and carminative. A vinous decoction of husked orange seeds is prescribed for urinary ailments in China and the juice of fresh orange leaves or a decoction of the dried leaves may be taken as a carminative or emmenagogue or applied on sores and ulcers. An orange seed extract is given as a treatment for malaria in Ecuador but it is known to cause respiratory depression and a strong contraction of the spleen.

Morton, J. 1987. Mandarin Orange. p. 142–145. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mandarin Orange

Citrus reticulata

Mandarin is a group name for a class of oranges with thin, loose peel, which have been dubbed "kid-glove" oranges. These are treated as members of a distinct species, *Citrus reticulata* Blanco. The name "tangerine" could be applied as an alternate name to the whole group, but, in the trade, is usually confined to the types with red-orange skin. In the Philippines all mandarin oranges are called *naranjita*. Spanish-speaking people in the American tropics call them *mandarina*.

Description

The mandarin tree may be much smaller than that of the sweet orange or equal in size, depending on variety. With great age, some may reach a height of 25 ft (7.5 m) with a greater spread. The tree is usually thorny, with slender twigs, broad-or slender-lanceolate leaves having minute, rounded teeth, and narrowly-winged petioles. The flowers are borne singly or a few together in the leaf axils. The fruit is oblate, the peel bright-orange or red-orange when ripe, loose, separating easily from the segments. Seeds are small, pointed at one end, green inside.

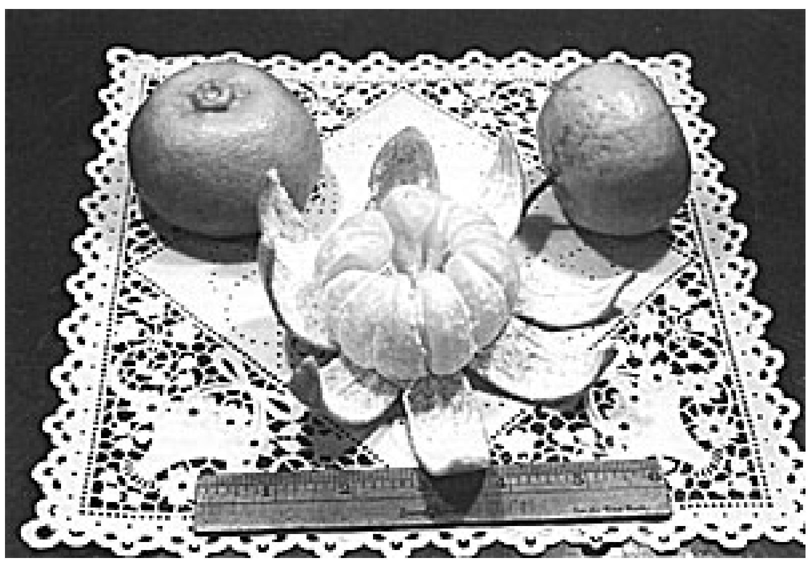


Fig. 37: Easily-peeled Mandarin oranges (*Citrus reticulata*) are ideal for eating out-of-hand and very popular in Central America.

Origin and Distribution

The mandarin orange is considered a native of south-eastern Asia and the Philippines. It is most abundantly grown in Japan, southern China, India, and the East Indies, and is esteemed for home consumption in Australia. It gravitated to the western world by small steps taken by individuals interested in certain cultivars. Therefore, the history of its spread can be roughly traced in the chronology of separate introductions. Two varieties from Canton were taken to England in 1805. They were adopted into cultivation in the Mediterranean area and, by 1850, were well established in Italy. Sometime between 1840 and 1850, the 'Willow-leaf' or 'China Mandarin' was imported by the Italian Consul and planted at the Consulate in New Orleans. It was carried from there to Florida and later reached California. The 'Owari' Satsuma arrived from Japan, first in 1876 and next in 1878, and nearly a million budded trees from 1908 to 1911 for planting in the Gulf States. Six fruits of the 'King' mandarin were sent from Saigon in 1882 to a Dr. Magee at Riverside, California. The latter sent 2 seedlings to Winter Park, Florida. Seeds of the 'Oneco' mandarin were obtained from India by the nurseryman, P.W. Reasoner, in 1888. In 1892 or 1893, 2 fruits of 'Ponkan' were sent from China to J.C. Barrington of McMeskin, Florida, and seedlings from there were distributed and led to commercial propagation.

The commercial cultivation of mandarin oranges in the United States has developed mostly in Alabama, Florida and Mississippi and, to a lesser extent, in Texas, Georgia and California. Mexico has overproduced tangerines, resulting in low market value and cessation of plantings. The 1971-72 crop was 170,000 MT, of which, 8,600 MT were exported to the United States and lesser amounts to East Germany, Canada and Argentina. There is limited culture in Guatemala and some other areas of tropical America. These fruits have never been as popular in western countries as they are in the Orient, Coorg, a mountainous region of the Western Ghats, in India, is famous for its mandarin oranges. For commercial exploitation, mandarins have several disadvantages: the fruit has poor holding capacity on the tree, the peel is tender and therefore the fruits do not stand shipping well, and the tree has a tendency toward alternate bearing.

Climate

Mandarin oranges are much more cold-hardy than the sweet orange, and the tree is more tolerant of drought. The fruits are tender and readily damaged by cold.

Varieties

Mandarin cultivars fall into several classes:

Class I, Mandarin:

'Changsa'–brilliant orange-red; sweet, but insipid; seedy. Matures early in the fall. The tree has high cold resistance; has survived 4º F (-15.56º C) at Arlington, Texas. It is grown as an ornamental.

'Le-dar'–arose from a climbing branch discovered on an 'Ellendale Beauty' mandarin tree in Bundaberg, Queensland, Australia, about 1959. The owners, named Darrow, took bud-wood from the branch and found that it retained its climbing tendency. Commercial propagation was undertaken by Langbecker Nurseries and the name was trademarked in 1965 when over 5,000 budded trees were put on sale. The budded trees produced large fruits, of rich color and high quality, maturing a little later than the parent.

'Emperor'–believed to have originated in Australia, and a leading commercial cultivar there; oblate, large, 2 1/2 in (6.5 cm) wide, 1 3/4 in (4.5 cm) high; peel pale-orange, medium thin; pulp pale-orange; 9-10 segments; seeds long, pointed, 10-16 in number. Midseason. Grown on rough lemon rootstock or, better still, on *Poncirus trifoliata*.

'Oneco'–closely related to 'Emperor'; from northwestern India; introduced into Florida by P.W. Reasoner in 1888. Oblate to faintly pear-shaped; medium to large, 2 1/2-3 1/2 in (6.25-9 cm) wide, 2 1/4-3 in (5.7-7.5 cm) high; peel orange-yellow, glossy, rough and puffy; pulp orange-yellow, of rich, sweet flavor; 5-10 seeds. Medium to late in season. Tree large and vigorous, high-yielding. Not grown commercially in the United States.

'Willow-leaf'–(China Mandarin')–oblate to rounded, of medium size, 2-2 1/2 in (5-6.25 cm) wide, 1 3/4-2 1/4 in (4.5-5.7 cm) high; peel orange, smooth, glossy, thin; pulp orange, with 10-12 segments; very juicy, of sweet, rich flavor; 15-20 seeds. Early in season. Tree is small to medium, with very slender, willowy branches, almost thornless, and slim leaves. Reproduces true from seed. Grown mainly as an ornamental and for breeding.

Class II, Tangerine:

'Clementine' (Algerian Tangerine')–introduced into Florida by the United States Department of Agriculture in 1909 and from Florida into California in 1914; also brought directly from the Government Experiment Station in Algeria about the same time; round to elliptical; of medium size, 2-2 3/8 in (5-6.1 cm) wide, 2-2 3/4 in (5-7 cm) high; peel deep orange-red, smooth, glossy, thick, loose, but scarcely puffy; pulp deep-orange with 8-12 segments; juicy, and of fine quality and flavor; 3-6 seeds of medium size, non-nucellar; season early but long, extending into the summer. Tree is of medium size, almost thornless; a shy bearer. In Spain it has been found that a single application of gibberellic acid at color-break, considerably reduces peel blemishes and permits late harvesting. 'Clementine' crossed with pollen of the 'Orlando' tangelo produced the hybrid selections, 'Robinson', 'Osceola', and 'Lee', released in 1959. The last two are no longer grown as fruit crops; only utilized in breeding programs.

'Cleopatra' ('Ponki', or 'Spice')–(now being shown as *Citrus reshni* Hort. ex Tanaka)–introduced into Florida from Jamaica before 1888; oblate, small; peel dark orange-red; pulp of good quality but seedy. Fruits too small to be of commercial value; they remain on the tree until next crop matures, adding to the attractiveness of the tree which is itself highly ornamental; much used as a rootstock in Japan and Florida.

'Dancy'–may have come from China; found in the grove of Col. G.L. Dancy at Buena Vista, Florida, and brought into cultivation in 1871 or 1872. Oblate to pear-shaped; of medium size, 2 1/4-3 in (5.7-7.5 cm) wide, 1 1/2-2 1/8 in (4-5.4 cm) high; peel deep orange-red to red, smooth, glossy at first but lumpy and fluted later, thin, leathery, tough; pulp dark-orange with 10-14 segments, of fine quality, richly flavored; 6-20 small seeds. In season in late fall and winter. This is the leading tangerine in the United States, mainly grown in Florida, secondarily in California, and, to a small extent, in Arizona. Tree is vigorous, cold-tolerant, bears abundantly. Alternate-bearing induced by an abnormally heavy crop, can be avoided by spraying with a chemical thinner (Ethephon) when the fruits are very young. Thinning enhances fruit size and market value. This cultivar is disease-resistant but highly susceptible to chaff scale *(Parlatoria pergandii)* which leaves green feeding marks on the fruit making it unmarketable. Control can be achieved by spring and summer or spring and fall spraying of an appropriate pesticide.

'Ponkan' ('Chinese Honey Orange')–round to oblate; large, 2 3/4-3 3/16 in (7-8 cm) wide; peel orange, smooth, furrowed at apex and base; medium thick; pulp salmon-orange, melting, with 9-12 segments, very juicy, aromatic, sweet, of very fine quality and with few seeds. Tree not as cold-hardy as 'Dancy', small, upright; can be maintained as a "dwarf' and in China, where the fruit is greatly prized, may be planted 900 to the acre (2,224/ha). R.C. Pitman, Jr., of Apopka, Florida, organized the Florida Ponkan Corporation in 1948, served as its President, and has continuously promoted the culture of this delicious fruit.

'Robinson'–the result of pollinating the 'Clementine' tangerine with the 'Orlando' tangelo, at the United States Department of Agriculture's Horticultural Field Station, Orlando, Florida, was introduced into cultivation in 1960. It is essentially a tangerine, has 10 to 20 seeds. Back-crossing with pollen of the 'Orlando' greatly elevates fruit-set but also results in increasing the seed count to an average of 22 per fruit. This cultivar had lost popularity with growers but the recent practice of spraying with Ethrel (a ripening agent) to speed up coloring on the tree and loosen the fruit has been such an important advance in harvesting and in reducing time in the coloring room that it has reinstated the 'Robinson' as a commerical cultivar. In 1980, the crop forecast was 1.1 million boxes, about 40% of that of 'Dancy'.

'Sunburst'–This cultivar was selected in 1967 from 15 seedlings; of hybrids of 'Robinson' and 'Osceola', the latter being another 'Clementine' pollinated with 'Orlando' tangelo but still dominantly a tangerine. 'Sunburst' was propagated on several rootstocks in 1970 and released in Florida in 1979. Oblate, medium-sized, 2 1/2-3 in (6.25-7.5 cm) wide; peel is orange to scarlet in central Florida, orange around the Indian River area; pulp in 11-15 segments with much colorful juice; seeds 10 to 20 according to degree of pollination; green inside. Matures in a favorable season: (mid-November to mid-December). Tree vigorous, thornless, early-bearing, self-infertile; needs cross-pollination for good fruit set; amenable to sour orange, rough lemon, 'Carrizo' and 'Cleopatra' root-stocks though the latter results in slightly reduced fruit size; medium cold-hardy; resistant to *Alternaria* and very tolerant of snow scale.

Class III, Satsuma (sometimes marketed as "Emerald Tangerine")

The Satsuma orange is believed to have originated in Japan about 350 years ago as a seedling of a cultivar, perhaps the variable 'Zairi'. It is highly cold-resistant; has survived 12º F (-11.11º C); is more resistant than the sweet orange to canker, gummosis, psorosis and melanose. It is budded onto *Poncirus trifoliata* in Florida, sweet orange in California. It has been found in Spain that spraying with gibberellic acid 4 to 5 weeks before commercial maturity prevents puffiness, delays ripening, and permits harvesting 2 months later than normal, but this leads to reduced yields the following year.

'Owari'–oblate to rounded or becoming pear-shaped with age; of medium size, 1 1/2-2 3/4 in (4-6.1 cm) wide, 1 1/2-2 1/2 in (4-6.25 cm) high; peel orange, slightly rough, becoming lumpy and fluted, thin, tough; pulp orange, of rich, subacid flavor; nearly seedless, sometimes 1-4 seeds. Early but short season. Peel often remains more or less green after maturity and needs to be artificially colored in order to market before loss of flavor. Tree small, almost thornless, large-leaved, with faint or no wings on petioles; cultivated commercially in northern Florida, Alabama and other Gulf States; very little in California.

'Wase'–Discovered at several sites in Japan from before 1895; believed to be a bud sport of 'Owari'; was propagated and extensively planted in Japan before 1910; was growing in Alabama in 1917; one tree was sent to California in 1929; oblate to rounded or somewhat conical; large, 2 1/3 in (5.81 cm) wide, 1 3/4 in (4.5 cm) high; peel orange, thin, smooth; pulp salmon-orange, melting, sweet, with 10 segments more or less. Very early in season. Tree is dwarf, slow-growing, heavy-bearing, but susceptible to pests and diseases; has been planted to a limited extent in California and southern Alabama.

'Kara' ('Owari' X 'King' tangor)**–**a hybrid developed at the California Citrus Experiment Station and distributed in 1935; sub-oblate or nearly round; of medium size, 2 1/8-3 in (5.4-7.5 cm) wide, 2 1/8-2 3/4 in (5.4-7 cm) high; peel deep-orange to orange-yellow, lumpy and wrinkled at apex, puffy with age, thin to medium, fairly tough; pulp deep yellow-orange, with 10-13 segments, tender, very juicy, aromatic, of rich flavor, acid until fully ripe, then sweet; usually 12-20 large seeds, at times nearly seedless. Late in season. Tree is vigorous, thornless, with large leaves, the petiole narrowly winged. Grown in coastal California.

Keeping Quality and Storage

Tangerines generally do not have good keeping quality. Commercially washed and waxed 'Dancy' tangerines show a high rate of decay if kept for 2 weeks, will totally decay if held 4 weeks, at 70º F (21º C). To prolong storage life, pads impregnated with the fungistat, diphenyl, have been placed in shipping cartons. The chemical is partly absorbed by the fruit and Federal regulations allow a residue of only 110 ppm. Storage trials have shown that washed and waxed 'Dancy' and 'Sunburst', with 2 pads per carton, absorbed more than 110 ppm in 2 weeks at 70º F (21º C). Though 'Dancy' absorbed more of the fungistat than 'Sunburst', it showed more decay. Storage of unwashed 'Dancy' fruits for 2 weeks at 39.2º F (3º C) with 1 pad per carton showed diphenyl absorption below the legal limit. Unwashed 'Sunburst' fruits with 2 pads can be stored 4 weeks without absorbing excessive diphenyl. Early-harvested tangerines are less susceptible to decay but apt to absorb an excess of diphenyl.

In the Coorg region of India, mandarins of the main crop, harvested in January/February, lose moisture and become shriveled and unmarketable in 10 days at room temperature, 69º F (20.26º C). Wax-coating extends shelf-life to 14 days. Fruits stored in perforated polyethylene bags remain marketable for 21 days at room temperature, and, whether waxed or unwaxed, held at 41º F (5º C), retain quality for 31 days.

Food Uses

Mandarin oranges of all kinds are primarily eaten out-of-hand, or the sections are utilized in fruit salads, gelatins, puddings, or on cakes. Very small types are canned in sirup.

The essential oil expressed from the peel is employed commercially in flavoring hard candy, gelatins, ice cream, chewing gum, and bakery goods. Mandarin essential oil paste is a standard flavoring for carbonated beverages. The essential oil, with terpenes and sesquiterpenes removed, is utilized in liqueurs. Petitgrain mandarin oil, distilled from the leaves, twigs and unripe fruits, has the same food applications. Tangerine oil is not suitable for flavoring purposes.

Food Value Per 100 g of Edible Portion*

Moisture	82.6-90.2 g
Protein	0.61-0.215 g
Fat	0.05-0.32 g
Fiber	0.3-0.7 g
Ash	0.29-0.54 g
Calcium	25.0-46.8 mg
Phosphorus	11.7-23.4 mg
Iron	0.17-0.62 mg
Carotene	0.013-0.175 mg
Thiamine	0.048-0.128 mg
Riboflavin	0.014-0.041 mg
Niacin	0.199-0.38 mg
Ascorbic Acid	13.3-54.4 mg

*Analyses of tangerines made in Central America.

In 1965, the 'Dancy' tangerine was found to contain more of the decongestant synephrine than any other citrus fruit-97-152 mg/liter, plus 80 mg/100 g ascorbic acid.

Mandarin peel oil contains decylaldehyde, *y*-phellandrene, *p*-cymene, linalool, terpineol, nerol, linalyl, terpenyl acetate, aldehydes, citral, citronellal, and *d*-limonene. Petitgrain mandarin oil contains *a*-pinene, dipentene, limonene, *p*-cymene, methyl anthranilate, geraniol, and methyl methylanthranilate.

Other Uses

Mandarin essential oil and Petitgrain oil and tangerine oil, and their various tinctures and essences, are valued in perfume-manufacturing, particularly in the formulation of floral compounds and colognes. They are produced mostly in Italy, Sicily and Algiers.

Morton, J. 1987. Tangor. p. 145–146. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Tangor

Citrus reticulata × Citrus sinensis

Tangors are deliberate or accidental hybrids of the mandarin *(Citrus reticulata)* and the sweet orange (C. *sinensis).* The following are among the better known:

Varieties

'King' ('King of Siam'); formerly identified as *Citrus nobilis* Lour.; is believed to have originated in Malaya and to have traveled from there to Japan and then to Florida; oblate to rounded; large, 2 1/2-3 3/4 in (6.25-9.5 cm) wide, 2 1/4-3 1/2 in (5.7-9 cm) high; peel deep orange-yellow to orange, thick, rough, lumpy; pulp dark-orange, with 10 to 12 segments, very little rag, melting, of fine quality and flavor; 5-15 or more seeds, white within. Late in season. Tree of medium size, erect, thorny to almost thornless, large-leaved, with narrowly-winged petioles; cold-resistant, very productive; may overbear and break branches. Formerly popular in Florida; of limited cultivation in California. No longer grown commercially in the United States. Does very well at cool elevations in Peru.

'Murcott' (Honey Murcott'; 'Murcott Honey Orange'; 'Red'; 'Big Red'; 'Honey Bell' tangelo)–believed to have resulted from breeding work by Dr. Walter Swingle and associates at the United States Department of Agriculture nursery in the Little River district of northeast Miami. The original tree was sent to R.D. Hoyt, in Safety Harbor, about 1913 for trial. Budwood was given to his nephew, Charles Murcott Smith, who propagated several trees about 1922. This led to propagation by several nurseries beginning in 1928 under the name, 'Honey Murcott'. Large-scale production began in 1952. The fruit is oblate, of medium size, 2 3/4-3 3/16 in (7.0-8.0 cm) wide, 1 4/5-2 1/16 in (4.7-5.2 cm) high; peel yellow to deep-orange, glossy, smooth, faintly ribbed, thin, clings to pulp but easily removed when fresh; pulp orange, 11-12 segments, with little rag; tender, having an abundance of reddish-orange juice, with high soluble solids; flavor rich, sweet-subacid; seeds 18-24, small, white inside. Because of the thin peel, the fruit is clipped from the tree, not pulled. It stores and ships well; is in high demand as a fresh fruit, not desirable for canned juice or frozen juice concentrate because of poor processed flavor. Tree is bushy with slender branches bearing fruits near the tips where they are subject to wind and cold damage. Very productive on rough lemon rootstock. Tends to alternate bearing. In heavy-fruiting years, crop may be so heavy as to break the limbs, or the tree may collapse ('Murcott Decline'), or many branches may die back.

This cultivar is subject to a virus disease known as *fovea*.

'Temple' (believed identical to the 'Magnet' of Japan)–a seedling discovered by a fruit buyer named Boyce who went to Jamaica in 1896 to purchase oranges after a severe freeze in Florida. He sent budwood to several friends in Winter Park, Florida, who later shared budwood with others. One budded tree fruiting in the grove of L.A. Hakes was brought to the attention of W.C. Temple who recommended it to H.E. Gillett, owner of Buckeye Nurseries. The latter named and propagated it and offered it for sale in 1919. It was not extensively planted until after 1940. The fruit is oblate to round, medium to large, 2 5/8-3 1/4 in (6.6-8.25 cm) wide, 2 1/4-2 1/2 in (5.7-6.25 cm) high; peel is deep-orange to red-orange, glossy, slightly rough, loose, thick, leathery; pulp orange, melting, of rich, sprightly flavor and superb quality; about 20 seeds of medium size, 25% being under-developed; green inside. Midseason. Tree not very cold-hardy, moderately thorny, bushy; most satisfactory on sour orange rootstock, and succeeds better in Florida than in California or Texas. Excessive applications of nitrogen and potassium increase acidity of the juice. For low-acid juice, low rates of nitrogen and potassium and high rates of phosphorus are necessary. Florida produced 3.3 million boxes in 1984-85 despite severe freezes.

'Umatilla' (incorrectly 'Umatilla Tangelo')–arose from pollination of the flowers of a 'Ruby' orange by 'Owari' Satsuma at Eustis, Florida, in 1911. The progeny was propagated in 1931. Much like 'King'; oblate to rounded; large, 3 1/4-4 3/4 in (8.25-12 cm) wide, 2 1/2-2 3/4 in (6.25-7 cm) high; peel red-orange, smooth, glossy, medium-thick, not very loose; pulp orange, with usually 10 segments, melting, very juicy, of rich sweet-acid flavor and fine quality; 10 or more large seeds or occasionally none. Late in season; holds well on tree. Tree is slow-growing, high-yielding; leaves thick and leathery without wings. Not extensively grown but prized for gift-boxes in Florida.

'Ortanique'–believed to be a chance cross of sweet orange and tangerine; discovered in the Christiana market, Jamaica, by a Manchester man named Swaby who bought 6 fruits. Of resulting seedlings, 2 bore fruit true to type which were exhibited at an agricultural show in the early 1900's. A man named C. P. Jackson, from Mandeville, bought 2 fruits, planted 130 seeds. Some of the seedlings were very thorny. Jackson selected the least thorny, least seedy, and named the fruit–a contraction of orange, tangerine, and unique. The Citrus Growers Association took charge of the marketing for export in 1944. Fruit closely resembles 'Temple'; oblate; peel deep-orange, thin, adherent; pulp divided into 16 segments with scant rag, very juicy, of distinctive acid-sweet flavor; seedless or with few seeds; subject to bruising when freshly picked; needs special handling by harvesters and packers. Grown commercially only in Jamaica but planted to some extent on other Caribbean islands. Fresh fruits and hot-pack concentrate have been shipped to the United Kingdom and New Zealand for many years. Citrus Growers Association took charge of marketing for export in 1944. The fruit is in demand domestically and abroad and brings a premium price. The tree is budded onto pummelo rootstock; cannot tolerate excessive moisture; optimum rainfall is 55-60 in (140-150 cm) annually, half in spring, half in fall. Ideal day temperature is 70º-80º or up to 90º F (21.11º-26.67º or up to 35º C), with 55º F (12.7º C) at night. The 'Ortanique' does well in hot, dry weather on shallow bauxite soil between 2,000 and 3,000 ft (600-900 m) elevation. There is less flavor in fruits from trees grown on clay or alluvial soils or at lower elevations. On clay, the 'Ortanique' is budded on sour orange rootstock. Rough lemon rootstock produces very inferior fruit. The tree begins to bear regularly at 3 years, and a 5-year-old tree will yield 1 1/2 to 2 1/2 90-lb (40.8 kg) field boxes; a 10-year-old tree, 3 1/2 to 4 1/2 boxes; and trees 15 to 20 years old, 4 to 5 1/2 boxes.

The 'Ortanique' has not performed well in Florida. In South Africa, fruiting has been somewhat irregular. Horticulturists at the Citrus and Subtropical Fruit Research Institute, Nelspruit, found it to be self-incompatible. Cross-pollination with the 'Valencia' orange, 'Minneola' and 'Orlando' tangelos and 'Marsh' grapefruit greatly increases fruit-set and elevates the seed count.

Pests and Diseases

In Jamaica, the 'Ortanique' is attacked by aphids *(Aphis gossypii),* rust mite *(Phyllocoptruta oleivora),* Florida red scale *(Chrysomphalus aonidum),* purple scale *(Lepidosaphes beckii),* and occasionally the West Indian red scale *(Selanaspidus articulatus).* Frequently seen are the fruit-piercing moth *(Gonodonta* spp.*)* and moths of the genus *Tortrix.*

The fungus, *Sphaeropsis tumefaciens,* sometimes causes large galls or knots around new twigs. Thread blight *(Corticium stevensii)* may occur in some localities.

Morton, J. 1987. Pummelo. p. 147–151. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Pummelo

Citrus maxima

This, the largest citrus fruit, is known in the western world mainly as the principal ancestor of the grapefruit. As a luscious food, it is famous in its own right in its homeland, the Far East. Botanically it is identified as *Citrus maxima* Merr., (C. *grandis* Osbeck; C. *decumana* L.). The common name is derived from the Dutch *pompelmoes,* which is rendered *pompelmus* or *pampelmus* in German, *pamplemousse* in French. An alternate vernacular name, shaddock, now little used, was acquired on its entry into the Western Hemisphere as related below. The current Malayan names are *limau abong, limau betawi, limau bali, limau besar, limau bol, limau jambua, Bali lemon,* and pomelo.

Description

The pummelo tree may be 16 to 50 ft (5-15 m) tall, with a somewhat crooked trunk 4 to 12 in (10-30 cm) thick, and low, irregular branches. Some forms are distinctly dwarfed. The young branchlets are angular and often densely hairy, and there are usually spines on the branchlets, old limbs and trunk. Technically compound but appearing simple, having one leaflet, the leaves are alternate, ovate, ovate-oblong, or elliptic, 2 to 8 in (5-20 cm) long, 3/4 to 4 3/4 in (2-12 cm) wide, leathery, dull-green, glossy above, dull and minutely hairy beneath; the petiole broadly winged to

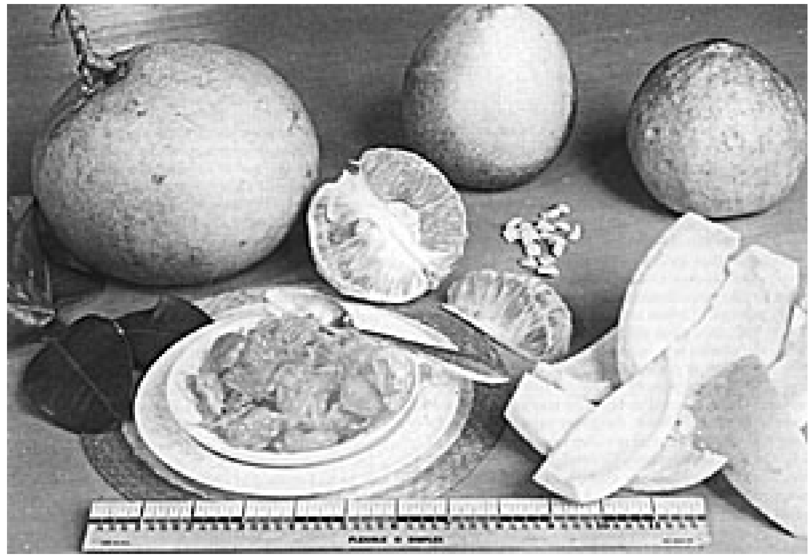


Fig. 38: Pummelos (Citrus maxima) vary in form, size, color and flavor of pulp.

occasionally nearly wingless. The flowers are fragrant, borne singly or in clusters of 2 to 10 in the leaf axils, or sometimes 10 to 15 in terminal racemes 4 to 12 in (10-30 cm) long; rachis and calyx hairy; the 4 to 5 petals, yellowish-white, 3/5 to 1 1/3 in (1.5-3.5 cm) long, somewhat hairy on the outside and dotted with yellow-green glands; stamens white, prominent, in bundles of 4 to 5, anthers orange. The fruit ranges from nearly round to oblate or pear-shaped; 4 to 12 in (10-30 cm) wide; the peel, clinging or more or less easily removed, may be greenish-yellow or pale-yellow, minutely hairy, dotted with tiny green glands; 1/2 to 3/4 in (1.25-2 cm) thick, the albedo soft, white or pink; pulp varies from greenish-yellow or pale-yellow to pink or red; is divided into 11 to 18 segments, very juicy to fairly dry; the segments are easily skinned and the sacs may adhere to each other or be loosely joined; the flavor varies from mildly sweet and bland to subacid or rather acid, sometimes with a faint touch of bitterness. Generally, there are only a few, large, yellowish-white seeds, white inside; though some fruits may be quite seedy. A pummelo cross-pollinated by another pummelo is apt to have numerous seeds; if cross-pollinated by sweet orange or mandarin orange, the progeny will not be seedy.

Origin and Distribution

The pummelo is native to southeastern Asia and all of Malaysia; grows wild on river banks in the Fiji and Friendly Islands. It may have been introduced into China around 100 B.C. It is much cultivated in southern China (Kwang-tung, Kwangsi and Fukien Provinces) and especially in southern Thailand on the banks to the Tha Chine River; also in Taiwan and southernmost Japan, southern India, Malaya, Indonesia, New Guinea and Tahiti. The first seeds are believed to have been brought to the New World late in the 17th Century by a Captain Shaddock who stopped at Barbados on his way to England. By 1696, the fruit was being cultivated in Barbados and Jamaica. Dr. David Fairchild was enthusiastic about the first pummelo he tasted, aboard ship between Batavia and Singapore in 1899. In 1902, the United States Department of Agriculture obtained several plants from Thailand (S.P.I. Nos. 9017, 9018, 9019). Only one (No. 9017) survived and was planted in the agricultural greenhouse in Washington, and budwood from it was sent to Florida, California, Puerto Rico, Cuba (the Isle of Pines), and Trinidad. When the trees fruited, the flavor and general quality were inferior and aroused no enthusiasm. Other introductions were attempted in 1911 but all the plants died in transit. In 1913, a horticulturist of the Philippine Bureau of Agriculture was given the assignment of collecting the best types of pummelos in Thailand. He shipped to San Francisco one tree of a 'Bangkok' type that had been introduced into the Philippines in 1912; it was planted in the greenhouse of the Plant Introduction Garden at Chico. When it fruited several years later, the fruit was of such poor quality that it was considered useless. However, budwood was sent to Riverside and grafted onto two grapefruit trees growing on sour orange rootstock. One of the trees died but the other bore high-quality fruits which were much admired. Budwood was sent to different locations in Florida. In 1919, two trees of a superior pummelo (possibly 'Hao Phuang') from Thailand, which had been doing well in the Philippines, were shipped to the United States Quarantine Station in Bethesda, Maryland, and one of these survived. In addition, seeds from Thailand and from fruits in Chinese markets had been sent to Washington and seedlings were growing in greenhouses.

Dr. Fairchild was eager to introduce the red-fleshed type he had enjoyed in 1899. In 1926, he collected budwood at a hotel in Bandoeng and sent it, together with seeds, to the United States Department of Agriculture but they did not survive the trip. However, seeds of a cultivar in Kediri with flesh nearly as red as his ideal pummelo did reach the Citrus Quarantine Station in Bethesda, Maryland (as S.P.I. No. 67641), and the seedlings were grown there successfully.

In all the succeeding years, the pummelo has never attained significant status in this hemisphere. Generally, it is casually grown as a curiosity in private gardens in Florida and the Caribbean area, and mainly for experimental and breeding purposes at the United States Department of Agriculture's research stations in Orlando and Leesburg, Florida, and at Indio, California, and Mayaguez, Puerto Rico, and at the University of California's Citrus Experiment Station, Riverside. There are small commercial plantings in southern Mexico furnishing fruits for local markets. At least one fruit-grower in Lady-lake, Florida, raises pummelos on a small commercial scale. He ships the fruits to New York's Chinatown for $3 each for Chinese New Year festivities. They must be 5 in (12.5 cm) or more in diameter.

Varieties

Professor G. Weidman Groff, in his *Culture and Varieties of Siamese Pummelos*, lists 20 named Thai cultivars, giving the date and identification number of their introduction into the United States. He describes nine. Dr. J.J. Ochse, in *Fruits and Fruitculture in the Dutch East Indies,* described 8 types commonly grown in Batavia. All have red or pink pulp; most have a more or less acid flavor, or a sweetish flavor with an astringent aftertaste. None seems to be of outstanding quality. Reuther, Webber and Batchelor, in *Citrus Industry,* Volume I, 2nd ed., describe 14 cultivars, including the best-known in Thailand, Japan, Indonesia and Tahiti and hybrids created in California. The following 22, from these and other sources, are briefly presented in alphabetical order:

'Banpeiyu' (believed to be the same as 'Pai Yau' of Taiwan)–originated in Malaya, introduced into Taiwan in 1920 and from there into Japan; nearly round, very large; peel pale-yellow, smooth, thick, tightly clinging; pulp pale-yellow, in 15-18 segments with thin but tough walls; firm but tender, juicy, of excellent, sweet-acid flavor; medium-late in season; keeps well for several months. Tree large, vigorous, with hairy new growth; leaves hairy beneath. Widely grown in the Orient; the leading cultivar of Japan where it attains high quality only in the warmest locations.

'Chandler'–a hybrid of 'Siamese Sweet' (white) and 'Siamese Pink' (acid) developed at Indio, California and released in 1961; oblate to globose; of medium size; peel smooth, at times minutely hairy, medium-thick; core small; pulp pink, fine-grained, tender, fairly juicy; segment walls thin; flavor superior to that of either parent; subacid, about 12% sugar. Seedy. Early in season; of good keeping quality.

'Daang Ai Chaa' ('Red Bantam')–grown in Thailand; round, faintly furrowed at base and apex;

peel very smooth with conspicuous oil glands; the albedo sometimes tinted with pink; pulp rich-red; the segment walls thick; pulp sacs separate easily from the walls and each other; juicy; of mild flavor, neither sweet nor acid. Tree is more or less dwarfed, with low-lying branches. Non-commercial.

'Double' (incorrectly called 'Banda Navel'; known locally as 'Lemon Banda', 'Lemon Bonting', 'Lemon pompelmoes')–grown in the Banda and Ambon Islands, the Moluccas, Batavia and Java; first reported by Rumphius in 1741; sought out and found by O.A. Reinking in 1926. He supplied budwood of various types to the Departments of Agriculture in Java, Manila, and Washington, D.C. Fruit is round, oblate or faintly pear-shaped; 6 to 8 in (15-20 cm) wide; peel smooth, up to 1 in (2.5 cm) thick; shows no evidence of deformity but, inside, there is a second, rindless fruit the size of a small orange embedded in the apex. The main fruit has 19 segments, the lesser fruit 4; pulp may be red, pink-and-white, or white; is sweet and juicy; mostly seedless, rarely with one or a few more seeds. Occasionally, under adverse conditions, there are many seeds. Fruits are borne in clusters of 5 or 6; not all on a tree will be double. Tree may be low and spreading, to 15 ft (4.5 m) or upright and 18 to 30 ft (5.5-9 in) high.

'Hirado' ('Hirado Buntan')–a chance seedling found in Nagasaki Prefecture, Japan; named and introduced into cultivation around 1910; oblate; large; peel bright-yellow, smooth, glossy, medium-thick, clings tightly; pulp pale greenish-yellow, in numerous segments with thin, tough walls; tender, medium-juicy; of good, subacid flavor, faintly bitter. Medium-early in season; of good keeping quality. Tree of fairly large size, vigorous, unusually cold-tolerant. Occupies second place as a commercial cultivar in Japan.

'Hom Bai Toey' ('Scented Toey Leaf')–grown in Thailand; nearly round, slightly depressed at apex; large, 5 1/8 in (13 cm) wide; peel yellow, smooth, nearly 5/8 in (1.5 cm) thick; pulp of peculiar aroma, white, non-juicy; of slightly bitter flavor. Non-commercial.

'Kao Lang Sat' (White Lang Sat')–grown in Thailand; oval-pyriform without neck, faintly furrowed at both ends; 4 in (10 cm) wide; peel slightly rough, less than 3/8 in (1 cm) thick; pulp has peculiar aroma; pale pinkish, resembling that of the Langsat (q.v.); divided into 11 or 12 segments; sacs very dry and loosely packed; very sweet without a trace of acid; of inferior quality. Non-commercial.

'Kao Pan' ('Kao Panne', 'Khao Paen', 'White flat')–grown mainly in Nakhon Chaisri district, south of Bangkok, Thailand, for about 160 years; subglobose, flattened at base and apex; 4 1/2 in (11.5 cm) wide; peel light lemon-yellow, smooth, 3/8 to 3/4 in (1-2 cm) thick, tightly clinging; shrinks in storage; core is large and stringy; pulp is divided into 12-15 segments difficult to separate; walls are thick and tough, inedible; they are skinned off and the individual pulp sacs separate readily from each other and are eaten by the handful, like those of the pomegranate (q.v.). They are very juicy, of sweet, faintly acid flavor with hardly a hint of bitterness. Seeds under-developed and inconspicuous in June as grown locally; may be fully developed and numerous in November or when planted elsewhere. Considered the most delicious of Thai pummelos. Almost ever-bearing. Tree is round-topped and spreading, nearly thornless, very productive, but not vigorous and is subject to insects and diseases, especially prone to citrus canker. Non-commercial in Thailand. Air layers were sent to the United States Department of Agriculture's Date Garden, Indio, California, in 1929 and grown as 'Siamese Pink'. All produced seedy fruits. Trees in the United States

Department of Agriculture's Foundation Farm near Leesburg, Florida, bear fruits of excellent flavor.

'Kao Phuang' ('Khao Phoang'; 'White tassel')–grown in Thailand; Groff records P.J. Wester's description of a cultivar that he named 'Siam', the budwood of which was taken by H.H. Boyle from a tree in the garden of Prince Yugelar in Bangkok, and grafted onto calamondin rootstock at the Lamao experiment station, Philippines, in 1913. The trees fruited in 1916. Reinking and Groff later determined that the Prince's tree was the 'Kao Phuang'. Fruit is elongated-pear-shaped with neck; 5 in (12.5 cm) wide or more; peel greenish to yellow, smooth, glossy, 1/2 to 3/4 in (1.25-2 cm) thick, not clinging; pulp in 11-13 segments which separate readily; walls medium thick and tough, ordinarily not eaten; pulp sacs easy to separate, very juicy; flavor excellent, somewhat acid, turning nearly sweet when fully ripe, non-bitter; seeds, few; virtually none in fruits of the third season. This is the leading and perhaps the only commercial cultivar of Thailand; in great demand; considerable quantities are exported to Hong Kong, Singapore and Malaysia. Tree is of upright habit with more thorns than 'Kao Pan'; vigorous, ever bearing, high-yielding. Thai growers maintain that this cultivar never attains the same quality when grown in other locations that it does in the Bang Bakok district. However, fruit produced at Indio, California, is of excellent quality.

'Kao Ruan Tia' ('White Dwarf')–grown in Thailand; bell-shaped; larger than 'Kao Phuang'; peel pale-yellow; pulp in as many as 16 segments; of excellent flavor; seeds numerous. Later in season than 'Kao Phuang'; non-commercial.

'Kao Yai' ('White Large')–native to the area east of the Chao Phraya River south of Bangkok; globose, symmetrical; very large, 5 1/2 in (14 cm) or more in diameter; peel light-yellow outside, slightly pinkish inside, exudes a little gum when cut, 1/2 to 3/4 in (1.25-2 cm) thick; pulp in 13 segments; sacs irregularly arranged, clinging tightly together; juicier and sweeter than 'Kao Phuang' but they become tough and indigestible if fruit is left too long on tree; seeds numerous and fully developed. Tree is upright, with a rounded top, large leaves, wavy-edged, with strongly winged petiole. Non-commercial.

'Khun Nok' ('Eagle'; 'Bang Khun Non'; 'Khun Hon Village')–closely allied to 'Kao Pan'; well suited to northern Thailand; fruit subglobose, much like 'Kao Pan'; 5 3/5 in (14.5 cm) wide; pulp of fine flavor and quality; seeds fully developed and numerous. Fruit stores and ships very well.

'Mato' ('Mato Butan'; 'Amoy')–Originated in China and introduced into Taiwan around 1700; obovoid to pear-shaped; peel pale-yellow; rough because of prominent oil glands, medium-thick, closely adhering to pulp; pulp white; segment walls thin, tough; sacs non-juicy, rather dry; flavor sweet. Early in season. The leading cultivar in Punan, China, and Taiwan; one of the three main cultivars in Japan.

'Nakhon' (mispelled 'Nakorn')–a seedling of 'Kao Pan' (PI 52388), introduced from Thailand in 1930 and grown by United States Department of Agriculture at Orlando, Florida, and at Foundation Farm at Leesburg; broad pear-shaped; small, 4 in (10 cm) wide; peel lemon-yellow; pulp white, of fine flavor. Midseason; remains in good condition for a long time on the tree.

'Pandan Bener'–grown in Java; oblate; peel smooth with small oil glands, thick but brittle; pulp dark-red; segment membranes thin but adherent; juice sacs solidly packed, less juicy than 'Pandan Wangi'; sweetish but somewhat astringent. Tree bears a moderate crop. Fruit is rarely attacked by the borer.

'Pandan Wangi'–grown in Java; oblate to round; peel rough because of large oil glands, fairly thick; pulp red, coarse-grained; segment walls thin, bitter, difficult to remove from the juice sacs which are fibrous, slightly juicy, but sweet. Tree vigorous, productive, pest-and disease-resistant but the fruits are heavily attacked by citrus rind borer.

'Reinking'–a selected seedling from a cross of 'Kao Phuang' and the 'Shamouti' orange made at Indio, California, but still a typical pummelo.

'Seeloompang'–grown in Java; pronouncedly oblate, flattened at both ends; peel green even when fully ripe, smooth, thin, brittle; pulp red; segment membranes non-adherent; juice sacs densely compacted, very juicy, acid-sweet and somewhat astringent. Very early in season.

'Siamese Sweet'–introduced by the United States Department of Agriculture in 1930 (CES 2240) and grown at the Citrus Research Center, Riverside, California; oblate to broad ovoid; pulp white, with large, crisp, non-juicy sacs easily separating from each other; mild-flavored but faintly bitter. Tree is a dwarf with drooping branches and hairy new growth.

'Tahitian' ('Moanalua'; often called 'Tahitian grapefruit')–grown from seed thought to have been taken from Borneo to Tahiti; later introduced into Hawaii; a typical pummelo but with a thin peel and amber-colored, very juicy pulp. The flavor and quality are excellent and it is locally popular.

'Thong Dee' (Khao Thongdi'; 'Golden')–grown in Thailand; oblate; large, 6 in (15 cm) wide; peel pinkish inside, 3/8 in (1 cm) thick; pulp white with light-brown streaks; pulp sacs large, separating easily from the segment walls; juicy; flavor good but inferior to that of 'Kao Pan'; seedy. Not outstanding as a shipper. Non-commercial. Tree vigorous and produces good quality fruits under unfavorable conditions. A seedling at the United States Department of Agriculture's research station in Orlando, Florida, bears fruits with pink flesh and of good quality despite having a number of seeds. In William Cooper's garden at Winter Park, a tree of this cultivar produces some seedless fruits but most are seedy. Trees at the Foundation Farm near Leesburg bear fruits of excellent flavor.

'Tresca'–a seedling from a tree in the Bahamas grew in the grove of Captain Fred Tresca in Manatee County, Florida. Discovered and propagated in 1887 by Reasoner's Nurseries, Oneco. Fruit is oblate to round, obovoid, or pear-shaped; of medium size, 4 in (10 cm) wide; peel light-yellow, smooth, thick; albedo cream-colored to white; pulp pale-orange, or pink, in 12 to 14 segments; of good flavor; very juicy; many, medium-sized seeds. Late in season. Tree of medium size; new growth hairy; very sensitive to cold. Has been grown commercially in Florida and marketed as a grapefruit. Flesh shows very little color in California.

Climate

The pummelo is tropical or near-tropical and flourishes naturally at low altitudes close to the sea. It has never performed well in New Zealand because of insufficient heat. In the prime growing region of Bang Bakok in southern Thailand, the mean temperature is 82.4º F (28º C) and mean annual rainfall is 56 in (143 cm), being heaviest from May through October and scant in January, February and March, and November and December.

Soil

It is obvious from its coastal habitat that the pummelo revels in the rich silt and sand overlying the organically enriched clay loam of the flood plain, and that it is highly tolerant of brackish water pushed inland by high tides. On the salty mud flats, farmers dig ditches and create elevated beds of soil for planting pummelo trees. They claim that salt contributes to the flavor and juiciness of the fruits. The salt content of the water varies throughout the year but may be as high as 2.11 % at times. In southern Florida and the Bahamas, the trees grow and fruit modestly on oolitic limestone. In Malaya, the tree grows well on the tailings of tin mines.

Propagation

Though the seeds of the pummelo are monoembryonic, seedlings usually differ little from their parents and therefore most pummelos in the Orient are grown from seed. The seeds can be stored for 80 days at 41º F(5º C) and 56-58% relative humidity. Only the best varieties are vegetatively propagated-traditionally by air-layering but more modernly by budding onto rootstocks of pummelo, 'King' or 'Cleopatra' mandarin, rough lemon, or Rangpur lime. In experimental work in the United States, the "T", or shield-budding, method has been found most satisfactory.

Culture

Pummelo, growers in Thailand and elsewhere in southeastern Asia are primarily Chinese who dike the swampy land, dig the ditches and canals for drainage and as routes of transportation, and build the raised beds. In the 3- to 5 -year period before the beds are ready for the pummelo trees, quick crops such as bananas, sugarcane and peanuts are grown on them. Water gates at intervals along the base of the dikes, allow water to flow through hollow coconut trunks and into the ditches in the dry season. Continual deepening and widening of ditches and adding of soil to the beds is necessary to counteract erosion. Coconut and betel nut palms are planted for shade for the young citrus trees but are removed at the end of 3-5 years, or sometimes not until the pummelos are 10 to 15 years old. Rice may be grown in the ditches. The pummelo trees are spaced 10 to 15 ft (3-4.5 m) apart. Some growers interplant the colurrinar tree, *Erythrina fusca* Lour., to shade the mature pummelos, and to help retain the soil with its extensive, fibrous root system, and enrich the soil with its falling leaves. Weeds are removed. by hoeing. Night soil, of course, is the standard fertilizer in the Orient and is used on pummelos but, more commonly, paddy ash (the ash of burned rice hulls) is placed in piles under each tree to gradually seep down to the roots. The air-layered trees have a low, spreading habit and must eventually be pruned.

An analysis of production methods by farmers whose main source of income is marketing pummelos was made by agriculturists at the University of Malaya in 1974. It was concluded that labor input was excessive; fertilizer (all organic on mature trees), was under-utilized on young trees; chemicals were over-utilized on young trees and under-utilized on older trees which the farmers are inclined to neglect because most of them suffer from *Phytophthora* root rot. Pummelo trees may need nutritional sprays to correct zinc, manganese or boron deficiencies.

Harvesting and Keeping Quality

Pummelos may flower 2 to 4 times a year. In the Old World, there are usually 4 harvesting seasons. The main crop matures in November but it is said that fruits that ripen at other seasons have fewer seeds and superior quality. In Florida, the fruits ripen from November to February and there may be a small crop in the spring. In Thailand, fruits for marketing are generally picked when just beginning to turn yellow, heaped in large piles for sale. If not disposed of immediately, they are stored in dry, ventilated sheds shaded by trees. The fruits keep for long periods and ship well because of the thick peel. After 3 months, the peel will be deeply wrinkled but the pulp will be juicier and of more appealing flavor than in the fresh fruit. If stored too long, they may become bitter. Paper-wrapped fruits in ventilated crates have kept in good condition for 6 to 8 months during sea transport to Europe. According to an old Chinese Atlas, the fruits of the 'Double' pummelo, if hung in the house, will remain in good condition for a year.

Pests and Diseases

Among the leading insect pests of pummelo in the Orient are a leaf miner, *Phyllocnistis citrella;* a flea beetle which attacks the leaves; a stinging red ant *(Pheidologeton* sp.) that damages roots, twigs, leaves and trunk, sometimes girdling and killing the tree. Scale insects *(Chrysomphalus aonidum* and C. *aurantii, Coccus hesperidum, Lepidosaphes gloverii, Parlatoria brasiliensis* and *P. zizyphus, Pseudaonidia trilobitiformis,* and *Saissetia sp.)* are prevalent but are partly controlled by natural enemies –a black ant *(Dolochonderus sp.)* and a parasitic fungus, *Aschersonia aleyrodis.* The weaver ant, *Oecophylla smaragdina,* tends scale insects for their honeydew. Fruit growers in China and Southeast Asia put out chicken entrails to encourage the weaver ant to construct its long, hanging nests on citrus trees because it controls the tree borers *(Pentatomidae)* and other pests. Though beneficial, it is a nuisance at harvest time because it inflicts painful stings. The "eggs" (pupae) are commonly eaten.

In Indonesia, the fruits of one cultivar, 'Bali Merah', which has a thin rind, are so heavily attacked by the citrus rind borer and other insects that they are commonly wrapped in old banana leaves, paper or cloth when young.

Sooty mold, develops on the honeydew excreted by the scale insects. The pummelo is subject to most of the diseases that affect the orange (q.v.). But Dr. Walter Swingle, on his trip to Japan, China and the Philippines, found some varieties very resistant to canker. Most of the older trees in Malaya, as already mentioned, succumb to *Phytophthora* root rot.

Mistletoe *(Loranthus* sp.) is a great pest on pummelo trees in Asia.

Food Uses

Though there is some labor involved, it is worth the effort to peel good pummelos, skin the segments, and eat the juicy pulp. The skinned segments can be broken apart and used in salads and desserts or made into preserves. The extracted juice is an excellent beverage. The peel can be candied.

Food Value Per 100 g of Edible Portion*	
Calories	25-58
Moisture	84.82-94.1 g
Protein	0.5-0.74 g
Fat	0.2-0.56 g
Carbohydrates	6.3-12.4 g

Fiber	0.3-0.82 g
Ash	0.5-0.86 g
Calcium	21-30 mg
Phosphorus	20-27 mg
Iron	0.3-0.5 mg
Vitamin A	20 I.U.
Thiamine	0.04-0.07 mg
Riboflavin	0.02 mg
Niacin	0.3 mg
Ascorbic Acid	30-43 mg

*Analyses made in China and the United States.

Toxicity

Like that of other citrus fruits, the peel of the pummelo contains skin irritants, mainly limonene and terpene, also citral, aldehydes, geraniol, cadinene and linalool, which may cause dermatitis in individuals having excessive contact with the oil of the outer peel. Harvesters, workers in processing factories, and housewives may develop chronic conditions on the fingers and hands.

Other Uses

The flowers are highly aromatic and gathered in North Vietnam for making perfume. The wood is heavy, hard, tough, fine-grained and suitable for making tool handles.

Medicinal Uses: In the Philippines and Southeast Asia, decoctions of the leaves, flowers, and rind are given for their sedative effect in cases of epilepsy, chorea and convulsive coughing. The hot leaf decoction is applied on swellings and ulcers. The fruit juice is taken as a febrifuge. The seeds are employed against coughs, dyspepsia and lumbago. Gum that exudes from declining trees is collected and taken as a cough remedy in Brazil.

Morton, J. 1987. Grapefruit. p. 152–158. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Grapefruit

Citrus paradisi

A relative newcomer to the citrus clan, the grapefruit was originally believed to be a spontaneous sport of the pummelo (q.v.). James MacFayden, in his *Flora of Jamaica,* in 1837, separated the grapefruit from the pummelo, giving it the botanical name, *Citrus paradisi* Macf. About 1948, citrus specialists began to suggest that the grapefruit was not a sport of the pummelo but an accidental hybrid between the pummelo and the orange. The botanical name has been altered to reflect this view, and it is now generally accepted as *Citrus X paradisi.*

When this new fruit was adopted into cultivation and the name grapefruit came into general circulation, American horticulturists viewed that title as so inappropriate that they endeavored to have it dropped in favor of "pomelo". However, it was difficult to avoid confusion with the pummelo, and the name grapefruit prevailed, and is in international use except in Spanish-speaking areas where the fruit is called *toronja.* In 1962, Florida Citrus Mutual proposed changing the name to something more appealing to consumers in order to stimulate greater sales. There were so many protests from the public against a name change that the idea was abandoned.

Description

Plate XVIII: NAVEL GRAPEFRUIT, *Citrus × paradisi*

The grapefruit tree reaches 15 to 20 ft (4.5-6 m) or even 45 ft (13.7 m) with age, has a rounded top of spreading branches; the trunk may exceed 6 in (15 cm) in diameter; that of a very old tree actually attained nearly 8 ft (2.4 m) in circumference. The twigs normally bear short, supple thorns. The evergreen leaves are ovate, 3 to 6 in (7.5-15 cm) long, and 1 3/4 to 3 in (4.5-7.5 cm) wide; dark-green above, lighter beneath, with minute, rounded teeth on the margins, and dotted with tiny oil glands; the petiole has broad, oblanceolate or obovate wings. The white, 4-petalled flowers, are 1 3/4 to 2 in (4.5-5 cm) across and borne singly or in clusters in the leaf axils. The fruit is nearly round or oblate to slightly pear-shaped, 4 to 6 in (10-15 cm) wide with smooth, finely dotted peel, up to 3/8 in (1 cm) thick, pale-lemon, sometimes blushed with pink, and aromatic outwardly; white, spongy and bitter inside. The center may be solid or semi-hollow. The pale-yellow, nearly whitish, or pink, or even deep-red pulp is in 11 to 14 segments with thin, membranous, somewhat bitter walls; very juicy, acid to sweet-acid in flavor when fully ripe. While some fruits are seedless or nearly so, there may be up to 90 white, elliptical, pointed seeds about 1/2 in (1.25 cm) in length. Unlike those of the pummelo, grapefruit seeds are usually polyembryonic. The number of fruits in a cluster varies greatly; a dozen is unusual but there have been as many as 20.

Origin and Distribution

The grapefruit was first described in 1750 by Griffith Hughes who called it the "forbidden fruit" of Barbados. In 1789, Patrick Browne reported it as growing in most parts of Jamaica and he referred to it as "forbidden fruit" or "smaller shaddock". In 1814, John Lunan, in *Hortus Jamaicensis*, mentions the "grapefruit" as a variety of the shaddock, but not as large; and, again, as "forbidden fruit", "a variety of the shaddock, but the fruit is much smaller, having a thin, tough, smooth, pale yellow rind". In 1824, DeTussac mentions the "forbidden fruit or smaller shaddock" of Jamaica as a variety of shaddock the size of an orange and borne in bunches. William C. Cooper, a citrus scientist (USDA, ARS, Orlando, Florida, to 1975), traveled widely observing all kinds of citrus fruits. In his book, *In Search of the Golden Apple*, he tells of the sweet orange and the grapefruit growing wild on several West Indian islands. He cites especially a fruit similar to grapefruit that is called *chadique* growing wild on the mountains of Haiti and marketed in Port-au-Prince. The leaves are like those of the grapefruit. He says that it was from the nearby Bahama Islands in 1823 that Count Odette Phillipe took grapefruit seeds to Safety Harbor near Tampa, Florida. When the seedlings fruited, their seeds were distributed around the neighborhood.

At first, the tree was grown only as a novelty in Florida and the fruit was little utilized. Even in Jamaica, the trees were often cut down. Mrs. Mary McDonald Carter of Eustis, Florida, was quoted in the *Farm and Livestock Record*, Jacksonville, in 1953, as relating that her father, John A. MacDonald, settled in Orange County in 1866. In 1870, he was attracted to a single grapefruit tree with clusters of lemon-colored fruits on the Drawdy property at Blackwater. He bought the entire crop of fruits, planted the seeds and established the first grapefruit nursery. The first grapefruit grove planted from this nursery by a man named Hill was sold in 1875 to George W. Bowen who developed it commercially. In 1881, MacDonald bought the Drawdy crop and once more raised seedlings for his nursery in Eustis. Early settlers began planting the tree and acquired a taste for the fruit. There was already a small demand in the North. New York imported 78,000 fruits from the West Indies in 1874. Florida started sending small shipments to markets in New York and Philadelphia between 1880 and 1885.

In 1898, Dr. David Fairchild was excited to learn of a grove of 2,000 grapefruit trees in the Kendall area south of Miami on the property of the Florida East Coast Railway. In 1904, he was amazed to see one tree in the door-yard of the Kennedy ranch in southern Texas where he thought the climate too cold for it. He was told that the tree had been frozen to the ground but had recovered. He predicted that a citrus industry could not be established in that region of the country. In 1928, he photographed the same tree, which had been killed back several times in the interim, but was again in fruit. By 1910, grapefruit had become an important commercial crop in the Rio Grande Valley and, to a lesser extent, in Arizona and desert valleys of California. By 1940, the United States was exporting close to 11,000,000 cases of grape-fruit juice and nearly one-half million cases of canned sections. Cultivation had reached commercial proportions in Jamaica and Trinidad and spread to Brazil, South America and Israel. In 1945/46, the United States (mainly Florida) produced a record of 2,285,000 tons of grapefruit. In 1967/68, this country accounted for 70% of the world crop despite a great decline in Texas production because of severe weather. Grapefruit was moving forward by leaps and bounds. Israel, in 1967, supplied only 11% of the world crop but, by 1970, her production had increased by 300%. In 1980, Florida exported just under 10 million boxes, making grapefruit this state's most valuable export crop. Japan is the main importer and has, at times, suspended shipments to determine the safety of fungicide residues or because of discovery of larvae of the Caribbean fruit fly. Great care is taken to maintain this important trade. Other countries which had entered the grapefruit industry were Mexico, Argentina, Cyprus, Morocco and some areas of South America which raise grapefruit for local markets. In Central America, the grapefruit is not much favored because of its acidity.

In the late 1960's and early 1970's, Mexico was rapidly expanding its grapefruit plantings, especially in the states of Tamaulipas and Veracruz, to save its citrus industry in view of the decline in market value of oranges and tangerines brought on by over-production. Furthermore, there were great advantages in the lower costs of producing grapefruit without irrigation and with good biological control of pests. Now Mexico exports large quantities of grapefruit to the United States and lesser amounts to Canada and Japan. Puerto Rico formerly exported grapefruit to the United States but is no longer able to compete in the trade and has only remnants of former plantations. Cuba has planted 370,000 acres (150,000 ha) of citrus, mostly grapefruit with expectations of exporting to the Soviet Union and eastern European countries. The grapefruit is grown only in a small way in the Orient where the pummelo is cultivated. In recent years, the grapefruit has become established in India in hot regions where the sweet orange and the mandarin are prone to sunburn.

Varieties

Named varieties of grapefruit appeared in the official list of the American Pomological Society in 1897, but pioneers had selected and named favorite clones for several years before that time. The following are among the most noteworthy of old and new cultivars:

'Duncan'–the original trees were virtually identical seedlings that grew in a grove owned by a man named Snedicor near Safety Harbor, Florida. Propagation was first undertaken by A. L. Duncan of Dunedin in 1892. The fruit is round or slightly obovate; large, 3 1/2 to 5 in (9-12.5 cm) wide; peel is very light yellow (usually called "white"), with large oil glands, medium-thick, highly aromatic; pulp is buff, in 12-14 segments with medium-tender membranous walls, very juicy, of fine flavor; seeds medium-large, 30-50. Early to mid-season. Tree is unusually cold-hardy. This was the leading cultivar for many years in Florida and Texas and was introduced into all the grapefruit-growing areas of the world. Today, in the United States, it has largely given way to cultivars with fewer seeds, but it is being grown commercially in India. Recent seed irradiation experiments have shown that a high percentage of seedless mutants results from exposure to 20-25 krad.

'Foster' ('Foster Pink Flesh')–Originated as a branch sport of a selection called 'Walters' in the Atwood Grove near Ellenton, Florida, discovered by M.B. Foster of Manatee in 1906, and propagated for sale by the Royal Palm Nurseries. Fruit is oblate to round; medium-large, averaging 3 3/4 in (9.5 cm) in width; peel light-yellow blushed with pink, smooth but with large, conspicuous oil glands; albedo pink; pulp light-buff, pinkish near the center; in 13 or 14 segments with pinkish walls, tender, juicy, of good quality despite seeds, up to 50 or even more, of medium size. Medium-early in season. Not very popular; grown to a limited extent in Florida, Texas, Arizona and India. In Texas, it is more colorful, the pulp being entirely pinkish in hue.

'Marsh' ('Marsh Seedless')–one of 3 seedling trees on the property of a Mrs. Rushing near Lakeland, Florida, purchased by William Hancock in 1862. Because the fruits of this tree were seedless, C.M. Marsh took budwood from it for nursery propagation and he bought young trees previously budded by others. He sold the budded offspring and, in time, the 'Marsh' was planted more than any other cultivar. The original tree was killed by cold in the winter of 1895-96. The fruit is oblate to round, medium in size, 3 1/2 to 4 3/4 in (9-12 cm) wide; peel is light-yellow, very smooth, with medium-size oil glands, mildly aromatic; pulp is buff, in 12-14 segments with tender membranes, melting, extremely juicy and rich in flavor; seeds absent or 3-8, medium-sized. Medium to late in season and holds well on the tree. Keeps well after harvest. The leading grapefruit cultivar; grown in Florida, California, Texas, Arizona, South America, Australia, South Africa, Israel and India. A local selection, presumably of a seedling 'Marsh', in Surinam is known there as 'Hooghart'. The two are almost indistinguishable.

'Oroblanco'–a triploid from a grapefruit X pummelo cross made in 1958 by geneticists R.K. Soost and J.W. Cameron of the University of California, Riverside. Patent obtained in 1981 and assigned to the University of California Board of Regents. Fruit form and size similar to 'Marsh'; peel paler and thicker; pulp paler and has larger hollow in center; sections easily skinned; tender, juicy, non-bitter; has faintly astringent after-taste before full maturity or in cooler climates; seedless. Season early: December to April at Riverside; early November through February at Landcove. Tree is vigorous, large, hardy, can tolerate temperatures down to 30º F (-1.11º C); yields medium to heavy crops and may tend to alternate bearing. Seems better adapted to California's inland citrus locations than to desert sites. Has been grown experimentally on trifoliate orange, 'Troyer' citrange, citremon 1449, Brazilian sour orange, grapefruit, sweet orange, rough lemon and 'Red' rough lemon rootstocks. The two latter have adversely affected internal quality

'Paradise Navel'–a selection from the 100-year-old Nicholson citrus grove near Winter Garden, Florida; propagated and patented by W.H. Nicholson, improved and released for distribution in 1976. Fruit is oblate, smaller than a typical grapefruit. Originally very seedy, but, by budding onto various rootstocks and transferring from one rootstock to another over a period of years, there eventually emerged one tree bearing fruit without seeds. Budwood from this tree has produced uniformity of seedlessness regardless of rootstock. The fruits have been sold to local customers but no scions nor trees were sold prior to 1976.

'Redblush' (including 'Ruby', 'Ruby Red', 'Shary Red', 'Curry Red', 'Fawcett Red', 'Red Radiance', and 'Webb' [Webb's Redblush Seedless'])**–**originated as sports–lower branches–growing out of 'Thompson' trees which a Texas nursery had purchased from Glen St. Mary Nursery and sold to growers in the Rio Grande Valley, and which were frozen back in 1929. All are seedless and otherwise similar to 'Thompson' but display redder color. 'Redblush' grapefruits have been extensively planted in Florida in the past few decades though the juice is not suitable for canning as it tends to turn brown with age. By 1950, 75% of Florida's grapefruit crop was of the pink or red seedless type. Under the name, 'Ruby Red', a member of this group is a standard commercial cultivar in Texas. In 1958, budwood of 'Redblush' from California was acquired by the Regional Fruit Research Station at Abohar, India, was propagated on rough lemon, and the resulting trees performed so well and showed such disease resistance that the cultivar was recommended for growing under irrigation in the and regions of the Punjab and Haryana, where it averages 250 fruits annually per tree. Probably includable in this group is 'Burgundy'. Its peel is not blushed but the pulp is intense red throughout the season. 'Ray Ruby' and the similar if not identical 'Henderson' are branch sports propagated in Texas and introduced into Florida in the 1970's. The peel is redder than that of 'Ruby Red' and the pulp is red though not as intense as 'Star Ruby' throughout the season. Recently, budwood of 'Ray Ruby' has become available from the Florida Department of Agriculture's Bureau of Citrus Budwood Registration in Winter Haven. 'Ray Ruby' is expected to perform better than 'Star Ruby' on standard rootstocks.

'Star Ruby'–a lower branch mutation bearing red-blushed fruits, noticed on a 'Foster' tree at San Benito, Texas, in the mid 1930's. The tree had been frozen back nearly to the bud union the previous year. Budwood from the branch was propagated by C. E. Hudson as the 'Hudson Red' but, because of its coarse texture and high number of seeds (40-60), it was not adopted commercially. Seeds were irradiated at the Texas A & I Citrus Center, Weslaco, in 1959. The seedling from one of these treated seeds was named the 'Star Ruby' and introduced into cultivation in 1971 by Richard Hensz of Texas A & I University. Several thousand trees were planted in Texas. At least 65,000 budded trees were brought into Florida in 1971 by commercial interests without proper qualifications and permits under the Division of Plant Industry. Investigation revealed a susceptibility to *Phytophthora* root rot and ringspot virus in Texas. The Florida State Agricultural Commissioner ordered the destruction of all unauthorized imported trees. About 25,000 were voluntarily destroyed by owners but the ruling was contested and the trees were placed under quarantine. Subsequently, ringspot virus was found on one of the imported trees which had already been used as a source of budwood. Infected trees from this source were found in a nursery and were destroyed together with all neighboring healthy trees. By April 1977, certified, disease-free budwood of 'Star Ruby' was made available and nearly 200,000 "budeyes" were released to growers. They were urged to make only limited plantings until more was known of this cultivar's fruiting habits. The tree tends to become more chlorotic than 'Ruby Red' when sunburned or affected by poor drainage, or high applications of herbicides and pesticides, and it is sensitive to adverse weather conditions.

'Star Ruby' has a yellow peel distinctly red-blushed and in tensely red pulp and juice, 3 times more colorful than 'Ruby Red'. Though the color decreases with maturity, it is maintained throughout the season. The pulp is smooth and firmer than that of 'Ruby Red' and has a bit more sugar and acid. Furthermore, there may be no seeds or no more than nine. Some of the juice color is dissipated by heat in the pasteurization process but there is still enough for the product to be blended with white or pink grapefruit juice to provide more consumer appeal.

'Sweetie'–a grapefruit × pummelo hybrid released in 1984 by the Citrus Marketing Board in Israel, has all the features of a typical grapefruit but the flavor is sweet.

'Thompson' (Pink Marsh')**–**In 1913, one branch of a 'Marsh' tree owned by W. R. Thompson, Oneco, Florida, bore pink-fleshed, seedless fruits. Propagation of budwood from the branch was undertaken by the Royal Palm Nurseries in 1924. A similar bud variation of the 'Marsh' had appeared around 1920 at Riverside, California. The fruit is oblate to round, of medium size, 2 3/4 to 3 3/4 in (7-9.5 cm) wide; peel is light-yellow, smooth, with small, inconspicuous oil glands, faintly aromatic; pulp is light- to deep-buff more or less flushed with pink, sometimes throughout, occasionally just near the center. There are 12 to 14 segments with abundant, colorless juice, and few seeds**–**usually 3 to 5. The color of the pulp is most intense in January and February. By late March and April it has faded to nearly amber.

'Triumph' (possibly the same as 'Royal' and 'Isle of Pines')**–**a seedling on the grounds of the Orange Grove Hotel in Tampa, Florida, propagated in 1884. The fruit is oblate to ellipsoid, slightly flattened at both ends; of medium size; peel light-yellow, very smooth, with oil glands of medium size; medium-thick; pulp pale, tender, juicy, only faintly bitter, the flavor having a touch of orange; the center is semi-hollow; of superior quality; 35-50 seeds. Medium-early in season, beginning in November. Grown only in dooryards in Florida, but has been widely distributed in citrus regions; does better than 'Marsh' in South Africa.

A grapefruit-like, triploid hybrid named 'Melogold' was developed by crossing a sweet pummelo with a seedy, white, tetraploid grapefruit in 1958. The fruit is larger than 'Marsh' grapefruit and its pummelo-like flavor is considered superior though it may have a trace of bitterness at the beginning and end of the season which extends from early November or December through February. 'Melogold' is grafted onto rough lemon and 'Troyer' citrange rootstocks and is recommended for interior California, not in hot desert nor in humid coastal situations. Patent rights are held by the University of California and budwood is released only to licensed nurserymen.

Climate

The grapefruit prospers in a warm subtropical climate. Temperature differences affect the length of time from flowering to fruit maturity. At Riverside, California the period is 13 months; at warmer Brawley in the Imperial Valley of southern California, only 7 to 8 months. The fruit is lower in acidity in the Indian River region and areas of southern Florida, the lower Rio Grande Valley of Texas, and in the tropics than in cooler situations.

Humidity contributes to thinness of peel, while in arid climates the peel is thicker and rougher and, as might be expected, the juice content is lower. Low winter temperatures also result in thicker peel the following year and even affect the fruit shape.

Ideal rainfall for grapefruit is 36 to 44 in (91.4-111.7 cm) rather evenly distributed the year around.

Soil

The grapefruit is grown on a range of soil types. In the main growing area of Florida, the soil is mildly acid sand and applications of lime may be beneficial. On the east coast there are coquina shell deposits and, in the extreme southern part of the peninsula, there is little soil mixed with the prevailing oolitic limestone. Where the grapefruit is grown in California, Arizona and Texas, the soils are largely alkaline and frequent irrigation causes undesirable alkaline salts to rise to the surface. In Surinam, grapefruit is grown on clay. Successful grapefruit culture depends mainly on the choice of rootstock best adapted to each type of soil.

Salinity of the soil and in irrigation water retards water uptake by the root system and reduces yields.

Propagation

In the early years of grapefruit-growing, the customary citrus rootstocks were utilized: sour orange on heavy hammock and flatwoods soils, rough lemon on sand, though trees grafted on this stock were short-lived. In the early 1950's, sweet orange was being preferred over sour orange. In 1946, the United States Department of Agriculture, Texas A & M University, and Rio Farms, Inc., of Monte Alto, Texas, launched a cooperative program of testing grapefruit on different rootstocks. Of 13 different rootstocks utilized, 'Swingle citrumelo', 'Morton' and 'Troyer' citranges gave the best yield of large fruits. Rough lemon and 'Christian' trifoliate orange reduced acidity. 'Swingle citrumelo' was never used extensively as a rootstock until 1974 when it was released to nurserymen and growers because of its tolerance of exocortis, xyloporosis, and tristeza and resistance to foot-rot and citrus nematode, and low uptake of salts, together with its ability to support heavy crops. It is now in third place after 'Troyer' citrange and sour orange.

In the past, 'Marsh' and 'Hooghart', the commercial grapefruits of Surinam, have been grown there on sour orange rootstock, but fear of tristeza inspired a rootstock testing program. Among the stocks tried, 'King' and 'Sunki' resulted in high yield and excellent quality in contrast to rough lemon and Rangpur lime. The two latter also showed susceptibility to *Phytophthora* root rot. 'Cleopatra' lowered the yield, and trifoliate orange proved unsatisfactory in such a humid climate. In the Lower Rio Grande Valley of Texas, grapefruit trees on 'Swingle citrumelo' have grown very poorly on heavy clay as compared to those on sour orange.

Culture

In general, culture of grapefruit is similar to that of the orange, q.v., except that wider spacing is necessary.

Nutritional experiments with grapefruit have shown that excessive nitrogen results in malformed fruit, coarser texture and less juice. Lack of certain minor elements is evident in symptoms often mistaken for disease. The condition called exanthema is caused by copper deficiency; mottle leaf results from zinc deficiency.

Harvesting and Handling

In Florida, all commercial cultivars reach legal maturity in September or October if sprayed after blooming with lead arsenate to reduce acidity. Even after legal maturity the grapefruit can be "stored" on the tree for months, merely increasing in size, and extending the marketing season. The fruits can be harvested until near the end of May when they begin to fall and seeds start sprouting in the fruit. The only adverse effect of late harvesting is a corresponding reduction in the following year's crop. It has been found that spot-picking of the largest fruits partially counteracts this effect of late harvest. Fruit drop can be retarded by spraying with a combination of gibberellic acid and 2,4-D. Either of these agents or both together will reduce the germination of seeds. Germination may be inhibited for periods up to 11 weeks by cool storage at 50º F (10º C).

Grapefruits were formerly harvested by climbing the trees or using picking hooks which frequently damaged the fruit. Today, the fruits on low branches are picked by hand from the ground; higher fruits are usually harvested by workers on ladders who snap the stems or clip the fruits as required. California began utilizing a modified olive limb-shaker for harvesting grapefruit in 1972. The machines work in pairs to harvest opposite sides of each tree and the trees must be pruned to remove deadwood and to give access to 3-5 main limbs for shaking. Lower branches must be lopped off to leave a clear 2 1/2 ft (75 cm) space for the catching frame. Mechanical harvesting causes some superficial injury. A team of 3 workers with one machine can harvest 150 to 188 field boxes–50 lbs (22.7 kg) when filled–per hour, as compared with 45 boxes per hour for 3 manual pickers. Stems are removed from the fruits before packing to avoid stem-damage.

Early in the season, when the fruits are mature but not fully colored, they are often degreened by exposure to ethylene gas. The grapefruit is remarkable for its durability, but modern practices of applying fungicide to the harvested fruit are given credit for the great reduction in marketing losses. The cull rate in New York wholesale warehouses in 1983 was found to be 1.4% (mostly fungal), as compared with 13 % estimated in 1960. Retail losses in 1983 were 3.5%, and only a small proportion were the result of physical injury.

Keeping Quality

The grapefruit keeps well at 65º F (18.33º C) or higher for a week or more and for 2 or 3 weeks in the fruit/vegetable compartment of the home refrigerator. The first sign of breakdown is dehydration and collapse of the stem-end. To retard moisture loss, fruits for marketing are washed and waxed as soon as possible after harvest. When kept in prolonged storage, the grapefruit is subject to chilling injury (peel pitting) at temperatures below 50º F (10º C). The degree of injury depends on several factors: the fruits on the outside of the tree are more susceptible than the fruits that have been sheltered by foliage. The use of preharvest growth regulators tends to reduce susceptibility, as does 100% relative humidity during storage. Preconditioning at 60.8º F (16º C) for 7 days before storing at 33.8º F (1º C) prevents injury. Lowering the temperature gradually after preconditioning is also beneficial, as is sealing the fruit in polyethylene shrink-film before refrigerating.

The banning of ethylene dibromide fumigation except for export has made it necessary to resort to cold treatment as an alternative measure against fruit fly infestation for shipment to Texas, Arizona and California. The United States Department of Agriculture now requires that imported citrus fruits be kept at 32º F (0º C) for 10 days or at 36º F (2.2º C) for 16 days after the fruit has been cooled down to the specified temperature. In Israel, investigators have found that waxing with a coating containing fungicide, and holding the packed fruit for 6 days at 62.6º F (17º C) before the cold treatment, gives good protection from chilling injury and decay in storage. Cold treatment costs 5 times as much as fumigation with ethylene dibromide. Methyl bromide has been tested and proposed as an effective fumigant,

Pests and Diseases

The grapefruit is subject to most of the same pests that attack the orange, including Caribbean and Mediterranean fruit flies. In addition to the cold treatment referred to above, irradiation has been studied as a method of disinfection, but has not been authorized for citrus fruit treatment. Exposure of early-season fruit to 60 and 90 krad causes scald and rind breakdown after 28 days of storage, and mainly pitting in midseason and late fruits. Minimal injury results from exposure to 7.5, 15, and 30 krad.

The following diseases have been reported for the grapefruit tree and its fruit by the Florida Division of Plant Industry: leaf spot (*A1ternaria citri, Mycosphaerella horii, Phyllosticta hesperidearum);* algal leaf spot *(Cephaleuros virescens);* greasy spot *(Cercospora citri-grisea);* tar spot *(C. gigantea);* anthracnose *(Colletotrichum gloeosporioides);* thread blight *(Corticium koleroga* and C. *stevensii);* gummosis *(Diaporthe citri);* dieback *(Diplodia natalensis);* heart rot *(Fomes applanatus, Ganoderma sessilis,* and *Xylaria polymorpha);* charcoal root rot *(Macrophomina phaseolina);* root rot *(Fusarium oxysporum);* sooty blotch *(Gloeodes pomigena);* flyspeck *(Leptothyrium pomi);* mushroom root rot *(Clitocybe tabescens);* foot rot *(Phytophthora megasperma, P. palmivora,* and *P. parasitica);* damping-off *(Rhizoctonia solani);* seedling blight *(Sclerotium rolfsii);* felt fungus, *(Septobasidium pseudopedi- cellatum);* branch knot *(Sphaeropsis tumefaciens);* leaves may be attacked by *Chaetothyricum hawaiiense,* and twigs by *Physalospora fusca*. Brown rot of fruit is caused by *Phytophthora citrophthora* and *P. terrestris;* stem-end rot, *Botryosphaeria ribis;* dry rot of fruit *(Nematospora coryli);* green mold *(Penicillium digitatum);* blue mold, (*P. italicum);* pink mold (*P. roseum);* scab *(Elsinoe fawcetti).*

The tree is highly susceptible to citrus canker and several viruses: crinkly leaf virus, psorosis, tristeza, xyloporosis, and infectious variegation. Mesophyll collapse is caused by extreme drought and dehydrating wind.

Food Uses

As a relatively new food, the grapefruit has made great advances in the past 75 years. In 1970, consumption of grapefruit was temporarily heightened by a widely promoted "grapefruit diet" plan claimed to achieve a loss of 10 lbs (4.5 kg) in 10 days and continuous gradual loss until the achievement of normal body weight. In 1983, the United States Department of Agriculture Marketing Service reported that, among fresh fruits and vegetables consumed in Metropolitan New York, grapefruit was exceeded only by potatoes, lettuce, oranges and apples.

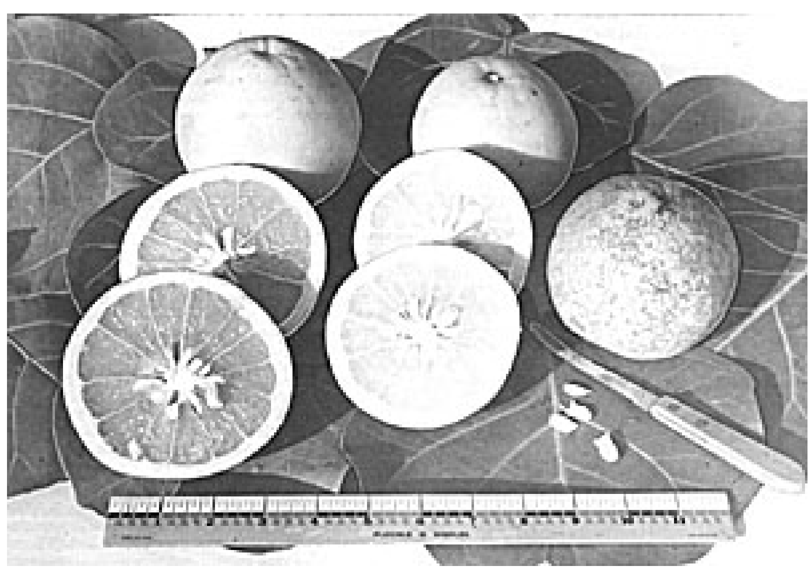


Fig. 39: Grapefruit *(Citrus paradisi):* pink (left); yellow (center); and russet (right). In: K. & J. Morton, *Fifty Tropical Fruits of Nassau*, 1946.

Grapefruit is customarily a breakfast fruit, chilled, cut in half, the sections loosened from the peel and each other by a special curved knife, and the pulp spooned from the "half-shell". Some consumers sweeten it with white or brown sugar, or a bit of honey. Some add cinnamon, nutmeg or cloves. As an appetizer before dinner, grapefruit halves may be similarly sweetened, lightly broiled, and served hot, often topped with a maraschino cherry. The sections are commonly used in fruit cups or fruit salads, in gelatins or puddings and tarts. They are commercially canned in sirup. In Australia, grapefruit is commercially processed as marmalade. It may also be made into jelly.

The juice is marketed as a beverage fresh, canned, or dehydrated as powder, or concentrated and frozen. It can be made into an excellent vinegar or carefully fermented as wine.

Grapefruit peel is candied and is an important source of pectin for the preservation of other fruits. The peel oil, expressed or distilled, is commonly employed in soft-drink flavoring, after the removal of 50% of the monoterpenes. The main ingredient in the outer peel oil is nookatone. Extracted nookatone, added to grapefruit juice powder, enhances the flavor of the reconstituted juice. Naringin, extracted from the inner peel (albedo), is used as a bitter in "tonic" beverages, bitter chocolate, ice cream and ices. It is chemically converted into a sweetener about 1,500 times sweeter than sugar. After the extraction of naringin, the albedo can be reprocessed to recover pectin.

Grapefruit seed oil is dark and exceedingly bitter but, bleached and refined, it is pale-yellow, bland, much like olive oil in flavor, and can be used similarly. Because it is an unsaturated fat, its production has greatly increased since 1960.

Food Value Per 100 g of Edible Portion*			
	Pulp (raw)	*Juice (raw)*	*Peel (candied)***
Calories	34.4-46.4	37-42	316
Moisture	87.5-91.3 g	89.2-90.4 g	17.4 g
Protein	0.5-1.0 g	0.4-0.5 g	0.4 g
Fat	0.06-0.20 g	0.1 g	0.3 g
Carbohydrates	8.07-11.5 g	8.8-10.2 g	80.6 g
Fiber	0.14-0.77 g	trace	2.3 g
Ash	0.29-0.52 g	0.2-0.3 g	1.3 g
Calcium	9.2-32.0 mg	9.0 mg	
Phosphorus	15-47.9 mg	15.0 mg	
Iron	0.24-0.70 mg	0.2 mg	
Sodium	1.0 mg	1.0 mg	
Potassium	135 mg	162 mg	
Vitamin A			
(white)	10 I.U.	10. I.U.	
(pink/red)	440 I.U.	440 I.U.	

Thiamine	0.04-0.057 mg	0.04 mg
Riboflavin	0.01-0.02 mg	0.02 mg
Niacin	0.157-0.29 mg	0.2 mg
Ascorbic Acid	36-49.8 mg	36-40 mg
Tryptophan	2 mg	
Methionine	0-1 mg	
Lysine	12-14 mg	

*According to analyses made in California, Texas, Florida, Cuba and Central America.

***Peel Oil:* 90% limonene; the volatile fraction (2-3%) consists mainly of oxygen compounds and sesquiterpenes; the waxy fraction (7-8%) consists of C_8 and C10 aldehydes, plus geraniol, cadinene and small amounts of citral and dimethyl arthranilate, plus acid. Also present are 9 coumarins and 0.88% 22-dihydrostigmasterol. The dried pulp and seeds contain β-sitosteryl-D-glucoside and β-sitosterol.

The glycoside 7 β-neohesperidosyl-4-(β-D-glucopyranosyl) naringenin occurs in the pulp segments. Feruloylputrescine is found in the juice and leaves. Mature grapefruit leaves contain the flavonoid, apigenin 7 β-rutinoside. Young leaves contain the 7 β-neohesperidoside and 7 β-rutinoside of naringenin.

Other Uses

Factory waste: The waste from grapefruit packing plants has long been converted into molasses for cattle.

Seed hulls: After oil extraction, the hulls can be used for soil conditioning, or, combined with the dried pulp, as cattlefeed. A detoxification process must precede the feeding of this product to pigs or poultry.

Wood: Old grapefruit trees can be salvaged for their wood. The sapwood is pale-yellow or nearly white, the heartwood yellow to brownish, hard, fine-grained, and useful for domestic purposes. Mainly, pruned branches and felled trees are cut up for firewood.

Medicinal Uses: An essence prepared from the flowers is taken to overcome insomnia, also as a stomachic, and cardiac tonic. The pulp is considered an effective aid in the treatment of urinary disorders. Leaf extractions have shown antibiotic activity.

Morton, J. 1987. Tangelo. p. 158–160. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Tangelo

Citrus paradisi × Citrus reticulata

Tangelos; are deliberate or accidental hybrids of any mandarin orange and the grapefruit or pummelo. The first known crosses were made by Dr. Walter T. Swingle at Eustis, Florida, in 1897, and Dr. Herbert J. Webber at Riverside, California, in 1898. They are so unlike other citrus fruits that they have been set aside in a class by themselves designated *Citrus X tangelo* J. Ingram & H. E. Moore (C. X *paradisi X C. reticulata).*

Tangelos range from the size of a standard sweet orange to the size of a grapefruit, but are usually somewhat necked at the base. The peel is fairly loose and easily removed. The pulp is often colorful, subacid, of fine flavor and very juicy. The trees are large, more cold-tolerant than the grapefruit but not quite as hardy as the mandarin. Nucellar embryos are not uncommon in these hybrids and most of the cultivars are self-sterile, so a majority come true from seed. Tangelos are not commonly grown in California but are produced commercially and in home gardens in Florida. They are much more satisfactory on limestone in southern Florida than the sweet orange and are prized for their quality.

Among the better-known tangelo cultivars are:

'K–Early' ('Sunrise Tangelo')–a hybrid propagated by growers. It is an early-maturing cultivar of such poor quality that it gave tangelos a bad reputation. The Official Rules Affecting the Florida Citrus Industry require that it be sold only as 'K-Early Citrus Fruit'.

'Minneola'–a hybrid of 'Bowen' grapefruit and 'Dancy' tangerine; oblate, faintly necked; medium-large, 3 1/4 in (8.25 cm) wide, 3 in (7.5 cm) high; peel deep red-orange, thin, firm, not loose; pulp orange, with 10-12 segments, melting, sweet-acid; of fine flavor; 7-12 small seeds, green inside. Late in season. Ships well. If crop is left too long on tree, the next crop will be light. Bears better if honeybees are provided and if 'Temple' tangor is interplanted as a pollenizer, but the 'Temple' is not as cold-hardy as the 'Minneola', and the trees tend to crowd each other. The 'Minneola' needs fertile soil, irrigation and adequate nutrition. Effects to increase production of seedless fruits include spraying the blooms with gibberellic acid, or girdling during full bloom. The former reduces fruit size and the latter may induce virus outbreaks causing scaling and flaking of the bark.

Plate XIX: TANGELO, *Citrus* × *tangelo*

'Nova'–a 'Clementine' tangerine and 'Orlando' tangelo cross made by Dr. Jack Bellows in 1942, first fruited in 1950, and released by the United States Department of Agriculture's Horticultural Field Station, Orlando, Florida, in 1964. Fruit is oblate to rounded, of medium size, 2 3/4-3 in (7-7.5 cm) wide, 2 1/2-2 3/4 in (6.25-7 cm) high; peel is orange to scarlet, thin, slightly rough, leathery, easy to remove; pulp dark-orange, with about 11 segments, of good, sweet flavor; seeds numerous if cross-pollinated; polyembryonic, green inside. Early in season (mid-September to mid-December). Does very well on 'Cleopatra' rootstock. The tree resembles that of the 'Clementine' tangerine, its twigs are thornless, and it is more cold-hardy than 'Orlando'. This cultivar is self-infertile and trials have shown that 'Temple' tangor is a good pollenizer.

'Orlando' (formerly Take')–result of 'Bowen' grapefruit pollinated with 'Dancy' tangerine, by Dr. Swingle in 1911. The fruit is oblate to rounded, of medium size, 3 in (7.5 cm) wide, 2 3/4 in (7 cm) high; peel deep-orange, slightly rough, not loose; pulp deep-orange, with 12 to 14 segments, melting, very juicy, sweet; seeds 10-12. Early in season but after 'Nova'. A good commercial fruit in Florida. Needs cross-pollination by 'Temple' tangor, or by 'Dancy' or 'Fairchild' tangerines. The presence of honeybees, even without interplanting with a pollinator tree, has greatly increased yields. 'Cleopatra' mandarin is often used as a rootstock on sandy soils, but higher yields have been obtained on sweet lime and rough lemon in Florida. In Texas, 'Orlando' is most productive on 'Swingle citrumelo', 'Morton citrange', 'Rangpur lime' and 'Cleopatra' mandarin. Fruit quality is best on 'Morton citrange', sour orange, 'Sun Cha Sha Kat', 'Keraji' and 'Kinokune' mandarins.

'Seminole'–a hybrid of 'Bowen' grapefruit and 'Dancy' tangerine; oblate, not necked; medium-large, 3 1/4 in (8.25 cm) wide, 2 3/4 in (7 cm) high; peel deep red-orange, thin, firm, almost tight but not hard to remove; pulp deep-orange with 11-13 segments, little rag, melting, of fine, subacid flavor; seeds small, 20-25, green inside. Early in season but holds well through March. Tree vigorous and high-yielding, scab-resistant; leaves with faint or no wings, tangerine-scented.

'Thornton'–a tangerine-grapefruit hybrid created by Dr. Swingle in 1899; oblate to obovate, a little rough and lumpy, puffy with age; medium-large, 3 1/4 -3 3/4 in (8.25-9.5 cm) wide, 2 7/8-3 1/4 in (7.25-8.25 cm) high; peel, light-orange, medium-thick, almost loose, easily removed; pulp pale- to deep-orange, with 10-12 segments, soft, melting, juicy, of rich subacid to sweet flavor; seeds slender, 10-25, green inside. Matures from December to March. Tree vigorous and high-yielding, large-leaved, well adapted to hot, dry regions of California. Fruit is a poor shipper.

Fig. 40: The 'Ugli' tangelo of Jamaica is believed to be a chance hybrid between a Mandarin orange and a grapefruit.

'Ugli'–believed to be a chance hybrid between a mandarin orange and grapefruit. The discoverer, G. G. R. Sharp, owner of Trout Hall Estate, Jamaica, reported that it was found growing in a pasture around 1917. He took budwood and grafted onto sour orange, and kept on regrafting the progeny with the fewest seeds. Sharp was exporting to England and Canada in 1934 and to markets in New York City in 1942. The fruit is obovoid, compressed to nearly oblate, necked at the base, puffy; large, 4 1/4 to 6 in (10.8-15 cm) wide, 3 1/4-4 1/2 in (8.25-11.5 cm) high; peel is light-yellow with light-green areas at apex, leathery, loose, medium-thin; albedo is thick; pulp light-orange, or apricot, divided into 12 segments with tough membranes, easily skinned; tender, melting, very juicy; of fine flavor, superior to grapefruit, only faintly bitter; seedless or with 3 or a few more medium-sized seeds, white inside. In Jamaica, matures in December and January.

In January 1942, Kendal Morton purchased fruits on the New York market, sent 2 to Dr. H. Harold Hume of the University of Florida, and 4 to Dr. H J. Webber of the University of California, Riverside. Dr. Webber was able to examine them only at the Quarantine Station but he wrote up the description for the first edition of the book, *The Citrus Industry,* by Batchelor and Webber. He planted the seeds and reported that, of 13 seedlings, 6 had strongly mandarin-scented leaves, 3 had weak-mandarin scent, and 4 had leaf-scent reminiscent of grapefruit or sweet orange leaves. Dr. Webber passed on in 1943 before he could carry out his plans to bud 2 trees from each seedling. Dr. W. P. Betters, Associate Horticulturist, reported that in 1947 the 4 seedlings still in the nursery were bearing fruit, mostly in May-June; the fruits averaged 6 in (15 cm) in diameter, the peel was orange-yellow with a slight tendency to regreen in the spring, the albedo was very thick and fibrous, the flavor of the orange, juicy pulp was good but with a grapefruit tang, and there was, on the average, one seed in each segment. These trees were destroyed in 1951 because they were in the path of campus development, but budwood was taken for propagation and the new trees were beginning to bear in 1954. The 'Ugli' was considered a good fruit for home dooryards in California and was being tried as a rootstock for lemon. The 'Ugli' is little known in Florida. James McClure of Lake Placid has a few trees that bear in February. There are small groves of 'Ugli' in South Africa. In New Zealand a similar fruit has been grown since 1861 as "Poor-man's orange", or "Poorman grapefruit".

'Alamoen'–a fruit rather like the 'Ugli' commonly grown from seeds in Surinam. J.B. Rorer, a Plant Pathologist in Trinidad, saw it in Surinam, considered it better-flavored than the grapefruit, and sent 3 specimens to Dr. David Fairchild in 1914. Under the introduction number 37804, seeds were planted at the United States Department of Agriculture's Garden at Chico, California. Fruits borne by the seedlings had very thick peel and very little juice. Two of the trees were sent to Dr. Fairchild and he planted them at his home, The Kampong, in Coconut Grove, Miami. They began fruiting in 1931 and the fruits were not equal in quality to those he had received from Surinam, which were much lighter in weight because of large, hollow centers. In 1944, he sent fruits to Dr. Webber who detected several points of similarity to the 'Ugli' but found the latter easier to peel and superior in quality and flavor.

Morton, J. 1987. Orangelo. p. 160. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Orangelo

orange × grapefruit

Several sweet orange X grapefruit crosses were made by citrus breeders in California in early years and were given the name "orangelo", a combination of orange and pomelo, the original name for the grapefruit. None of the hybrids was sufficiently productive to be of horticultural value. However, the group name is the only one on record to which such hybrids can be referred. The only promising one being currently exploited is the following:

Chironja'–This seemingly spontaneous hybrid was noticed by Carlos G. Moscoso, Fruit Specialist in Horticulture, Agricultural Extension Service, of the University of Puerto Rico, when he was interviewing citrus growers in the interior, mountainous, coffee zone of that island in November 1956. He saw a tree with large, bright-yellow fruits in contrast to the normal sweet orange and grapefruit trees grown by farmers as shade for their coffee plantations. He learned that there were several other trees of the same type on other farms in the neighborhood, some of them quite a few years old and all raised from seed and showing only slight variations in form and size, and greater variation in season of fruiting.

He described the fruit as round to pear-shaped, necked, equal to grapefruit in size; peel a brilliant yellow, slightly adherent, easy to remove; the inner peel non-bitter; pulp yellow orange, with 9-13 segments having tender walls and much juice; the mild flavor reminiscent of both orange and grapefruit, hardly acid or bitter even when immature. The seed count ranges from 7 to 15, with an average of 11, and some fruits have as few as 2. The fruit is borne singly or in clusters. The tree, reaching 22 ft (6.7 m), has leaves that smell like and resemble those of the grapefruit except that they are usually deformed. Young shoots may have prominent thorns. Flowering and fruiting may occur throughout the year, though most trees flower mainly in late spring and early summer.

By 1969, horticulturists in Puerto Rico had evaluated 500 seedlings in a test planting and selected 12 clones, 3 being considered superior. It was observed that 7-year-old trees may produce 300 to 500 fruits over a period of one year, while a 7-year-old grapefruit tree in Puerto Rico may produce about 70.

In rootstock trials, grapefruit rootstock gave best results at the Adjuntas Agricultural Experiment Substation and sour orange at the Isabela Substation. On grapefruit root-stock, the 'Chironja' is larger than ordinary but not as sweet. A planting of seedlings was made at the Corozal Substation with simultaneous planting of grafted trees for comparison. So much variation was seen in the seedlings it was concluded that the 'Chironja' must be vegetatively propagated for uniform results. Ten clones selected from the Corozal planting were grafted onto sour orange and set out at the 3

Substations. The trees reached heavy production at 6 years of age. Yield was highest at Isabela Substation and 'Clone 2-4' had the best yield, the thinnest peel and the most seeds. 'Clone 2-3' had 11 seeds and 'Clone 3-6' had 14.

Storage tests revealed that fruit in polyethylene bags at 44.5º F (7º C) and relative humidity of 90%, maintained acceptable quality for 70 days. But fruits harvested 5 months after fruit-set and stored for periods of 30 to 55 days were of the best quality. Fruits harvested 7 months after fruit-set retained high quality for only 25 days.

The 'Chironja's' productivity makes it popular with Puerto Rican growers and it is in demand on Puerto Rican markets, mainly because it is more colorful than the grapefruit, sweeter, and easy to peel.

The fruit is cut in half and eaten with a spoon as a grapefruit is eaten, or is peeled and the sections eaten individually, or they are squeezed for juice. The sections can be canned in sirup with added citric acid to enhance the flavor. The rind can be candied successfully.

Morton, J. 1987. Lemon. p. 160–168. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Lemon

Citrus limon

The leading acid citrus fruit, because of its very appealing color, odor and flavor, the lemon, *Citrus limon* Burm. f. (syns. C. *limonium* Risso, C. *limonia* Osbeck, *C. medica* var. *limonium* Brandis), is known in Italy as *limone;* in most Spanish-speaking areas as *limón, limón agria, limón real,* or *limón francés;* in German as *limonen;* in French as *citrónnier;* in Dutch as *citroen.* In Haiti, it is *limon France;* in Puerto Rico, *limon amarillo.* In the Netherlands Antilles, *lamoentsji,* or *lamunchi,* are locally applied to the lime, not to the lemon as strangers suppose. The lemon is not grown there.

Several lemon-like fruits are domestically or commercially regarded as lemons wherever they are grown and, accordingly, must be discussed under this heading. These include: Rough lemon (C. *jambhiri* Lush.), Sweet lemon *(C. limetta* Risso), 'Meyer' (lemon X mandarin hybrid); 'Perrine' (lime X lemon hybrid); 'Ponderosa' (presumed lemon X citron hybrid), qq.v. under "Varieties".

Description

Plate XX: MEYER LEMON, possibly *Citrus limon* × *C. reticulata*

The true lemon tree reaches 10 to 20 ft (3-6 m) in height and usually has sharp thorns on the twigs. The alternate leaves, reddish when young, become dark-green above, light-green below; are oblong, elliptic or long-ovate, 2 1/2 to 4 1/2 in (6.25-11.25 cm) long, finely toothed, with slender wings on the petioles. The mildly fragrant flowers may be solitary or there may be 2 or more clustered in the leaf axils. Buds are reddish; the opened flowers have 4 or 5 petals 3/4 in (2 cm) long, white on the upper surface (inside), purplish beneath (outside), and 20-40 more or less united stamens with yellow anthers. The fruit is oval with a nipple-like protuberance at the apex; 2 3/4 to 4 3/4 in (7 -12 cm) long; the peel is usually light-yellow though some lemons are variegated with longitudinal stripes of green and yellow or white; it is aromatic, dotted with oil glands; 1/4 to 3/8 in (6-10 mm) thick; pulp is pale-yellow, in 8 to 10 segments, juicy, acid. Some fruits are seedless, most have a few seeds, elliptic or ovate, pointed, smooth, 3/8 in (9.5 mm) long, white inside.

Origin and Distribution

The true home of the lemon is unknown, though some have linked it to northwestern India. It is supposed to have been introduced into southern Italy in 200 A.D. and to have been cultivated in Iraq and Egypt by 700 A.D. It reached Sicily before 1000 and China between 760 and 1297 A.D. Arabs distributed it widely in the Mediterranean region between 1000 and 1150 A.D. It was prized for its medicinal virtues in the palace of the Sultan of Egypt and Syria in the period 1174-1193 A.D. Christopher Columbus carried lemon seeds to Hispaniola in 1493. The Spaniards may have included lemons among the fruits they introduced to St. Augustine. They were grown in California in the years 1751-1768. Lemons were reported to be increasingly planted in northeastern Florida in 1839. Because of heavy imports from Sicily, commercial culture in Florida and California was begun soon after 1870 and grew to the point where 140,000 boxes were being shipped out of Florida alone. The small Florida industry was set back by a freeze in 1886, the susceptibility of the lemon to scab, and the unfavorable climate for curing the fruit, and also competition from California. Following the devastating freeze of 1894-95, commercial lemon culture was abandoned in Florida. Not until 1953 was interest in lemon-growing revived in Central Florida to take advantage of the demand for frozen concentrate and for natural cold-press lemon oil. At that time, Florida was importing lemons from Italy for processing. Plantings grew to 8,700 acres by 1975. Freezes caused 50% reduction by 1980. Still, in 1984, Florida exported $2 million worth of lemons.

In the meantime, Arizona had developed lemon orchards, though on a smaller scale than

California. In the 1956-57 season, California produced 11 million gallons (42 million liters) of frozen lemon concentrate while Florida's output was still very small. California and Arizona became the leading sources of lemons in the western hemisphere. In recent years, California has produced nearly double the crop that can be profitably marketed fresh or processed. Foreign competition has increased and many California growers have destroyed their lemon groves or topworked the trees to oranges, but new cultural techniques making summer production possible may reverse the trend.

Guatemala has in the past 2 decades developed commercial lemon culture, primarily to produce the peel oil for its essential oil industry and secondarily for the purpose of dehydrating the fruit and preparing a powder for reconstituting into juice. Southern Mexico, too, is now a major grower of lemons, also primarily for lemon peel oil. Lemons are rarely grown for the fresh fruit market in Latin America. In South America, Argentina leads in lemon culture with Chile a distant second. Among the world's leading lemon growers and exporters are Italy, Spain, Greece, Turkey, Cyprus, Lebanon, South Africa and Australia. Lemons can be grown only at medium and high elevations in the Philippines.

Varieties

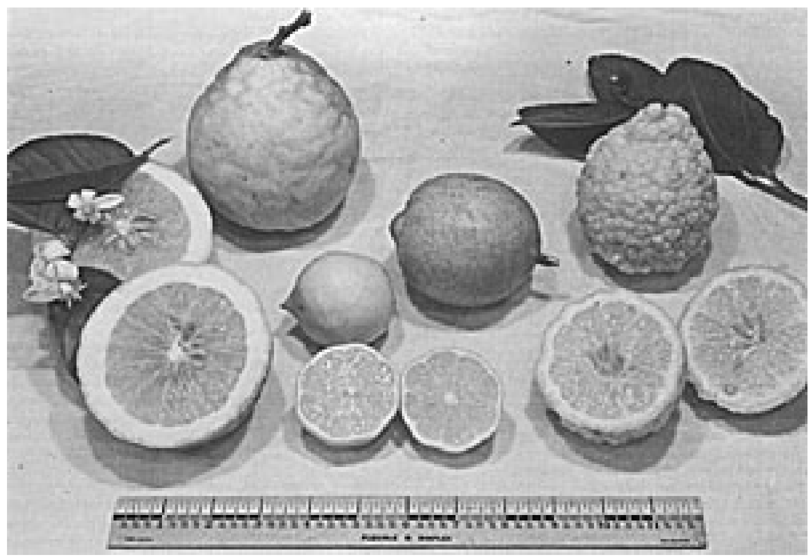


Fig 41: Lemons: 'Ponderosa', perhaps a lemon X citron hybrid (left); 'Lisbon'-type commercial lemons (*Citrus limon)* (center); and rough lemon (C. *jambhiri)* (right).

With the resumption of lemon-growing in Florida, workers at the Citrus Experiment Station, Lake Alfred, began a search for the most suitable cultivars, whether in dooryards, or in the United States Department of Agriculture planting at Orlovista, or the Lake Alfred collection. By late 1950, 200 selections had been brought together from various parts of the United States. Of these, 40 were budded onto 30-year-old grapefruit trees on rough lemon rootstock on the Minute Maid property at Avon Park. Two selections grown elsewhere were included in the studies-evaluation for thorniness, cold-and disease-susceptibility, sizes, juiciness, flavor, number of segments and seeds, yields, and quality of peel oil. The majority of the selections were judged undesirable; only a few showed promise for processing and fresh fruit marketing purposes. For processing, 'Villafranca' rated highest, followed by 'Eustis', 'Bearss', 'Perkin' and 'Avon'. Any of these, properly harvested and cured would be suitable for marketing fresh. Libby, McNeil & Libby, when planning for their lemon orchard at Babson Park, Florida, about 1948, tested varieties from all major lemon-producing areas of the world and chose 'Bearss' as rating highest in quality and quantity of juice, which was their chief concern at the time. In 1960, they added marketing of the fresh fruit and found the 'Bearss' equally desirable for this purpose.

The following are brief descriptions of most of the better known cultivars of true lemons and of lemon-like fruits that are accepted as lemons in home or commercial usage, and a few of the lesser-known.

'Armstrong' ('Armstrong Seedless')–a sport discovered in a private grove at Riverside, California, about 1909. Patented in 1936 by Armstrong Nurseries. Resembles 'Eureka' except that it usually bears seedless or near-seedless fruits. If planted among other lemon trees will occasionally have a few seeds.

'Avon'–first noticed as a budded tree in Arcadia, Florida. A budded tree propagated from the original specimen around 1934 was planted in the Alpine Grove in Avon Park; it produced heavy crops of fruits highly suitable for frozen concentrate. It, therefore, became the source of budwood for commercial propagation by Ward's Nursery beginning in 1940.

'Bearss' ('Sicily', but not the original introduction by Gen. Sanford in 1875, which has disappeared)–a seedling believed to have been planted in 1892, discovered in the Bearss grove near Lutz, Florida, about 1952. Closely resembles 'Lisbon'. It is highly susceptible to scab and greasy spot and oil spotting. The tree is vigorous and tends to produce too many water sprouts. Nevertheless, it has been propagated commercially by Libby, McNeill & Libby since 1953 because the peel is rich in oil. It constitutes 20% of Brazil's lemon/lime crop. ,

'Berna' ('Bernia', 'Vema', 'Vernia')–oval to broad-elliptic, with pronounced nipple, short neck; peel somewhat rough, medium-thick, becoming thinner in summer, tightly clinging. Seeds generally few or absent. Ripens mostly in winter; fruits keep well on tree until summer but become too large. Tree is vigorous, large, prolific. This is the leading cultivar of Spain and important in Algeria and Morocco. It is too much like the 'Lisbon' to be of value in California. In Florida, it has been found deficient in acid, low in juice, and too subject to scab.

'Eureka'–originated from seed taken from an Italian lemon (probably the 'Lunario') and planted in Los Angeles in 1858; selected in 1877 and budwood propagated by Thomas Garey who named it 'Garey's Eureka'. The fruit is elliptic to oblong or rarely obovate, with moderately protruding nipple at apex, a low collar at the base; peel yellow, longitudinally ridged, slightly rough because of sunken oil glands, medium-thick, tightly clinging; pulp greenish-yellow, in about 10 segments, fine-grained, tender, juicy, very acid. Fruits often borne in large terminal clusters unprotected by the foliage. Bears all year but mostly late winter, spring and early summer when the demand for lemons is high. Tree of medium size, almost thornless, early-bearing, prolific; not especially vigorous, cold-sensitive, not insect-resistant; relatively short-lived. Not suitable for Florida. Grown commercially in Israel. One of the 2 leading cultivars of California, though now being superseded by clonal selections with more vigor, e.g., 'Allen', 'Cascade', 'Cook', and 'Ross'. 'Lambert Eureka' is a chance seedling found in 1940 on the property of Horace Lambert in New South Wales. It is vigorous and productive.

'Femminello Ovale'–one of the oldest Italian varieties; short-elliptic with low, blunt nipple; slightly necked or rounded at base; of medium size; peel yellow, finely pitted, medium-smooth, medium-thick, tightly clinging; pulp in about 10 segments, tender, juicy, very acid, of excellent quality, with few, mostly undeveloped, seeds. Fruits all year but mainly in late winter and spring; ships and stores well. The tree is almost thornless, medium-to very-vigorous, but highly susceptible to *mal secco* disease. This is the leading cultivar in Italy, accounting for 3/4 of the total lemon production, and 1/5 of the crop is processed as single-strength juice.

'Genoa'–introduced into California from Genoa, Italy, in 1875. Almost identical to 'Eureka'; ovoid or ovate-oblong with blunt nipple at apex; base rounded or slightly narrowed; of medium size; peel yellow, medium-thick, tightly clinging; pulp in 10-12 segments, melting, medium-juicy, with 29 to 51 seeds which are light-brown within. Tree is shrubby, nearly trunk-less, spreading, very thorny, cold-hardy. Grown commercially in India, Chile and Argentina.

'Harvey'–of unknown parentage; was found by Harvey Smith on the property of George James in Clearwater, Florida. Fruit much like 'Eureka'. Tree highly cold-tolerant, compatible with several rootstocks. Commercially propagated by Glen St. Mary Nurseries Company, near Jacksonville, Florida, since 1943.

'Interdonato' ('Special')–a lemon X citron hybrid that originated on property of a Colonel Interdonato, Sicily, around 1875; oblong, cylindrical, with conical, pointed nipple at apex, short neck or collar at base; large; peel yellow, smooth, glossy, thin, tightly clinging; pulp greenish-yellow, in 8 or 9 segments, crisp, juicy, very acid, faintly bitter. Very few seeds. Earliest in season; mostly fall and early winter. Tree vigorous, usually thornless, medium-resistant to *mal secco*; of medium yield; accounts for 5% of Italy's crop.

'Lisbon' (perhaps the same as 'Portugal' in Morocco and Algeria)–originated in Portugal, possibly as a selection of 'Gallego'; reached Australia in 1824; first catalogued in Massachusetts in 1843; introduced into California about 1849 and catalogued there in 1853; introduced into California from Australia in 1874 and again in 1875. Fruit almost identical to 'Eureka'; elliptical to oblong, prominently nippled at apex, base faintly necked; peel yellow, barely rough, faintly pitted, sometimes slightly ribbed, medium-thick, tightly clinging; pulp pale greenish-yellow, in about 10 segments, fine-grained, tender, juicy, very acid, with few or no seeds. Main crop in February, second crop in May. Fruit is borne inside the canopy, sheltered from extremes of heat and cold. Tree large, vigorous, thorny, prolific, resistant to cold, heat, wind. Not well adapted to Florida. It is low-yielding and short-lived in India. Surpasses 'Eureka' in California. Has given rise to a number of clonal selections, particularly 'Frost', originated by H. B. Frost at the Citrus Research Station, Riverside, California in .1917 and released about 1950; also 'Prior Lisbon' and the more vigorous 'Monroe Lisbon'.

'Meyer'–a hybrid, possibly lemon X mandarin orange; introduced into the United States as S.P.I. #23028, by the agricultural explorer, Frank N. Meyer, who found it growing as an ornamental pot-plant near Peking, China, in 1908; obovate, elliptical or oblong, round at the base, occasionally faintly necked and furrowed or lobed; apex rounded or with short nipple; of medium size, 2 1/4 to 3 in (5.7-7.5 cm) wide and 2 1/2 to 3 1/2 in (6.25-9 cm) high; peel light-orange with numerous small oil glands, 1/8 to 1/4 in (3-6 mm) thick; pulp pale orange-yellow, usually in 10 segments with tender walls, melting, juicy, moderately acid with medium lemon flavor; seeds small, 8 to 12. Tends to be everbearing but fruits mostly from December to April. Tree small, with few thorns, prolific, cold-resistant; produces few water sprouts, and is only moderately subject to greasy spot and oil spotting. It is easily and commonly grown from cuttings. Does well on sweet orange and rough lemon rootstocks; is not grafted onto sour orange because it is a carrier of a virulent strain of tristeza. Grown for home use in California; in Florida, both for home use and to some extent commercially for concentrate though the product must be enhanced by the addition of peel oil from true lemons, since that from 'Meyer' peel is deficient in flavoring properties. Has been fairly extensively planted in Texas and in Queensland, Australia, and New Zealand.

'Monachello' (Moscatello')–suspected of being a lemon X citron hybrid; elliptical, with small nipple and no neck, merely tapered at apex and base; medium-small; peel yellow, smooth except for large, sunken oil glands, thin, clinging very tightly; pulp in 10 segments, tender, not very juicy, not sharply acid. Bears all year but mainly winter and spring. Tree not vigorous, slow-growing, almost thornless, with abundant, large leaves; bears medium-well, resistant to *mal secco*, and has been extensively planted in Italy in areas where the disease is common.

'Nepali Oblong' (Assam', 'Pat Nebu')–originated in Assam; fruit resembles citron in some aspects; long-elliptic to oblong-obovate, with wide, short nipple; medium-large; peel greenish-yellow, smooth, glossy, medium-thick; pulp greenish-yellow in 11 segments, fine-grained, very juicy, of medium acidity, with few or no seeds. Everbearing. Tree large, vigorous, spreading, medium-thorny, prolific; foliage resembles that of the citron. Commercial in India.

'Nepali Round'–of Indian origin; round, without distinct nipple; juicy; seedless. Tree large, vigorous, compact, nearly thornless, medium-prolific. Successfully cultivated in South India.

'Perrine'–a Mexican lime X 'Genoa' lemon hybrid created by Dr. Walter Swingle and colleagues in 1909, but still a fairly typical lemon; it is lemon-shaped, with small nipple at apex, necked at base; of medium size; peel pale lemon-yellow, smooth, slightly ridged, thin, tough; pulp pale greenish-yellow, in 10 to 12 segments having thin walls; tender, very juicy, with slightly lime-like flavor but acidity more like lemon; seeds usually 4 to 6, occasionally as many as 12, long-pointed. Everbearing. Tree cold-sensitive but less so than the lime; resistant to wither tip and scab but prone to gummosis and other bark diseases. In the early 1930's, was extensively planted in southern Florida on rough lemon rootstock, but no longer grown.

'Ponderosa' ('Wonder'; 'American Wonder')–a chance seedling, possibly of lemon/citron parentage, grown by George Bowman, Hagerstown, Maryland around 1886 or 1887; appeared in nursery catalogs in 1900 and 1902; obovate, lumpy and faintly ribbed, slightly necked at base; large, 3 1/2 to 4 1/8 in (9-11 cm) wide, 3 1/2 to 4 3/4 in (9-12 cm) high; peel light orange-yellow, with medium-large oil glands, flush or slightly depressed; 3/8 to 1/2 in (1-1.25 cm) thick; pulp pale-green, in 10 to 13 segments with thick walls; juicy, acid; seeds of medium size, 30 to 40 or more, brown within. Everbearing. Tree small, moderately thorny; buds and flowers white or barely tinged with red-purple. More sensitive to cold than true lemons. Grown for home use and as a curiosity in California and Florida and in small-scale commercial plantings since 1948. Rather widely cultivated as an indoor potted plant in temperate regions.

'Rosenberger'–a clone found in a grove of 'Lisbon' and 'Villafranca' trees at Upland, California; was planted in the Rosenberger orchard and gained recognition as a superior cultivar. Tree closely resembles that of 'Villafranca'. Fruit is somewhat like 'Lisbon' but is shorter and broader and less tapered at base. Tree vigorous and prolific. Became popular in California in the 1960's.

'Rough Lemon' ('Florida Rough'; French'; 'Mazoe'; Jamberi')–perhaps a lemon X citron hybrid, but has been given the botanical name of C. *jambhiri* Lush. Believed to have originated in northern India, where it grows wild; carried in 1498 or later by Portuguese explorers to southeastern Africa where it became naturalized along the Mazoe River; soon taken to Europe, and brought by Spaniards to the New World; is naturalized in the West Indies and Florida; oblate, rounded or oval, base flat to distinctly necked, apex rounded with a more or less sunken nipple; of medium size, averaging 2 3/4 in,(7 cm) wide, 2 1/2 (6.25 cm) high; peel lemon-yellow to orange-yellow, rough and irregular, with large oil glands, often ribbed; 3/16 to 3/8 in (5-10 mm) thick; pulp lemon-yellow, usually in 10 segments, medium-juicy, medium-acid, with moderate lemon odor and flavor; seeds small, 10 to 15, brownish within. Reproduces true from seeds, which are 96% to 100% nucellar. Tree large, very thorny; new growth slightly tinged with red; buds and flowers with red-purple. The scant pulp and juice limit the rough lemon to home use. It is appreciated as a dooryard fruit tree in Hawaii and in other tropical and subtropical areas where better lemons are not available. The tree has been of great importance as a rootstock for the sweet orange, mandarin orange and grapefruit. It is not now used as a rootstock for lemon in Florida because of its susceptibility to "blight" (young tree decline). It is also prone to Alternaria leaf spot (*A1ternaria citri)* in the nursery, to foot rot *(Phytophthora parasitica).* Incidence varies with the clone and certain clones show significant resistance. In trials at Lake Alfred, 3 atypical clones showed immunity to leaf spot, while a typical rough lemon clone, 'Nelspruit 15', from South African seed, proved highly resistant to leaf spot and also extremely cold tolerant.

'Santa Teresa'–an old tree discovered to be disease-free in a 'Fermminello Ovale' orchard in Italy that had been devastated by *mal secco.* Budded trees from the original specimen were being commonly planted in the 1960's wherever the disease was prevalent in Italy.

Sweet Lemon (C. *limetta Risso)–a* general name for certain non-acid lemons or limettas, favored in the Mediterranean region, In India, they are grown in the Nilgiris, Malabar and other areas. The fruits are usually insipid, occasionally subacid or acid. The seeds are white within and the tree is large, resembling that of the orange. One cultivar, called 'Dorshapo' after the plant explorers, Dorsett, Shamel and Popenoe, who introduced it from Brazil in 1914, resembles the 'Eureka' in most respects except for the lack of acidity. Another, called 'Millsweet', apparently was introduced into California from Mexico and planted in a mission garden. It was reproduced at the old University of California Experiment Station at Pomona. Neither is of any commercial value.

'Villafranca'–believed to have originated in Sicily; introduced into Sanford, Florida, from Europe around 1875 and later into California. Closely resembles 'Eureka'; of medium size. Tree is more vigorous, larger, more densely foliaged, and more thorny than 'Eureka' but becomes thornless with age. One strain is everbearing; another fruits heavily in summer. This was the leading lemon cultivar in Florida for many years; is cultivated commercially in Israel; is low-yielding and short-lived in India. It is little grown in California but has given rise to certain selections that are of importance, particularly 'Galligan Lisbon' and 'Corona Foothill Eureka'.

Climate

Because of its more or less continuous state of growth, the lemon is more sensitive to cold than the orange and less able to recover from cold injury. The tree is defoliated at 22º to 24º F (-5.56º-4.44º C). A temperature drop to 20º F (-6.67º C) will severely damage the wood unless there has been a fortnight of near-freezing weather to slow down growth. Flowers and young fruits are killed by 29º F (-1.67º C) and nearly mature fruits are badly damaged below 28º F (-2.22º C). On the other hand, the lemon attains best quality in coastal areas with summers too cool for proper ripening of oranges and grapefruit. Therefore, the lemon has a relatively limited climatic range. In Florida, lemons are produced commercially as far north as Ft. Pierce on the East Coast and Ruskin on the West Coast. The 'Meyer' lemon, as a dooryard tree, can be grown wherever oranges thrive, even as far west as Pensacola.

The fruits are scarred and the tree readily defoliated by winds, and benefit by the protection of windbreaks.

Lemons are grown in both dry and humid atmospheres, the latter being a disadvantage mainly in the processes of curing and storing. Over a large lemon-growing region in California, annual rainfall varies from 25 to 125 cm. In long, dry periods, the lemon must be irrigated.

Fig. 42: Flowers of the lemon (*Citrus limon*) are larger and showier than those of the orange.

Soil

The lemon tree has the reputation of tolerating very infertile, very poor soil. In Florida, groves are mostly on sand. In California, excellent growth is maintained on silty clay loam of high water-holding capacity. In Guatemala, recommended soils are sand, clay and sandy-clay-deep, with high permeability and good drainage. Black soils are also suitable if not lying over calcareous subsoil. Ph should be between 5.5 and 6.5. If acidity is high, it is necessary to apply lime to achieve the optimum level.

Propagation

The rough lemon is widely grown from seed. The 'Meyer' lemon is easily reproduced by rooting large cuttings in the nursery and planting them directly in the grove. They fruit 2 to 3 years sooner than budded trees and have a long life, remaining in full production for over 30 years, perhaps much longer.

In Florida, commercial lemons have been budded onto 'rough lemon', sweet orange, and 'Cleopatra' mandarin rootstocks. More recent practices are the utilization of sour orange, Volkamer lemon (C. *volkameriana),* and alemow (C. *macrophylla* Wester, an old Philippine lemon/ pummelo hybrid). The latter is employed in California on soils containing an excess of soluble salts and boron. If citranges are used as rootstocks for 'Eureka', bud union crease will kill the tree.

Culture

Lemon trees should be spaced 25 ft (7.6 in) apart each way. If crowded or "hedged", production declines. The trees must be pruned when young and kept below 10 or 12 ft (3-3.6 m) in height.

They are cut back severely after 12 years or replaced. Weeds must be controlled but lemon trees are very sensitive to herbicides.

In Florida, fertilizing may be done 3 times a year between mid-November and the end of April, at the gradually increasing rate of 4 to 10 lbs (1.8-4.5 kg) per tree up to an age of 50 years. Nitrogen and potash are given in equal amounts under normal soil conditions. A nutritional spray with copper added is applied after spring bloom. Fertilizer and irrigation programs should be varied according to the desired goal: fresh fruit marketing or processing. High nitrogen steps up yield and peel oil content but also results in more scab infection and poor curing. Potash increases acidity. Heavy irrigation increases yield and peel oil, scab infection, size of fruit and accelerates maturity.

In California, foliar spraying of urea is preferred over ground application of nitrogen which can lead to accumulations of salts and also contamination of groundwater. Leaf analyses are made to determine the nitrogen requirements of each cultivar for maximum yield. 'Eureka', in a 6-year test, showed no response to increased levels of nitrogen. In New Zealand, mature trees (15 to 20 years old) are given 25 to 30 lbs (11.3-13.6 kg) of complete mixed fertilizer annually, also heavy dressings of organic manure or mulch.

In Sicily, growers have, for over 50 years, made a practice of withholding water in summer-for 35 to 60 days-until the trees begin to wilt. Then the trees are heavily irrigated and given high nitrogen fertilizer which induces a second bloom in August or early September, producing a crop the following summer when lemons are scarce and prices are high. This system, called the "Verdelli process", was adopted on a little over 1,000 acres (405 ha) in California in 1983. Adequate bloom did not occur on sandy or shallow soils, but 80% of the plantings on gradually dehydrating, fine-textured soil bloomed well. Nearly $3 million was expected from this extra crop of summer lemons in the Central Valley and the Riverside area in 1984. New horticultural techniques are needed to overcome the handicaps of higher use of fertilizer, increased insect and fungus problems, effects of moisture stress on fruit quality, and low temperature hazard to immature fruits in winter.

In 1965, a team of California horticulturists initiated experimental trellis culture of 'Prior Lisbon' lemon on C. *macrophylla* rootstock. It was found that the labor of training, and repeated pruning either manually or by machine hedging and topping, was excessive and uneconomic.

Guatemalan and Mexican growers interplant short-term crops such as beans, cassava, yautía *(Xanthosoma)*, in the rainy season, and tomatoes and peppers during the winter when the lemon trees will be irrigated and fertilized.

Harvesting and Handling

The marketability of lemons depends on the stage at which they are picked. Italian lemons for export are harvested as early as possible and are naturally "cured" in transit. In early days, California and Florida lemons were allowed to remain on the trees until they became too large. It was realized that early picking is necessary and California and Arizona adopted the practices of picking at any time after the fruits reach a 25 % juice content, and using rings to gauge the commercially acceptable size, and repeated spot-picking with clippers. Mechanical picking is impossible with lemons. The fruits are highly prone to oil spotting (oleocellosis) and cannot be handled roughly nor picked wet.

Formerly, Florida lemons were picked from mid-July to October for shipping fresh, and the balance in November was harvested for processing. Lemons under 2 1/8 in (5.4 cm) are too immature to attain proper quality for marketing and fruits over 2 1/2 in (6.25 cm) are too large. Manual spot-picking has been commonly practiced, but some producers have found it too costly, and are harvesting the entire crop at one time and grading for fresh sale or processing in the packing-house, discarding all undersized fruits. The lemons, after sorting according to color, washing and coating with a fungicide and a thin layer of wax are stored (cured) until ready for shipping.

Yield

Lemon tree yields vary considerably with the cultivar, the location and weather conditions. A yield of 3 boxes per tree is commercially satisfactory in Florida. In India, a 6-year-old tree bore 966 fruits and, at 9 years of age, had produced a total of 3,173 fruits.

Storage

Florida's climate is unfavorable for long-term curing. It has been claimed that a 10-day curing period is adequate and degreening of Florida fruit is not needed. A major producer keeps the newly harvested fruits for 48 hours at 60º F (15.56º C) and 95% humidity, then passes them through a pre-grading procedure to eliminate all that are unusable. The usable fruits are then treated with fungicide against stem-end rot and returned to the curing room. Those harvested early in the season need 3 weeks to color-up, the last may require less than a week. Finally, the fruits are washed, given a second fungicidal treatment, dried, waxed and packed.

Generally, lemons are cured at 56º to 58º F (13.33º-14.4º C)and 85-90% relative humidity. Green fruits may be held for 4 months or more, while the peel becomes yellow and thinner, the pulp juicier (6-80%) and the proportion of soluble solids higher (7-24%). Sometimes the degreening process is hastened by exposing the fruit to ethylene gas, ethephon, or silane, but this practice tends to stimulate decay, mainly through the shedding of the "button" (stem stub), the absence of which allows entry of *Diplodia natalensis, Phomopsis citri,* or *Alternaria* mycelium. Various auxins have been studied to determine which can be applied before storage to prevent button loss without delaying degreening. In 1982, Israeli investigators reported that decay losses from degreening procedures can be greatly reduced (from over 50% to 6.3%) by packaging the fruits in 10 micrometer-thick high-density polyethylene. This treatment makes it possible to store lemons with minimum damage for as long as 6 months.

In the past, New Zealand lemons for storage have been individually wrapped in diphenyl-treated paper after washing and dipping in a 200 ppm solution of 2,4,5-T and then waxing. The fruits were marketable after storing for 4 months at room temperature. Lemons can be kept for weeks in the home refrigerator if placed in a jar with a tight-fitting lid to prevent loss of moisture.

Lemons for export from Florida to Hawaii and Arizona must be fumigated with methyl bromide because of possible infestation by the Caribbean fruit fly. For sale within the state, other methods must be employed.

Pests and Diseases

In Southeast Asia, many species of ants attack the root system and the farmer times the opening of the water gates so as to force the ants to the surface of the beds, where he burns them with fire.

One of the 3 most serious arthropod pests of the lemon and other citrus trees in California is California red scale, *Aonidiella aurantii.* In the southern part of the state it is under biological control but it requires applications of pesticides in the San Joaquin Valley. In Florida, rust mites, purple mites and purple scale may at times be troublesome but they are all controllable with appropriate sprays.

Young lemon trees in California sometimes require protection from wild rabbits.

Diseases are the greater challenges. In Florida, the main lemon diseases are scab *(Elsinoe fawcetti)* on fruit, leaves and twigs; anthracnose of fruit (stylar-end-rot), leaves and twigs caused by both *Colletotrichum gloeosporioides* and *Glomerella cingulata;* greasy spot *(Mycosphaerella citri* or *Cercospora citri-grisea);* and gummosis *(Diaporthe citri).* The latter organism also causes melanose and die-back, and stem-end rot. Stem-end rot may also arise from attack by *Botryosphaeria ribis* and *Diplodia natalensis.*

Other lemon diseases recorded in Florida are branch knot *(Sphaeropsis tumefaciens),* damping-off *(Rhizoctonia solani),* leaf spot *(Mycosphaerella horii, AIternaria citri,* and *Catenularia sp.;* algal leaf spot or green scurf *(Cephaleuros virescens);* tar spot *(Cercospora gigantea);* felt fungus *(Septobasidium pseudopedicellatum);* charcoal root rot *(Macrophomia phaseolina);* root rot *(Fusarium oxysporum, Pythium ultimum*, and *Phytophthora parasitica;* heart rot and wood rot *(Fomes applanatus* and *Ganoderma sessilis);* crinkly leaf and exocortis viruses; and green mold *(Penicillium digitatum);* blue mold (P. *italicum);* and pink mold (P. *roseum).* In 1955, the lemon budwood certification program was begun to provide virus-free stock for growers.

Red algae infests lemon trees and causes much dieback unless controlled with copper fungicide in the summer. Zinc deficiency causes stunting of twigs, reduced flowering, premature dropping of fruit, and yellow bands along the leaf veins. Manganese deficiency is evidenced by interveinal chlorosis and subsequent necrosis, shedding of leaves, flowers and young fruit. In India, fruit cracking occurs when dry periods are followed by heavy rains. Cracking can be largely avoided by frequent light irrigation during the dry period and early picking.

Stored lemons are subject to the stem-end rots and the molds listed above. The albedo may show small dark sunken areas even though this defect is not visible externally. Cultivars differ in their ability to resist decay.

Food Uses

Slices of lemon are served as a garnish on fish or meat or with iced or hot tea, to be squeezed for the flavorful juice. In Colombia, lemon soup is made by adding slices of lemon to dry bread roll that has been sautéed in shortening until soft and then sieved. Sugar and a cup of wine are added and the mixture brought to a boil, and then served.

Lemon juice, fresh, canned, concentrated and frozen, or dehydrated and powdered, is primarily used for lemonade, in carbonated beverages, or other drinks. It is also used for making pies and tarts, as a flavoring for cakes, cookies, cake icings, puddings, sherbet, confectionery, preserves and pharmaceutical products. A few drops of lemon juice, added to cream before whipping, gives stability to the whipped cream.

Lemon peel can be candied at home and is preserved in brine and supplied to manufacturers of confectionery and baked goods. It is the source of lemon oil, pectin and citric acid. Lemon oil, often with terpenes and sesquiterpenes removed, is added to frozen or otherwise processed lemon juice to enrich the flavor. It is much employed as a flavoring for hard candies.

Food Value Per 100 g of Edible Portion*

	Fruit (fresh, peeled)	*Juice (fresh)*	*Juice (canned, unsweetened)*	*Juice (frozen, unsweetened)*	*Lemonade (concentrate, frozen)*	*Peel (raw)*
Calories	27	25	23	22	195	
Moisture	90.1 g	91.0 g	91.6 g	92.0 g	48.5 g	81.6 g
Protein	1.1 g	0.5 g	0.4 g	0.4 g	0.2 g	1.5 g
Fat	0.3 g	0.2 g	0.1 g	0.2 g	0.1 g	0.3 g
Carbohydrates	8.2 g	8.0 g	7.6 g	7.2 g	51.1 g	16.0 g
Fiber	0.4 g	trace	trace	trace	0.1 g	
Ash	0.3 g	0.3 g	0.3 g	0.2 g	0.1 g	0.6 g
Calcium	26 mg	7 mg	7 mg	7 mg	4 mg	134 mg
Phosphorus	16 mg	10 mg	10 mg	9 mg	6 mg	12 mg
Iron	0.6 mg	0.2 mg	0.2 mg	0.3 mg	0.2 mg	0.8 mg
Sodium	2 mg	1 mg	I mg	I mg	0.2 mg	6 mg
Potassium	138 mg	141 mg	141 mg	141 mg	70 mg	160 mg
Vitamin A	20 I.U.	20 I.U.	20 I.U.	20 I.U.	20 I.U.	50 I.U.
Thiamine	0.04 mg	0.03 mg	0.03 mg	0.03 mg	0.02 mg	0.06 mg
Riboflavin	0.02 mg	0.01 mg	0.01 mg	0.01 mg	0.03 mg	0.08 mg
Niacin	0.1 mg	0.1 mg	0.1 mg	0.1 mg	0.3 mg	0.4 mg
Ascorbic Acid	53 mg	46 mg	42 mg	44 mg	30 mg	129 mg

*Analyses of true lemons, as marketed.

"Lemon Peel Oil consists mainly of terpenes, particularly limonene, also gamma terpinene and beta-phellandrene. There are small amounts of sesquiterpenes and aldehydes. Among the aliphatic aldehydes are n-octyl aldehyde, n-nonyl aldehyde, and citral.

Toxicity

The thorns of the lemon tree inflict painful punctures and scratches. Lemon peel oil may cause contact dermatitis, chronic in those who handle, cut and squeeze lemons daily. Parts of the body touched by contaminated hands may show severe reactions after exposure to the sun. People that suck lemons may suffer irritation and eruptions around the mouth. The wood of lemon trees and its saw-dust may induce skin reactions in sensitive woodworkers.

Other Uses

Lemon juice is valued in the home as a stain remover, and a slice of lemon dipped in salt can be used to clean copper-bottomed cooking pots. Lemon juice has been used for bleaching freckles and is incorporated into some facial cleansing creams.

Lemon peel oil is much used in furniture polishes, detergents, soaps and shampoos. It is important in perfume blending and especially in colognes.

Petitgrain oil (up to 50% citral), is distilled from the leaves, twigs and immature fruits of the lemon tree in West Africa, North Africa and Italy. With terpenes removed, it is greatly prized in colognes and floral perfumes.

Lemon peel, dehydrated, is marketed as cattlefeed.

Lemonade, when applied to potted plants, has been found to keep their flowers fresh longer than normal. But it cannot be used on chrysanthemums without turning their leaves brown.

Wood: The wood is fine-grained, compact, and easy to work. In Mexico, it is carved into chessmen, toys, small spoons, and other articles.

Medicinal Uses: Lemon juice is widely known as a diuretic, antiscorbutic, astringent, and febrifuge. In Italy, the sweetened juice is given to relieve gingivitis, stomatitis, and inflammation of the tongue. Lemon juice in hot water has been widely advocated as a daily laxative and preventive of the common cold, but daily doses have been found to erode the enamel of the teeth. Prolonged use will reduce the teeth to the level of the gums. Lemon juice and honey, or lemon juice with salt or ginger, is taken when needed as a cold remedy. It was the juice of the Mediterranean sweet lemon, not the lime, that was carried aboard British sailing ships of the 18th Century to prevent scurvy, though the sailors became known as "limeys".

Oil expressed from lemon seeds is employed medicinally. The root decoction is taken as a treatment for fever in Cuba; for gonorrhea in West Africa. An infusion of the bark or of the peel of the fruit is given to relieve colic.

Morton, J. 1987. Mexican Lime. p. 168–172. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Citrus aurantifolia Swingle

C. acida Roxb.

C. lima Lunan

C. medica var.*acida* Brandis

Limonia aurantifolia Christm.

Rutaceae

Mexican Lime

Of the two acid, or sour, limes in world trade, the one longest known and most widely cultivated is the Mexican, West Indian, or Key lime, *Citrus aurantifolia* Swingle (syns. C. *acida* Roxb., C. *lima* Lunan; C. *medica* var. *ácida* Brandis; and *Limonia aurantifolia* Christm.). It is often referred to merely as "lime". In Spanish it is, *lima ácida, lima chica, lima boba, limón chiquito, limón criollo, limón sutil, limón corriente,* or *limón agria.* In French, it is *limette* or *limettier acide;* in German, *limett;* Italian, *limetta;* in Dutch, *lemmetje* or *limmetje.* In East Africa, it is *ndimu;* in the Philippines, *dalayap* or *dayap;* in Malaya, *limau asam;* in India, *nimbu, limbu, nebu, lebu* or *limun.* In Papiamento in the Netherlands Antilles it is *lamoentsji* or *lamunchi,* in Brazil, *limao galego,* or *lintao miudo.* In Egypt and the Sudan it is called *limûn baladi,* or *baladi,* in Morocco, *doc.*

Description

The Mexican lime tree is exceedingly vigorous; may be shrubby or range from 6 1/2 to 13 ft (2-4 m) high, with many slender, spreading branches, and usually has numerous, very sharp, axillary spines to 3/8 in (1 cm) long. The evergreen, alternate leaves are pleasantly aromatic, densely set; elliptic- or oblong-ovate, rounded at the base, 2 to 3 in (5-7.5 cm) long, leathery; light purplish when young, dull dark-green above, paler beneath, when mature; with minute, rounded teeth and narrowly-winged petioles. Faintly fragrant or scentless, the axillary flowers, to 2 in (5 cm) across are solitary or 2 to 7 in a raceme, and have 4 to 6 oblong, spreading petals, white but purple-tinged when fresh, and 20-25 bundled white stamens with yellow anthers. The fruit, borne singly or in 2's or 3's (or sometimes large clusters), at the twig tips, is round, obovate, or slightly elliptical, sometimes with a slight nipple at the apex; the base rounded or faintly necked; 1 to 2 in (2.5-5 cm) in diameter; peel is green and glossy when immature, pale-yellow when ripe; somewhat rough to very smooth, 1/16 to 1/8 in (1.5-3 mm) thick; the pulp is greenish-yellow in 6 to 15 segments which do not readily separate; aromatic, juicy, very acid and flavorful, with few or many small seeds, green inside.

Origin and Distribution

The Mexican lime is native to the Indo-Malayan region. It was unknown in Europe before the Crusades and it is assumed to have been carried to North Africa and the Near East by Arabs and taken by Crusaders from Palestine to Mediterranean Europe. In the mid-13th Century, it was cultivated and well-known in Italy and probably also in France. It was undoubtedly introduced into the Caribbean islands and Mexico by the Spaniards, for it was reportedly commonly grown in Haiti in 1520. It readily became naturalized in the West Indies and Mexico, There is no known record of its arrival in Florida. Dr. Henry Perrine planted limes from Yucatan on Indian Key and possibly elsewhere. In 1839, cultivation of limes in southern Florida was reported to be "increasing". The lime became a common dooryard fruit and by 1883 was being grown commercially on a small scale in Orange and Lake Counties. When pineapple culture was abandoned on the Florida Keys, because of soil depletion and the 1906 hurricane, people began planting limes as a substitute crop for the Keys and the islands off Ft. Myers on the west coast. The fruits were pickled in saltwater and shipped to Boston where they were a popular snack for school children. The little industry flourished especially between 1913 and 1923, but was demolished by the infamous hurricane of 1926. Thereafter, the lime was once again mainly a casual dooryard resource on the Keys and the southern part of the Florida mainland.

In 1953, George D. Fleming, Jr., proprietor of Key Lime Associates, at Rock Harbor, on Key Largo, was the chief producer of limes. Though he had sold several of his groves, he was developing a new one as part of a "vacation cottage colony".

Fearing that this little lime might disappear with lack of demand and the burgeoning development of the Keys, the Upper Florida Keys Chamber of Commerce launched in 1954, and again in 1959 with the help of the Upper Keys Kiwanis Club, an educational campaign to arouse interest and encourage residents to plant the lime and nurseries to propagate the tree for sale.

The Mexican lime continues to be cultivated more or less on a commercial scale in India, Egypt, Mexico, the West Indies, tropical America, and throughout the tropics of the Old World. There are 2,000,000 seedling trees near Colima, Mexico. Mexico raises this lime primarily for sale as fresh fruit but also exports juice and lime oil. New plantings are being made to elevate oil production. In 1975, Rodolfo Guillen Paiz, Chief of the Citrus and Tropical Fruit Subproject of ANACAFE in Guatemala, reported the initiation of a program to establish the Mexican lime as an all-year commercial crop for the fresh fruit market, the production of juice and lime peel oil, and, as a first step, the creation of a collection of selections as a genetic base for development of an industry, possibly in association with cattle-raising since it had been observed that cattle do little damage to the trees.

Production of Mexican limes for juice has been the major industry on the small Caribbean island of Dominica for generations. There are at least 8 factories expressing the juice which is exported largely to the United Kingdom in wooden casks after "settling" in wooden vats and clarifying. In England, it is bottled as the world-famous "Rose's Lime Juice" put out by L. Rose & Co., Ltd., or as the somewhat different product of the chief competitor, A. C. Shellingford & Co. Surplus juice, over their requirements, is sold to soft-drink manufacturers. Since 1960, Rose has produced lime juice concentrate in Dominica for export. There is also considerable export of lime oil distilled from lime juice and oil expressed from the whole fruit. Jamaica, Grenada, Trinidad and Tobago, Guyana, and the Dominican Republic export lesser amounts of juice and oil. But the Dominican Republic has recently enlarged its plantings in order to increase its oil output. Montserrat ships only juice. Ghana is now the leading producer of lime juice and oil for L. Rose & Co., Ltd. Gambia began serious lime processing in 1967.

The Mexican lime grows wild in the warm valleys of the Himalayas and is cultivated not only in the lowlands but up to an elevation of 4,000 ft (1,200 m). It was first planted on the South Pacific island of Niue in 1930. A small commercial industry has been expanding since 1966. Some of the fruit is sold fresh but most of the crop is processed for juice and oil by the Niue Development Board Factory. These products are shipped to New Zealand, as are a good part of the peels for the manufacture of marmalade and jam. Production was crippled by a hurricane in 1979. This storm inspired a search for rootstocks that could be expected to withstand strong winds.

Varieties

There are few varieties of the Mexican lime, except for several spineless selections, inasmuch as there is no great variation in the wild or under cultivation. Some old named cultivars may not be recognized today.

'Everglade' (Philippine Islands #2182')–a seedling of a Mexican lime pollinated by flowers of a grapefruit or pummelo, but the fruits show no grapefruit or pummelo characteristics. Introduced into Trinidad in 1922. Planted in the Citrus Experiment Station collection at Riverside, California, it showed little or no distinguishing features. It is limelike, elliptical, with fairly large nipple at apex; 1 1/2 to 2 in (4-5 cm) wide, 1 3/4 to 2 1/8 in (4.5-5.4 cm) high; peel light-yellow when ripe, medium-smooth, the largest oil glands slightly sunken; thin, about 1/16 in (1.5 m); pulp light-greenish, in 8 to 10 segments with tender walls; aromatic, very juicy, of excellent quality and texture; the flavor sprightly acid; seeds 2 to 10, averaging about 5. The fruits are borne in large clusters because all the flowers are perfect. Tree is highly susceptible to withertip.

'Kagzi'–the name given the Mexican lime most commonly cultivated throughout India. It is represented by numerous subtypes differing slightly in size, shape and color.

'Palmetto'–a selected seedling from a Mexican lime pollinated by the 'Sicily' lemon; first described by Dr. H.J. Webber in the United States Department Yearbook for 1905; elliptical or nearly round with small nipple at apex; small of size, 1 3/8 to 1 1/2 in (3.6-4 cm) wide; 1 3/8 to 1 3/4 in (3.6-4.5 cm) high; peel pale-yellow when ripe, smooth, very thin, less than 1/16 in(1.5 mm); pulp light greenish-yellow, in 8 to 10 segments; tender, very juicy, of fine quality, aromatic, with sprightly acid flavor; usually 3 to 6 seeds.

'Yung' ('Spineless Mexican')–of unknown origin; was introduced into California from Mexico by George Yung around 1882.

Another spineless sport was reported in Dominica in 1892 and apparently the same was sent to the United States Department of Agriculture from Trinidad in 1910, and several thornless sports were found in lime groves near Weslaco, Texas, after a 1925 freeze. In 1967, seeds of a lime tree seen flourishing in the desert at Yuma, Arizona were brought to southern Florida by Burt Colburn and planted. Of 50 resulting seedlings, 8 were practically thornless. Budwood from these was grafted onto rough lemon stock for distribution.

In Trinidad, hybridization was undertaken in 1925 in the hope of developing a type immune to withertip. A seedling selection from hybrids was labeled 'T-l'. The fruits were not as juicy in the green stage and a bit larger than the typical Mexican lime. Back-crossing was done to arrive at 'T-145' more closely resembling a typical Mexican lime in size.

Climate

The Mexican lime is more sensitive to cold than the lemon, and can be grown only in protected locations in California. It thrives in a warm, moist climate with annual rainfall between 80 and 150 in (203-381 mm). Nevertheless, it tolerates drought better than any other citrus fruit. When there is excessive rainfall, the tree is subject to fungus diseases.

Soil

The oolitic limestone of the Florida Keys seems perfectly acceptable to the Mexican lime. The tree grows reasonably well in a variety of other soils. In sandy locations on the Florida mainland, best growth is achieved by the periodic addition of lime to raise the pH. Other-wise there will be a lighter crop of fruits; they will be larger than normal with thicker peel and less juice. In Hawaii, this lime is cultivated in rich sandy or gravelly, well-drained soil. Porous lava soil is acceptable if there is abundant rainfall. Stiff clay soils are unsuitable. On the island of Niue, limes are grown on a thin layer of topsoil underlain with limestone. Farmers are advised to avoid breaking up the limestone too much and mixing excessive calcium with the topsoil.

Propagation

The Mexican lime is usually propagated by seed because most seeds are polyembryonic and reproduce faithfully to the parent. In some areas, root sprouts from mature trees are taken up and transplanted into groves. Sprouting may be encouraged by digging around the parent tree to sever the roots wholly or partly. Cuttings of mature wood may also serve for propagation but usually do not develop strong root systems. Selected clones have been budded onto rough lemon or sour orange. The latter is said to provide more resistance to hurricanes. Pummelo has been used in Hawaii but doesn't make a perfect union. In Indonesia, this lime has always been air-layered. In the 1940's, air-layering became popular in Florida. It was adopted in India with 100% success, using indole butyric acid to aid root development of the 'Kagzi' lime.

Culture

In pioneer days, people on the Florida Keys had unsophisticated methods of raising limes. They often sowed the seeds thickly in a pot-hole in the limestone having a bit of soil in the bottom. When the seedlings were a few inches high, they were taken up and transplanted during the rainy season into any pot-hole with enough soil to sustain them until the roots were strong enough to penetrate the porous rock. The result was irregular groves, and this practice was called "jungle" planting. Sometimes volunteer seedlings would be taken up from beneath fruiting trees and transplanted in the same manner. Later on, growers began to dynamite holes in a regular pattern in order to have uniform rows. The breaking up of the rock enhanced root development.

The trees are best set 25 ft (7.5 m) apart each way, which allows for 70 trees per acre (28/ha). Closer spacings of 15 or 20 ft (4.5-6 m) do not permit enough room for good cultural practices. For many years, the trees on the Keys were fertilized only by a mulch of cured seaweed. On the mainland, nitrogen was supplied by leguminous cover crops such as velvet bean *(Mucuna deeringiana* Merr.), beggarweed *(Desmodium canum* Sch. & Thell.), or Showy Crotalaria *(Crotalaria spectabilis* Roth.). Dade County growers came to apply commercial fertilizer, using a 2-8-10, or 2-10-10 NPK formula. Increasing potash is a means of checking growth and promoting fruiting.

Before planting, in Niue, 1 to 2 tablespoons of zinc sulphate are placed in each hole. One month later, and then every 4 months thereafter, 3 1/2 oz (100 g) of mixed nitrogen and potassium are applied around the base. In the second year, the amount given is 18 oz (500 g) in 3 applications; in the third year, 3.3 lbs (1.5 kg); in the 4th year, 6.5 lbs (3 kg) and the 5th year and beyond, 9 lbs (4.5 kg).

Seedlings will begin to fruit in 3 to 6 years and reach full production in 8 to 10 years. The fruits ripen and fall 5 to 6 months after flowering. Trees grown from air layers or cuttings tend to fruit the first year and then cease fruiting until they have attained some growth. If the trees have been correctly pruned when young, there is no further need for pruning except to remove deadwood and water-sprouts, or for the purpose of thinning the fruits to increase size.

Harvesting

On the Florida Keys, the trees produce some fruits more or less the year around, but there are two main seasons–May/June and November/December. The peak season on Niue is in April and May. The fruits may be picked while still somewhat green for home use or for the fresh fruit market, but grove workers are reluctant to pick them because of the thorniness of the tree, unless they are provided with protective gloves. If picked too soon, the peel is apt to develop a dark "rind scald". The ideal stage is when the color has changed from dark to light green, the surface is smooth and the fruit feels slightly soft to the touch. For processing, the fully ripe, yellow limes are gathered from the ground twice a week. Because of the rough ground, pioneer growers on the Keys collected the fruits with wheelbarrows pushed along boards placed over the limestone.

Storage

The Mexican lime ripens to full yellow and loses weight rapidly at normal room temperature in warm climates. In the home, the fruits can be held fresh for 2 or 3 weeks if kept in water in a closed jar. They are prone to cold injury under refrigeration at 44.6º F (7º C). A storage temperature of 48.2º F (9º C) with 85-90% relative humidity has been recommended for delaying ripening and loss of moisture. Controlled atmospheres low in oxygen and high in carbon dioxide are also effective in prolonging storage life. Experiments in the Sudan have shown that packing the fruits in polyethylene bags with an ethylene absorbent retards ripening and moisture loss and makes possible the shipping of the fruit by air freight to the United Kingdom.

In India, Mexican limes picked green were coated with wax emulsion containing the growth regulator, indole butyric acid, at 2,000 ppm and kept at room temperature of 65º to 85º F (18.33-29.44º C) and relative humidity of 60 to 90% for 17 days. On removal from storage, 75% of the fruits were marketable, while fruits left untreated and those coated with wax only were completely unmarketable.

A study in Trinidad demonstrated that Mexican limes treated with gibberellic acid, packaged in polyethylene bags to retain moisture, and stored at ambient temperature, remained in marketable condition for 65 days. Yellowing was retarded and there was no adverse effect on quality.

Pests

The Mexican lime is attacked by few pests. On the island of Niue, the most important enemy is snow scale, *Unaspis citri,* in prolonged droughts. Severe infestations cause dieback of branches; lighter attacks induce splitting of the bark which permits entry of other insects and fungi. The scale insect is transported from tree to tree by ants.

Diseases

Withertip, or lime anthracnose, *(Gleosporium limetticolum) is* a serious affliction of the Mexican lime in Florida. *Fusarium oxysporum* causes wilt of seedlings in Florida greenhouses, induces twig dieback in India, and has been identified on Mexican lime grafted onto Rangpur mandarin lime in Brazil.

When the weather is too humid, the Mexican lime is prone to attack by the fungus, *Elsinoe fawcetti*, causing scab. It is also subject to algal disease and oil spotting can be severe. In Niue, the trees are often afflicted with collar rot, caused by *Phytophthora sp.* The fungus, *Sphaeropsis tumefaciens,* causing lime knot and witches broom, has destroyed many trees in Jamaica.

In 1982, a new strain of citrus canker, *Xanthomonas campestris pv. citri,* was found on 20,000 trees in the state of Colima, Mexico, in a 5-sq. mile (12.8 sq. km) area. Seedlings that had been shipped from this area were destroyed and the United States Department of Agriculture culture set up the requirement that all citrus imports from Mexico would have to be accompanied by a phytosanitary certificate. Canker is a common plague of limes in India and in 1960 the Horticultural Research Institute reported that Streptomycin sulfate at 500 ppm reduced the incidence by 34%.

The fruits are attacked by decay organisms in storage, principally *Rhizopus nigricans* and *Penicillium spp.*

Food Uses

The Mexican lime, because of its special bouquet and unique flavor, is ideal for serving in half as a garnish and flavoring for fish and meats, for adding zest to cold drinks, and for making limeade. In the Bahamas, fishermen and others who spend days in their sailboats, always have with them their bottles of homemade "old sour"–lime juice and salt. Throughout Malaysia, this lime is grown mainly to flavor prepared foods and beverages. Commercially bottled lime juice is prized the world over for use in mixed alcoholic drinks. If whole limes are crushed by the screw-press process, the juice should be treated to remove some of the peel oil. It is calculated that 2,200 lbs (1 metric ton) of fruit should yield 1,058 lbs (480 kg) of juice.

Lime juice is made into sirup and sauce and pies similar to lemon pie. "Key Lime Pie" is a famous dish of the Florida Keys and southern Florida, but today is largely made from the frozen concentrate of the 'Tahiti' lime.

Mexican limes are often made into jam, jelly and marmalade. In Malaya, they are preserved in sirup. They are also pickled by first making 4 incisions in the apex, covering the fruits with salt, and later preserving them in vinegar. Before serving, the pickled fruits may be fried in coconut oil and sugar and then they are eaten as appetizers.

Pickling is done in India by quartering the fruits, layering the pieces with salt in glass or glazed clay jars, and placing in the sun for 3 to 4 days. The contents are stirred once a day. Green chili peppers, turmeric, ginger or other spices may be included at the outset. Coconut or other edible oil may be added last to enhance the keeping quality. Another method of pickling involves scraping the fruits, steeping them in lime juice, then salting and exposing to the sun.

Hard, dried limes are exported from India to Iraq for making a special beverage.

The oil derived from the Mexican lime is obtained by three different methods in the West Indies:

1) by hand-pressing in a copper bowl studded with spikes (which is called an écuelle). This method yields oil of the highest quality but it is produced in limited amounts. It is an important flavoring for hard candy.

2) by machine pressing, cold expression, of the oil from the spent half-shells after juice extraction, or simultaneously but with no contact with the juice.

3) by distillation from the oily pulp that rises to the top of tanks in which the washed, crushed

fruits have been left to settle for 2 weeks to a month. This yields the highest percentage of oil. With terpenes and sesquiterpenes removed, it is extensively used in flavoring soft drinks, confectionery, ice cream, sherbet, and other food products. The settled juice is marketed for beverage manufacturing. The residue can be processed to recover citric acid.

The minced leaves are consumed in certain Javanese dishes. In the Philippines, the chopped peel is made into a sweetmeat with milk and coconut.

Food Value Per 100 g of Edible Portion*

Moisture	88.7-93.5 g
Protein	0.070-0.112 g
Fat	0.04-0.17 g
Fiber	0.1-0.5 g
Ash	0.25-0.40 g
Calcium	4.5-33.3 mg
Phosphorus	9.3-21.0 mg
Iron	0.19-0.33 mg
Vitamin A	0.003-0.040 mg
Thiamine	0.019-0.068 mg
Riboflavin	0.011-0.02 3 mg
Niacin	0.14-0.25 mg
Ascorbic Acid	30.0-48.7 mg

*According to analyses made in Central America.

Other Uses

Juice: In the West Indies, the juice has been used in the process of dyeing leather. On the island of St. Johns, a cosmetic manufacturer produces a bottled Lime Moisture Lotion as a skin-conditioner.

Peel: The dehydrated peel is fed to cattle. In India, the powdered dried peel and the sludge remaining after clarifying lime juice are employed for cleaning metal.

Peel oil: The hand-pressed peel oil is mainly utilized in the perfume industry.

Twigs: In tropical Africa, lime twigs are popular chewsticks.

Medicinal Uses: Lime juice dispels the irritation and swelling of mosquito bites.

In Malaya, the juice is taken as a tonic and to relieve stomach ailments. Mixed with oil, it is given as a vermifuge. The pickled fruit, with other substances, is poulticed on the head to allay neuralgia. In India, the pickled fruit is eaten to relieve indigestion. The juice of the Mexican lime is regarded as an antiseptic, tonic, an antiscorbutic, an astringent, and as a diuretic in liver ailments, a digestive stimulant, a remedy for intestinal hemorrhage and hemorrhoids, heart palpitations, headache, convulsive cough, rheumatism, arthritis, falling hair, bad breath, and as a disinfectant for all kinds of ulcers when applied in a poultice.

The leaves are poulticed on skin diseases and on the abdomen of a new mother after childbirth. The leaves or an infusion of the crushed leaves may be applied to relieve headache. The leaf decoction is used as eye drops and to bathe a feverish patient; also as a mouth wash and gargle in cases of sore throat and thrush.

The root bark serves as a febrifuge, as does the seed kernel, ground and mixed with lime juice.

In addition, there are many purely superstitious uses of the lime in Malaya.

Morton, J. 1987. Tahiti Lime. p. 172–175. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Tahiti Lime

Citrus latifolia Tan.

This acid lime lacks the long history and wide usage that glamorize the small Mexican lime. Its identity has been in doubt and only in recent years has it been given the botanical name, *Citrus latifolia* Tan. An alternate common name is Persian lime.

Description

The Tahiti lime tree is moderately vigorous, medium to large, up to 15 or 20 ft (4.5-6 m), with nearly thornless, widespread, drooping branches. The leaves are broad-lanceolate, with winged petioles; young shoots are purplish. Flowers, borne off and on during the year but mainly in January, are slightly purple-tinged. The fruit is oval, obovate, oblong or short-elliptical, usually rounded at the base, occasionally ribbed or with a short neck; the apex is rounded with a brief nipple; 1 1/2 to 2 1/2 in (4-6.25 cm) wide, 2 to 3 in (5-7.5 cm) high; peel is vivid green until ripe when it becomes pale-yellow; smooth, thin, tightly clinging; pulp is light greenish-yellow when ripe, in 10 segments, tender, acid, but without the distinctive bouquet of the Mexican lime; usually seedless, rarely with one or a few seeds, especially if planted among a number of other *Citrus* species. The Tahiti lime flowers have no viable pollen.

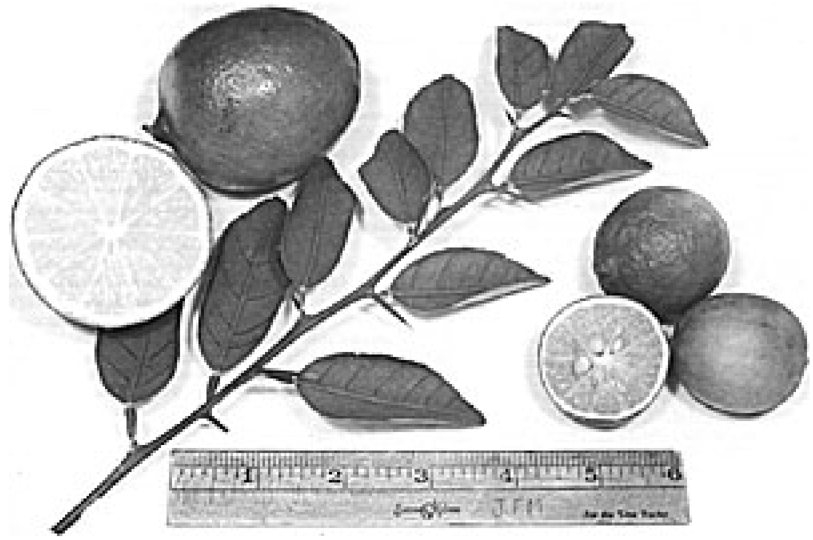


Fig. 43: Tahiti, or Persian lime (*Citrus latifolia*) (left); and the Mexican, or West Indian (*C. aurantifolia*) which is especially aromatic.

Origin and Distribution

The origin of the Tahiti lime is unknown. It is presumed to be a hybrid of the Mexican lime and citron, or, less likely, the lemon, and it is genetically a triploid though only the normal 18 chromosomes have been reported. Dr. Groff, in a reference to *Citrus aurantifolia* in his "Culture and Varieties of Siamese Pummelos . . . ", said: ". . .it is represented by a large variety known as *Manow klom* and by a small one known as *Manow yai."* One might speculate as to whether the large variety might be the female parent of the Tahiti lime. At any rate, it is believed that the Tahiti was introduced into the Mediterranean region by way of Iran (formerly called Persia). It is said that, for some centuries, a virtually identical lime called 'Sakhesli' has been cultivated on the island of Djerba off the coast of Tunisia, and that the local name means "from Sakhos", an old Arabic name for Chios, a Grecian island. Portuguese traders probably carried it to Brazil, and it was apparently taken to Australia from Brazil about 1824. It reached California from Tahiti between 1850 and 1880 and had arrived in Florida by 1883. It was being grown at Lake Placid in 1897. This lime was adopted into cultivation in California but is not extensively grown there, the bulk of California's lime crop being mainly the Mexican lime. In Florida, the Tahiti quickly took the place of the more sensitive small lime and the lemon. Following World War I, the Tahiti lime became a well-established commercial crop. At first, there was market resistance, buyers viewing the Tahiti lime as a "green lemon", and, for some time, Canadians would not accept it because they were accustomed to the more flavorful Mexican lime. In the 1930's, many Florida citrus growers planted limes for extra income and, in 1949, the development of limeade concentrate provided further impetus to the Tahiti lime industry.

In 1954, Libby, McNeil & Libby topworked 100 acres (40 ha) of grapefruit trees in Florida to Tahiti lime. Production increased 60% from 1970 to 1980. In 1979, the total crop was valued at close to $9 million. Nearly 1 million bushels (250 limes per bushel) were shipped fresh and the same amount was processed. By 1980, there were approximately 8,000 acres (about 3,250 ha) of commercial groves. Five years later, Dade County shipped 110 million lbs (50 million kg) of fresh fruit worth about $14 million to the growers, from a total of 6,500 acres (2,630 ha). Florida produces 90% of the national crop, for marketing fresh and for canned lime juice, frozen lime juice, frozen lime juice concentrate, frozen limeade and powdered lime juice. The Florida Lime and Avocado Administrative Committee conducts research on production and carries on national promotional activity.

Varieties

There have been only a few named cultivars, or alleged cultivars, of the Tahiti lime:

'Bearss' ('Bearss Seedless', 'Byrum Seedless')–This was first put forward as a new variety of Tahiti lime originating in the grove of T.J. Bearss at Porterville, California, in 1895. It was described and illustrated in 1902 and cultivated and catalogued by the Fancher Creek Nursery Company in 1905. It was grown in California, Arizona and Hawaii under the name, 'Bearss', at least until the late 1940's. However, comparative studies made in California led to the decision that the 'Bearss' did not differ sufficiently from the typical Tahiti lime to be maintained as a distinct cultivar.

'Idemor'–a limb sport found around 1934 in a grove owned by G.L. Polk in Homestead, Florida, and patented in 1941 (U.S. Plant Patent #444). The fruit is smaller and more rotund than the typical Tahiti. A very similar sport has been reported from Morocco. This lime is no longer planted because of its susceptibility to virus diseases.

'Pond'–In 1914, budwood was obtained by Dr. H.J. Webber from a Tahiti lime tree in the Moanalua Gardens, in Honolulu. Budded trees bore fruits that were somewhat smaller than the typical Tahiti but otherwise much the same. The trees were somewhat lower growing. This cultivar seems to have disappeared.

USDA 'No. 1' and 'No. 2'–selections from many seedlings grown by Dr. James Childs of the United States Department of Agriculture at the Horticultural Field Station, Orlando, Florida. They are free of exocortis and xyloporosis viruses and are available to growers through Florida's Budwood Registration Program. The fruit does not differ significantly in character from the typical Tahiti lime. The development of these virus-free clones has been a great boon to Florida's lime industry.

Climate

The Tahiti lime is hardier than the Mexican lime and better adapted to the mainland of Florida. Most of the commercial groves are in Dade County, but, with some cold protection, this lime can be grown on the east and west coasts and the central ridge as far north as Winter Haven. Even in southern Florida, drastic drops in temperature have made it necessary to protect lime groves with wind machines or overhead sprinkling,

Soil

The plantings in southern Florida are on oolitic limestone. Those further north are on deep sand. The soil must be well drained. In low land subject to standing water, lime trees are planted on elevated beds.

Propagation

The seeds of the Tahiti lime are largely monoembryonic; few seeds are available for planting; and seedlings, for the most part, are exceedingly variable. Only 10 trees of 114 seedlings grown at the Agricultural Research and Education Center of the University of Florida, Homestead, showed typical Tahiti lime characters vegetatively and in the fruit, except for long thorns on the trunk and branches.

This lime has been customarily budded onto rough lemon, but in recent years more commonly on the alemow, *C. macrophylla*. Many sweet orange and grapefruit trees have been successfully topworked to the Tahiti lime. Today, 40% of the commercial Tahiti lime trees have been grown from air-layers.

Culture

In Dade County's limestone, the trees are planted at the intersection of mechanically-cut trenches 16 in (40.5 cm) deep, or on mounds of crushed limestone and soil on scarified ground. The Tahiti lime tree is less vigorous than the Mexican lime and accordingly lends itself to close-planting. Spacing may be as close as 10 or 15 ft (3-4.5 m) in rows 20 ft (6 m) apart, which permits about 150 to 200 trees per acre (60-80/ha). When the trees overlap, they are mechanically hedged and topped. Greater yields will result if the trees are spaced at 20 ft (6 m) and hedging and topping are performed at 2 -to 3 -year intervals. The tree produces few water sprouts. A 12-month study in Cuba showed that hedging does not affect yield a year later, and does not alter the normal growth of the tree.

Air-layered trees begin to bear a year before budded trees but, as they mature, they generally do not yield as well. Because of their year-around growth, lime trees demand more fertilization and irrigation than other *Citrus* species. In commercial groves, irrigation is provided by overhead sprinklers, portable or stationery.

In early days, many trees were afflicted with bark lesions and even girdling, killing the affected branches or the entire tree if on the trunk. Splitting high-nitrogen fertilizer applications into 4 applications annually instead of 2 seemed to eliminate the problem. More recently, it has been recommended that a 4-6-6 formula of NPK be applied every 60 days. Potash is particularly important in relation to yield. In California, experimental spraying with gibberellic acid (10 ppm) delayed maturity and increased fruit size. The fruit stayed green longer in the packinghouse.

Harvesting

Tahiti limes are harvested 8 to 12 times a year–once a month in winter, but 70% of the crop matures from May to fall. The peak period is July to September. The demand persists year-around and off-season fruits sell at premium prices. Most harvesting is by hand but some use a "gig". If picked too immature, the fruits will be deficient in juice. Since 1955, a Federal Marketing Order has prevented the harvesting of immature fruit and has provided for the industry's setting of standards of quality, grade and size. The minimum permissible juice content is 42%. If left too long on the tree, the fruits will be subject to stylar-end-breakdown and are apt to turn yellowish before they reach distant markets.

The limes are collected in wooden field boxes and conveyed by truck to packinghouses where they are graded, washed, waxed, and packed in 10-,20-,40-,or 55-lb (4.5-,9-,18-,or 25-kg) corrugated cartons for shipment to retailers. About 40% of the crop is processed locally for lime juice concentrate. Cull limes are shipped to out-of-state manufacturers of citrus juices and peel oil extractors. Limes for shipment to Hawaii and Arizona must be fumigated with methyl bromide because of possible infestation by Caribbean fruit fly.

Yield

The yield from 7 ft (2.13 m) trees grafted on alemow rootstock has averaged 90 lbs (41 kg), while trees of the same size on rough lemon yielded 63 lbs (29 kg). Under advanced methods of management, Florida lime groves produce 600 bushels per acre (243 bu/ha) annually.

Storage

The Tahiti lime requires no curing. The fresh fruits remain in good condition for 6 to 8 weeks under refrigeration.

Pests and Diseases

The citrus red mite (purple mite, red spider, spider mite), and the broad mite may heavily infest Tahiti lime leaves and fruits.

Formerly, the trees and fruits commonly evidenced lime blotch (yellow areas on leaves and fruits) but the replacing of susceptible trees has largely eliminated this problem. The tree is immune to withertip, moderately susceptible to scab and greasy spot. Red alga is a major problem, causing bark splitting and dieback of branches. It can be prevented by regular and thorough spraying with copper or other suitable fungicides. The tree is subject to several viruses: crinkly leaf, psorosis, tatterleaf , tristeza, exocortis and xyloporosis.

The fruits are highly subject to oil spotting (oleocellosis), which occurs most frequently during rainy seasons and when limes are harvested when wet with dew. Stylar-end-breakdown, or stylar-end-rot, has been a very serious post-harvest disorder in the summer. It may develop within 2 hours after picking or several days later. It is apparently induced in oversize fruits, larger than 2 1/2 in (6.25 cm) picked early in the morning when internal pressure is high and left too long in the hot sun in the field boxes. The effect is an expansion and rupturing of juice vesicles and the development of a brown, soft area at the apex of the fruit, occasionally at the base also. Fruit losses have been as high as 40%. Precooling the fruits for 24 hours greatly reduces the incidence of this disease.

Food Uses

The Tahiti lime is utilized for making limeade and otherwise for the same purposes as the Mexican lime. In Florida, a wedge of lime is commonly served with avocado, and lime juice is frequently used as an alternative to vinegar in dressings and sauces.

It was formerly held that the oil from the peel of the Tahiti lime was of inferior quality. Since the late 1960's, it has been accepted by the trade and produced in quantity as a by-product of the juice -extraction process. It is utilized for enhancing lime juice and for most of the other purposes for which Mexican lime peel oil is employed.

Toxicity

Excessive exposure to the peel oil of the Tahiti lime may cause dermatitis. Rolling the limes between the hands before squeezing in order to extract more of the juice will coat the hands with oil and this will be transferred to whatever parts of the body are touched before washing the hands. Subsequent exposure to sunlight often results in brown or red areas that itch intensely, and sometimes severe blistering. The sap of the tree and scratches by the thorns may cause rash in sensitive individuals.

Other Uses

Lime juice is employed as a rinse after shampooing the hair. Light streaks have been bleached in the hair by applying lime juice and then going out into the sun for a time. One should be sure that there is no peel oil on the hands when doing this. Lime juice has been applied on the face as a freshening lotion. Some Florida housewives use lime juice for cleaning the inside of coffeepots, and grind a whole lime in the electric garbage-disposal to eliminate unpleasant odor. Dilute lime juice will dissolve, overnight, calcium deposits in teakettles.

Medicinal Uses: Lime juice, given quickly, is an effective antidote for the painful oral irritation and inflammation that result from biting into aroids such as *Dieffenbachia spp.*, *Xanthosoma spp., Philodendron spp.,* and their allies. Lime juice has also been applied to relieve the effects of stinging corals.

Morton, J. 1987. Sweet Lime. p. 175–176. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sweet Lime

Citrus limettioides Tan.

C. lumia Risso et Poit.

The sweet lime, *Citrus limettioides* Tan. (syn. C. *lumia* Risso et Poit.), is called *limettier doux* in French; *lima dulce* in Spanish; *mitha limbu, mitha nimbu,* or *mitha nebu,* in India *(mitha* meaning "sweet"); *quit giây* in Vietnam; *limûn helou,* or *succari* in Egypt; *laymûn-helo* in Syria and Palestine. It is often confused with the sweet lemon, *C. limetta* Tan., (q.v. under LEMON) which, in certain areas, is referred to as "sweet lime". In some of the literature, it is impossible to tell which fruit is under discussion.

Description

The tree, its foliage, and the form and size of the fruit resemble the Tahiti lime; the leaves are serrated and the petioles nearly wingless. The fruit is not at all similar to the Mexican lime. The flowers are borne singly in the leaf axils or in terminal clusters of 2 to 10; the fruits may be solitary or in bunches of 2 to 5.

Origin and Distribution

It is not known where or how the sweet lime originated, but it is thought to be a hybrid between a Mexican-type lime and a sweet lemon or sweet citron. Mediterranean botanists refer to it as native to India. Central and northern India, northern Vietnam, Egypt and other countries around the coasts of Mediterranean, and tropical America, are the chief areas of cultivation. It came to the

United States from Saharanpur, India, in 1904 (S. P. I. #10365).

There is very limited culture in California where the fruits produced by desert-grown trees differ markedly from those in cooler coastal regions. It is not grown for its fruit nor used as a rootstock in Florida because of its high susceptibility to viruses. In India and Israel it is much utilized as a rootstock for the sweet orange and other *Citrus* species.

Varieties

There are said to be several strains in India differing in fruit shape and tree productivity.

'Indian' ('Palestine')–oblong, ovoid or nearly round, with rounded base and small nipple at apex, occasionally slightly ribbed; peel aromatic, greenish to orange-yellow when ripe, smooth, with conspicuous oil glands, thin; pulp pale-yellow, usually in 10 segments, tender, very juicy, non-acid, bland, faintly bitter. The tree may be large or shrubby; is spreading, irregular, thorny, with leaves resembling those of the orange but paler and with more prominent oil glands, their petioles faintly winged. Buds and flowers are white. The tree is hardier than that of the acid lime; bears late in the rainy season in India when other citrus fruits are out-of-season.

'Columbia'–a clonal selection mentioned by Reuther *et al. (Citrus Industry,* Vol. 1, rev'd, 1967).

'Soh Synteng'–a strongly acid variation in Assam with new shoots and flower buds briefly pinkish.

Pollination

The sweet lime is self-compatible. In studies aimed at improving yield, Indian scientists found that self-pollination results in maximum fruit set, while cross-pollination with sweet orange or grapefruit results in greater fruit retention, at the same time increasing fruit size and seed count. Therefore, the practice of interplanting with sweet orange and grapefruit has been adopted in commercial orchards.

Propagation

In India, the sweet lime is grown from cuttings.

Food Uses

In the West Indies and Central America, the fruits are commonly enjoyed out-of-hand. The stem-end is cut off, the core is pierced with a knife, and the juice is sucked out. The fruit is eaten fresh in India as well as cooked and preserved.

The hand-pressed peel oil has a strong lemon odor. It contains pinene, limonene, linalool, linalyl acetate and possibly dipentene and citral.

Medicinal Uses

In India the sweet lime is therapeutically valued for its cooling effect in cases of fever and jaundice.

Morton, J. 1987. Calamondin. p. 176–178. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Calamondin

Citrus mitis Blanco

C. microcarpa Bunge

C. madurensis Lour.

X *Citrofortunella mitis* J. Ingram & H. E. Moore

Prized for its ornamental value more widely than for its fruit, the calamondin was formerly identified as *Citrus mitis* Blanco (syn. C. *microcarpa* Bunge); more recently in *Citrus* circles, erroneously, as *C. madurensis* Lour.; now it has been given the hybrid name: X *Citrofortunella mitis* J. Ingram & H. E. Moore. Among alternate common names are: calamondin orange; Chinese, or China, orange; Panama orange; golden lime; scarlet lime; and, in the Philippines, *kalamondin*, *kalamunding*, *kalamansi*, *calamansi*, *limonsito*, or *agridulce*. Malayan names are *limau kesturi* ("musk lime") and *limau chuit*. In Thailand it is *ma-nao-wan*.

Description

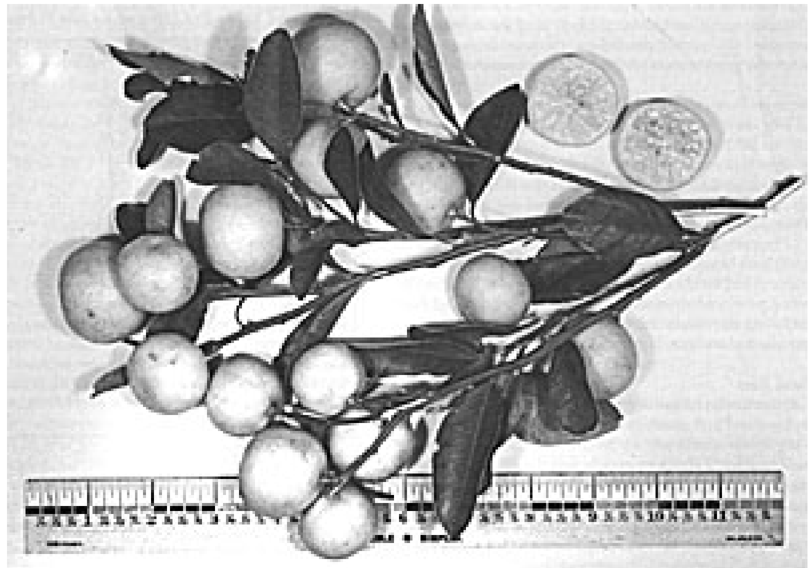


Fig. 44: The calamondin (X *Citrofortunella mitis),* a showy ornamental, makes excellent marmalade.

The calamondin tree, ranging from 6 1/2 to 25 ft (2-7.5 m) high, is erect, slender, often quite cylindrical, densely branched beginning close to the ground, slightly thorny, and develops an extraordinarily deep taproot. The evergreen leaves (technically single leaflets) are alternate, aromatic, broad-oval, dark-green, glossy on the upper surface, yellowish-green beneath, 1 1/2 to 3 in (4-7.5 cm) long, faintly toothed at the apex, with short, narrowly-winged petioles. The richly and sweetly fragrant flowers, having 5 elliptic-oblong, pure-white petals, are about 1 in (2.5 cm) wide and borne singly or in 2's or 3's terminally or in the leaf axils near the branch tips. The showy fruits are round or oblate and to 1 3/4 in (4.5 cm) wide, with very aromatic, orange-red peel, glossy, and dotted with numerous small oil glands; tender, thin, easily-removed, sweet, and edible. The pulp, in 6 to 10 segments, is orange, very juicy, highly acid, seedless or with 1 to 5 small, obovoid seeds, green within.

Origin and Distribution

The calamondin is believed native to China and thought to have been taken in early times to Indonesia and the Philippines. It became the most important *Citrus* juice source in the Philippine Islands and is widely grown in India and throughout southern Asia and Malaysia. It is a common ornamental dooryard tree in Hawaii, the Bahamas, some islands of the West Indies, and parts of Central America. Dr. David Fairchild introduced it into Florida from Panama in 1899. It quickly became popular in Florida and Texas. The California climate is not as favorable but a variegated form ('Peters') is cultivated there.

Since 1960, thousands of potted specimens have been shipped from southern Florida to all parts of the United States for use as house plants. Israel is now similarly raising such plants for the European market. The calamondin is also valued as a rootstock for the oval kumquat (q.v.) for pot culture.

At the Agricultural Experiment Station of the University of Florida in Gainesville, the calamondin is much utilized for greenhouse research on the various aspects of flowering and fruiting in Citrus.

Climate

The calamondin is as cold-hardy as the Satsuma orange and can be grown all along the Gulf Coast of the southern United States. It is moderately drought-tolerant.

Soil

The tree seems able to tolerate a wide range of soils from clay-loam in the Philippines to limestone or sand in Florida.

Propagation

Calamondin trees may be easily grown from seeds, which are polyembryonic with 3 to 5 embryos each. For commercial fruit production in the Philippines, the trees are budded onto calamondin seedlings. In Florida, propagation by cuttings rooted under constant mist is the more common commercial procedure for pot culture. Even leaf-cuttings will root readily.

Culture

Plants grown from cuttings fruit during the rooting period and will reach 18 to 24 in (45-60 cm) in height in 10 1/2 months. The flowers are self-fertile and require no cross-pollination. Transplanted into a large container and well cared for, a calamondin will grow at the rate of 1 ft (30 cm) per year; will produce an abundant crop of fruit at the age of 2 years and will continue to bear the year around. Potted plants for shipment can be stored in the dark for 2 weeks at 53.6º F (12º C) without loss of leaves or fruits in storage or in subsequent transit and marketing.

In orchard plantings, Philippine workers have established that a complete commercial fertilizer with a 1:1 nitrogen to potassium ratio gives the best growth. There are 2 applications: one prior to the onset of the rainy season and the second just before the cessation of rains. Adequate moisture is the principal factor in yield, size and quality of the fruit. Drought and dehydrating winds often lead to mesophyll collapse.

Harvesting

Calamondins are harvested by clipping the stems as they become fully colored throughout the year. In the Philippines the peak season is mid-August through October.

Storage

The fruits will keep in good condition for 2 weeks at 48º to 50º F (8.89º-10º C) and 90% relative humidity. Weight loss will be only 6.5%. Waxing retards ascorbic acid loss for 2 weeks in storage but not thereafter.

Pests and Diseases

The calamondin is a prime host of the Mediterranean and Caribbean fruit flies, and for this reason is much less planted in Florida than formerly. It may be attacked by other pests and diseases that affect the lemon and lime including the viruses: crinkly leaf, exocortis, psorosis, xyloporosis and tristeza, but it is immune to canker and scab.

Food Uses

Calamondin halves or quarters may be served with iced tea, seafood and meats, to be squeezed for the acid juice. They were commonly so used in Florida before limes became plentiful. Some people boil the sliced fruits with cranberries to make a tart sauce. Calamondins are also preserved whole in sugar sirup, or made into sweet pickles, or marmalade. A superior marmalade is made by using equal quantities of calamondins and kumquats. In Hawaii, a calamondin-papaya marmalade is popular. In Malaya, the calamondin is an ingredient in chutney. Whole fruits, fried in coconut oil with various seasonings, are eaten with curry. The preserved peel is added as flavoring to other fruits stewed or preserved.

The juice is primarily valued for making acid beverages. It is often employed like lime or lemon juice to make gelatin salads or desserts, custard pie or chiffon pie. In the Philippines, the extracted juice, with the addition of gum tragacanth as an emulsifier, is pasteurized and bottled commercially. This product must be stored at low temperature to keep well. Pectin is recovered from the peel as a by-product of juice production.

Food Value Per 100 g of Edible Portion*		
	Whole Fruit %	*Juice %*
Calories/lb	173 (380/kg)	
Moisture	87.08-87.12	89.66
Protein	0.86	0.01
Fat	2.41	0.53
Carbohydrates	3.27	
Ash	0.54-0.64	0.62
Calcium	0.14	
Phosphorus	0.07	
Iron	0.003	
Citric Acid	2.81	5.52

*The chemistry of the calamondin has received only moderate attention. Wester (1924) and Marañon (1935) reported the above constituents from Philippine analyses. Mustard found the ascorbic acid content of the *whole fruit* to be, 88.4-111.3 mg/100 g; of the *juice*, 30-31.5 mg; and of the *peel*, 130-173.9 mg.

Other Uses

The fruit juice is used in the Philippines to bleach ink stains from fabrics. It also serves as a body deodorant.

Medicinal Uses: The fruits may be crushed with the saponaceous bark of *Entada Phaseoloides* Merr. for shampooing the hair, or the fruit juice applied to the scalp after shampooing. It eliminates itching and promotes hair growth. Rubbing calamondin juice on insect bites banishes the itching and irritation. It bleaches freckles and helps to clear up *acne vulgaris* and *pruritus vulvae.* It is taken orally as a cough remedy and antiphlogistic. Slightly diluted and drunk warm, it serves as a laxative. Combined with pepper, it is prescribed in Malaya to expel phlegm. The root enters into a treatment given at childbirth. The distilled oil of the leaves serves as a carminative with more potency than peppermint oil. The volatile oil content of the leaves is 0.90% to 1.06%.

Morton, J. 1987. Mandarin Lime. p. 178–179. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mandarin Lime

Citus × limonia Osbeck

This is a group name embracing three more or less similar fruits:

1) **Rangpur** *(Citrus X limonia* Osbeck) is also called rangpur lime, *rungpur,* marmalade lime, lemandarin; Canton lemon in southern China, *hime* lemon in Japan; *Japanche citroen* in Indonesia; *sylhet* lime, *surkh nimboo* and *shabati* in India; *limao cravo* in Brazil. It is probably a lemon X mandarin orange hybrid originating in India. Sir Joseph Hooker recorded this as a small, slender tree in the very bottom of valleys, along the foot of the Himalayas, from Gurhwal to the Khasia Hills. The Reasoner Brothers, nurserymen, at Oneco, Florida, introduced seeds from northwestern India and catalogued the tree as a lime.

The fruit resembles a mandarin orange; is round, oblate, or obovate, of irregular surface, the base becoming furrowed and slightly necked with age, the apex rounded or faintly nippled; 1 3/4 to 2 1/2 in (4.5-6.25 cm) wide, 1 5/8 to 2 1/4 in (4.1-5.7 cm) high; peel is reddish-orange, with large oil glands, thin, easily removed; pulp has limelike aroma, is deep-orange, in 8 to 10 segments having tender walls and separating readily from each other; melting, very juicy; flavor exceedingly sour but suggestive of orange; there may be 6-18 seeds, small, green within.

The tree is fast-growing, more or less spreading, reaching 15 to 20 ft (4.5-6 m); has short thorns; the flower buds and petals are purple-tinted. It is more cold-tolerant than the lime and in California has endured freezes better than the lemon. Unfortunately, it is highly subject to scab. It bears abundantly, from November through winter, and the fruits remain on the tree in good condition. It is a casual dooryard tree in Florida and a minor commercial fruit tree in California. Until the late 1930s, it was much used in Brazil and Argentina as a rootstock but trees budded onto it proved to be short-lived It is grown to some extent in Australia and the Hawaiian Islands, rarely in Trinidad where it was introduced from Montserrat in 1920.

In India, mandarin orange juice is improved by adding 20-40% Rangpur juice. Small, whole fruits can be candied or pickled, but the Rangpur is not fully appreciated until it is made into marmalade. This product is superb and rivals or excels that made from the sour orange.

2) **Kusiae** or kusiae lime is presumably a form of the Rangpur though it is even more limelike in aroma. It is believed to have evolved in India where virtually identical fruits are called *nasaran* and *nemu tenga*. Hawaiians believe that early Spanish settlers planted it on Kusiae, or Strongs Island, in the Caroline Islands of Micronesia. In 1885, Henry Swinton introduced it into Hawaii

where it was described and pictured by Gerrit Wilder in 1911. Budwood was taken from Wilder's garden in Honolulu to the Citrus Experiment Station at Riverside, California, in 1914.

The fruit is oval, oblate or round, furrowed and sometimes faintly necked at the base, the apex rounded or with a slight pointed nipple; 1 1/2 to 2 1/2 in (4-6.25 cm) wide; the peel is deep-yellow with prominent oil glands, medium-thick to thin, leathery, easily removed; pulp is honey-yellow, in 8 or 9 segments having tender walls; melting, somewhat less acid than the true lime and not so rich in flavor; contains 6 to 10 small seeds; the abundant juice is colorless, transparent.

The tree is vigorous, of bushy habit, branched to the ground, but reaching 10 to 20 ft (4.5-6 m) in height; has only a few small thorns and oval to lanceolate leaves; new growth is pale-green; sends up many root sprouts, forming thickets. It is generally grown from seeds and seedlings may be less thorny and seedy than their parents; can be grafted onto sour orange or other non-sprouting citrus rootstocks to avoid root suckers. Fruiting begins in 1 1/2 to 3 years and the tree is nearly everbearing and prolific. In Hawaii, 11-year-old trees have borne 2,000 fruits, nearly 200 lbs (90.5 kg) per tree. The Kusiae lime is cold-tolerant, immune to withertip but prone to scab and root-rot. It is a common dooryard fruit tree in Hawaii and also grown in Trinidad, little-known elsewhere.

3) **Otaheite,** or Otaite, orange, or Otaheite Rangpur, formerly known as *C. otaitensis* Risso & Poit. (syn. *C. taitensis* Risso), is now thought to be a non-acid form of the Rangpur. Its origin is unknown. It was introduced into France from Tahiti by way of England in 1813; was being grown in Paris by the botanist Noisitte in 1915. It was catalogued by a San Francisco nurseryman in 1882.

The fruit is oblate to spherical, 1 1/2 to 2 in (4-5 cm) wide, furrowed and rounded or slightly necked at the base, the apex rounded or with a flat nipple; peel is orange with small oil glands; thin; pulp is orange, in 7 to 10 segments, juicy, slightly limelike in aroma and flavor but bland with scarcely any acidity; seedless, or with 3 to 6 small, abortive seeds.

The tree is a dwarf, spreading, thornless, with oblong to elliptic, finely-toothed leaves having narrowly-winged petioles; the new growth is deep-purple; flowers are fragrant and purple outside. Grown from cuttings or airlayers, the tree is widely sold in the United States as a potted "miniature orange", especially in the Christmas season when it bears flowers and fruits concurrently.

Morton, J. 1987. Citron. p. 179–182. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Citron

Citrus medica Linn.

A fruit better known to most consumers in its preserved rather than in its natural form, the citron, *Citrus medica* Linn., is called in French, *cedrat, cidratier, citronnier des Juifs;* in Spanish, *cidra, poncil, poncidre, cedro limón, limón cidra, limón Francés*, though in Central America it is often referred to as *toronja*, the popular Spanish name for grapefruit. In Portuguese, it is *cidrao;* in Italian, *cedro* or *cedrone;* in German, *cedratzitrone* or *cederappelen;* in Dutch, *citroen;* in India, *citron, beg-poora*, or *leemoo;* in Malaya, *limau susu, limau mata kerbau, limau kerat lingtang;* in Thailand, *som-mu, som manao* or *som ma-nguâ;* in Laos, *manao ripon, mak vo* or *mak nao;* in Vietnam, *thank-yen* or *chanh;* in Samoa, *tipolo* or *moli-apatupatu;* in China, *kou-yuan.* Theophrastus wrote of it as the Persian, or Median, Apple, and it was later called the Citrus Apple.

Description

The citron is borne by a slow-growing shrub or small tree reaching 8 to 15 ft (2.4-4.5 m) high with stiff branches and stiff twigs and short or long spines in the leaf axils. The leaflets are evergreen,

Plate XXI: CITRON, *Citrus medica*

lemon-scented, ovate-lanceolate or ovate elliptic, 2 1/2 to 7 in (6.25-18 cm) long; leathery, with short, wingless or nearly wingless petioles; the flower buds are large and white or purplish; the fragrant flowers about 1 1/2 in (4 cm) wide, in short clusters, are mostly perfect but some male because of pistil abortion; 4- to 5-petalled, often pinkish or purplish on the outside, with 30 to 60 stamens. The fruit is fragrant, mostly oblong, obovoid or oval, occasionally pyriform, but highly variable; various shapes and smooth or rough fruits sometimes occurring on the same branch; one form is deeply divided from the apex into slender sections; frequently there is a protruding style; size also varies greatly from 3 1/2 to 9 in or even 1 ft (9-22.8 or 30 cm) long; peel is yellow when fully ripe; usually rough and bumpy but sometimes smooth; mostly very thick, fleshy, tightly clinging; pulp pale-yellow or greenish divided into as many as 14 or 15 segments, firm, not very juicy, acid or sweet; contains numerous monoembryonic seeds, ovoid, smooth, white within.

Origin and Distribution

The citron's place of origin is unknown but seeds were found in Mesopotamian excavations dating back to 4000 B.C. The armies of Alexander the Great are thought to have carried the citron to the Mediterranean region about 300 B.C. A Jewish coin struck in 136 B.C. bore a representation of the citron on one side. A Chinese writer in AD 300 spoke of a gift of "40 Chinese bushels of citrons from Ta-ch'in" in AD 284. Ta-ch'in is understood to mean the Roman Empire. The citron was a staple, commercial food item in Rome in AD 301. There are wild citron trees in Chittagong, Sitakund Hill, Khasi and Garo hills of northern India. Dioscorides mentioned citron in the 1st Century AD and Pliny called it *malus medica, malus Assyria* and *citrus* in AD 177. The fruit was imported into Greece from Persia (now Iran). Greek colonists began growing the citron in Palestine about 200 B.C. The tree is assumed to have been successfully introduced into Italy in the 3rd Century. The trees were mostly destroyed by barbarians in the 4th Century but those in the "Kingdom of Naples" and in Sardinia and Sicily survived. By the year 1003, the citron was commonly cultivated at Salerno and fruits (called *poma cedrina)* were presented as a token of gratitude to Norman lords. For centuries, this area supplied citron to the Jews in Italy, France and Germany for their Feast of the Tabernacles *(sukkot)* ceremony. Moses had specified the cone of the cedar, *hadar (kedros* in Greek) and when it fell into disfavor it was replaced by the citron, and the Palestine Greeks called the latter *kedromelon* (cedar apple). *Kedros* was Latinized as *cedrus* and this evolved into *citrus,* and subsequently into citron. For many years, most *Citrus* species were identified as botanical varieties of *Citrus medica.*

Spaniards probably brought the citron with other *Citrus* species to St. Augustine, Florida, though it could have survived there only in greenhouses. The tree was introduced into Puerto Rico in 1640. Commercial citron culture and processing began in California in 1880. The trees suffered severe cold damage in 1913 and, within a few years, the project was abandoned. From 1926 to 1936, there were scattered small plantings of citron in Florida, and particularly one on Terra Ceia Island, supplying fruits to the Hills Brothers Canning Company. The groves eventually succumbed to cold and today the citron is grown in southern Florida only occasionally as a curiosity. The main producing areas of citron for food use are Sicily, Corsica and Crete and other islands off the coasts of Italy, Greece and France, and the neighboring mainland. Citron is also grown commercially in the central, mountainous coffee regions of Puerto Rico. Some is candied locally but most is shipped in brine to the United States and Europe. Citron is casually grown in several other islands of the Caribbean and in Central and South America. It has been rather commonly grown in Brazil for many years. There have long been scattered citron trees in the Cauca Valley of Colombia. After 5 years of study, horticulturists decided in 1964 that commercial culture could be profitable. Citron trees are not uncommon in some of the Pacific Islands but are rare in the Philippines.

Varieties

Plate XXII: FINGERED CITRON, *Citrus medica* var. *sarcodactylus*

Citron cultivars are mainly of two types: 1) those with pinkish new growth, purple flower buds and purple-tinted petals, acid pulp and dark inner seed coat and chalazal spot; 2) those with no pink or purple tint in the new growth nor the flowers, with non-acid pulp, colorless inner seed coat, and pale-yellow chalazal spot. Among the better-known cultivars are:

'Corsican'–origin unknown but the leading citron of Corsica; introduced into the United States around 1891 and apparently the cultivar grown in California; ellipsoid or faintly obovate, furrowed at base; large; peel yellow, rough, lumpy, very thick, fleshy; pulp crisp, non-juicy, non-acid, seedy. Tree small, spreading, moderately thorny with some large spines.

'Diamante' ('Cedro Liscio'; possibly the same as 'Italian' and 'Sicilian')–of unknown origin but the leading cultivar in Italy and preferred by processor's elsewhere; long-oval or ellipsoid, furrowed at base, broadly nippled at apex; peel yellow, smooth or faintly ribbed; very thick, fleshy; pulp crisp, non-juicy, acid; seedy. Tree small, spreading, thorny as 'Corsican'. Very similar is a cultivar called "Earle" in Cuba.

'Etrog' ('Ethrog', 'Atrog'; *C. medica* var. *Ethrog* Engl.)–the leading cultivar in Israel; ellipsoid, spindle-shaped or lemon-like with moderate neck and often with persistent style at base; usually with prominent nipple at apex; medium-small as harvested; if not picked early, it will remain on the tree, continuing to enlarge for years until the branch cannot support it. For ritual use, the fruit should be about 5 oz (142 g) and not oblong in form. Peel is yellow, semi-rough and bumpy, faintly ribbed, thick, fleshy; flesh is crisp, firm, with little juice; acid; seedy. Tree is small, not vigorous; leaves rounded at apex and cupped. This cultivar has been the official citron for use in the Feast of the Tabernacles ritual but if unavailable any yellow, unblemished, lemon-sized citron with adhering style can be substituted.

'Fingered Citron', Plate XXI, ('Buddha's Hand', or 'Buddha's Fingers'; *C. medica* var. *sarcodactylus* Swing.); called *fu shou* in China, *bushukon* in Japan, *limau jari, jeruk tangan, limau* *kerat lingtang*, in Malaya; *djerook tangan* in Indonesia; *som-mu* in Thailand; *phât thu* in Vietnam. The fruit is corrugated, wholly or partly split into about 5 finger-like segments, with little or no flesh; seedless or with loose seeds. The fruit is highly fragrant and is placed as an offering on temple altars. It is commonly grown in China and Japan; is candied in China.

In India, there are several named types, in addition to the 'Fingered', in the northwest:

'Bajoura'–small, with thin peel, much acid juice.

'Chhangura'–believed to be the wild form and commonly found in a natural state; fruit rough, small, without pulp.

'Madhankri' or 'Madhkunkur'**–**fruit large with sweetish pulp.

'Turunj'–fruit large, with thick peel, the white inner part sweet and edible; pulp scant, dry, acid. Leaves are oblong and distinctly notched at the apex.

Climate

The citron tree is highly sensitive to frost; does not enter winter dormancy as early as other *Citrus* species. Foliage and fruit easily damaged by very intense heat and drought. Best citron locations are those where there are no extremes of temperature.

Soil

The soils where the citron is grown vary considerably, but the tree requires good aeration.

Propagation

Citron trees are grown readily from cuttings taken from branches 2 to 4 years old and quickly buried deeply in soil without defoliation. For quicker growth, the citron may be budded onto rough lemon, grapefruit, sour orange or sweet orange but the fruits do not attain the size of those produced from cuttings, and the citron tends to overgrow the rootstock. Rough lemon has been found too susceptible to gummosis to be employed as a rootstock for citron in Colombia. The 'Etrog', to be acceptable for ritual use, must not be budded or grafted.

Culture

The citron tree tends to put out water sprouts that should be eliminated, and the grower should prune branches hanging so low that they touch the ground with the weight of the fruit. Italian producers keep the tree low and stake the branches, and may even trim off the thorns, to avoid scarring of the fruits. The trees begin to bear when 3 years old and reach peak production in 15 years; die in about 25 years.

In 'Etrog' orchards, the Israeli growers are careful to take every precaution to protect the fruit, tying the fruiting branch securely in place and trimming away any twigs that might touch the fruit. To avoid moving irrigation equipment through the groves, the trees are manually watered and frequently sprayed to eliminate destructive insects.

If citrons are allowed to fully ripen on the tree they will be very aromatic and the peel yellow, the inner peel very tender. In India, a fruiting branch may be bent down and the immature fruit put into a jar shaped like a human head (or other form) so that the mature fruit will be of the same shape. These are sold as curiosities and are said to be intensely fragrant.

Harvesting

The citron tree blooms nearly all year, but mostly in spring and the spring blooms produce the major part of the crop. The fruit is dark-green when young, takes 3 months to turn yellow. To retain the green color, firmness and uniformity desired by the dealers in candied citron, the fruit must be picked when only 5 to 6 in (12.5-15 cm) long and 3 to 4 in (7.5-10 cm) wide. Mature trees yield an average of 66 lbs (30 kg) per year but exceptional trees have borne as much as 150 to 220 lbs (68-100 kg). 'Etrog' fruits are wrapped in hemp fiber immediately after picking. Those for local use are inspected by rabbis, and those for export by agents of the Ministry of Agriculture.

Pests and Diseases

The citron tree is undoubtedly subject to most of the pests that attack other *Citrus* species. The citrus bud mite *(Eriophyes sheldoni),* citrus rust mite (*Phyllocoptruta oleivora),* and snow scale *(Unaspis citri)* are among its major enemies.

Horticulturists in Florida report that citron trees in this state are nearly always unthrifty, are subject to gummosis, and usually in a state of decline and dieback, and are accordingly poor bearers.

Branch knot, caused by the fungus *Sphaeropsis tumefaciens*, was first noticed on citron trees in Puerto Rico in 1977. By 1983, it had become a serious threat to the local citron industry. The deformations become large and necrotic, lead to witches' broom, dieback and breaking of branches.

Food Uses

The most important part of the citron is the peel which is a fairly important article in international trade. The fruits are halved, depulped, immersed in seawater or ordinary salt water to ferment for about 40 days, the brine being changed every 2 weeks; rinsed, put in denser brine in wooden barrels for storage and for export. After partial de-salting and boiling to soften the peel, it is candied in a strong sucrose/glucose solution. The candied peel is sun-dried or put up in jars for future use. Candying is done mainly in England, France and the United States. The candied peel is widely employed in the food industry, especially as an ingredient in fruit cake, plum pudding, buns, sweet rolls and candy.

Puerto Rican food technologists reported in 1970 that the desalted citron could be dehydrated in a hot air tray dryer at 108º F (42.22º C), reducing the weight by 95% to lower costs of shipment, then stored in polyethylene bags and later reconstituted and candied. In 1979, after further experiments, it was announced that fresh citron cubes, blanched for 1/2 minute in water at 170º F (76.7º C) can be candied and the product is equal in quality to the brined and candied peel, and this procedure saves the costs of salt, storage, and shipping of heavy barrels. If the citron lacks flavor, a few orange or lemon leaves may be added to the sirup.

The fruit of the wild 'Chhangura' is pickled in India. In Indonesia, citron peel is eaten raw with rice. The entire fruit of the 'Fingered citron' is eaten.

If there is sufficient juice in the better cultivars, it is utilized for beverages and to make desserts. In

Guatemala, it is used as flavoring for carbonated soft-drinks. In Malaya, citron juice is used as a substitute for the juice of imported, expensive lemons. A product called "citron water" is made in Barbados and shipped to France for flavoring wine and vermouth.

In order to expand the market for citron, Puerto Rican workers have established that the green-mature fruits can be peeled by immersing in a boiling lye solution to save the labor of hand-peeling and then the fruits can be made into marmalade, jelly, and fruit bars that are crusty on the outside, soft within.

In Spain, a sirup made from the peel is used to flavor unpalatable medical preparations.

Food Value Per 100 g of Edible Portion*

Moisture	87.1 g
Protein	0.081 g
Fat	0.04 g
Fiber	1.1 g
Ash	0.41 g
Calcium	36.5 mg
Phosphorus	16.0 mg
Iron	0.55 mg
Carotene	0.009 mg
Thiamine	0.052 mg
Riboflavin	0.029 mg
Niacin	0.125 mg
Ascorbic Acid	368 mg

*According to analyses made in Central America.

Other Uses

Fruit: Chinese and Japanese people prize the citron for its fragrance and it is a common practice in central and northern China to carry a ripe fruit in the hand or place the fruit in a dish on a table to perfume the air of a room. The dried fruits are put with stored clothing to repel moths. In southern China, the juice is used to wash fine linen. Formerly, the essential oil was distilled from the peel for use in perfumery.

Leaves and twigs: In some of the South Pacific islands, "Cedrat Petitgrain Oil" is distilled from the leaves and twigs of citron trees for the French perfume industry.

Flowers: The flowers have been distilled for essential oil which has limited use in scent manufacturing.

Wood: Branches of the citron tree are used as walking-sticks in India. The wood is white, rather hard and heavy, and of fine grain. In India, it is used for agricultural implements.

Medicinal Uses: In ancient times and in the Middle Ages, the 'Etrog' was employed as a remedy for seasickness, pulmonary troubles, intestinal ailments and other disorders. Citron juice with wine was considered an effective purgative to rid the system of poison. In India, the peel is a remedy for dysentery and is eaten to overcome halitosis. The distilled juice is given as a sedative. The candied peel is sold in China as a stomachic, stimulant, expectorant and tonic. In West Tropical Africa, the citron is used only as a medicine, particularly against rheumatism. The flowers are used medicinally by the Chinese. In Malaya, a decoction of the fruit is taken to drive off evil spirits. A decoction of the shoots of wild plants is administered to improve appetite, relieve stomachache and expel intestinal worms. The leaf juice, combined with that of *Polygonum* and *Indigofera* is taken after childbirth. A leaf infusion is given as an antispasmodic. In Southeast Asia, citron seeds are given as a vennifuge. In Panama, they are ground up and combined with other ingredients and given as an antidote for poison. The essential oil of the peel is regarded as an antibiotic.

Morton, J. 1987. Kumquat. p. 182–185. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Kumquat

Fortunella sp. Swingle

Kumquats have been called "the little gems of the citrus family". They were included in the genus *Citrus* until about 1915 when Dr. Walter T. Swingle set them apart in the genus *Fortunella,* which embraces six Asiatic species. The common name, which has been spelled cumquat, or comquot, means "gold orange" in China. The Japanese equivalent is *kin kan* or *kin kit* for the round type, *too kin kan,* for the oval type. In Southeast Asia, the round is called *kin, kin kuit,* or *kuit xu,* and the oval, *chu tsu* or *chantu.* In Brazil, the trade name may be kumquat, kunquat, or *laranja de ouro, dos orientais.*

Description

The kumquat tree is slow-growing, shrubby, compact, 8 to 15 ft (2.4-4.5 m) tall, the branches light-green and angled when young, thornless or with a few spines. The apparently simple leaves are alternate, lanceolate, 1 1/4 to 3 3/8 in (3.25-8.6 cm) long, finely toothed from the apex to the middle, dark-green, glossy above, lighter beneath. Sweetly fragrant, 5-parted, white flowers are borne singly or 1 to 4 together in the leaf axils. The fruit is oval-oblong or round, 5/8 to 1 1/2 in (1.6-4 cm) wide; peel is golden-yellow to reddish-orange, with large, conspicuous oil glands, fleshy, thick, tightly clinging, edible, the outer layer spicy, the inner layer sweet; the pulp is scant, in 3 to 6 segments, not very juicy, acid to subacid; contains small, pointed seeds or sometimes none; they are green within.

Origin and Distribution

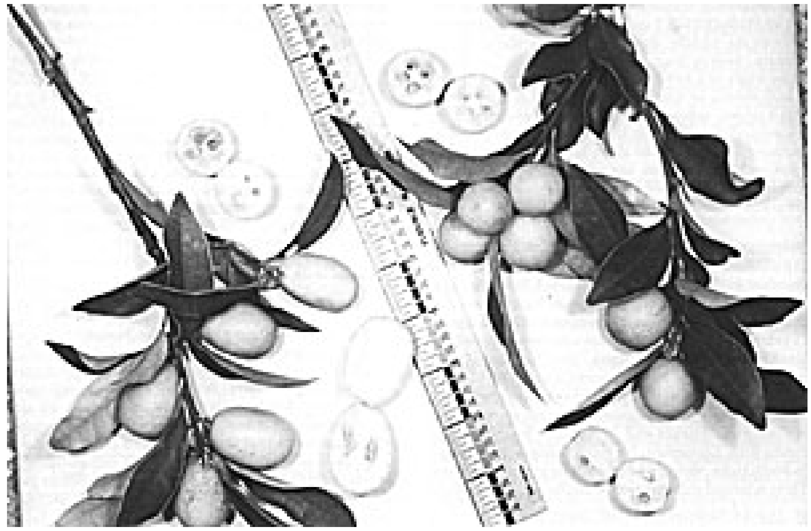


Fig. 45: Nagami, or Oval, kumquat *(Fortunella margarita)* (left); and Marumi, or Round, kumquat *(F. japonica)* (right).

Kumquats are believed native to China. They were described in Chinese literature in 1178 A.D. A European writer in 1646 mentioned the fruit as having been described to him by a Portuguese missionary who had labored 22 years in China. In 1712, kumquats were included in a list of plants cultivated in Japan. They have been grown in Europe and North America since the mid-19th Century, mainly as ornamental dooryard trees and as potted specimens in patios and greenhouses. They are grown mainly in California, Florida and Texas; to a lesser extent in Puerto Rico, Guatemala, Surinam, Colombia and Brazil. In South India, they can be grown only at high elevations. There is limited cultivation in Australia and South Africa.

Varieties

The various kumquats are distinguished as botanical species rather than as cultivars. The following are those most utilized for food:

'Hong Kong', or Hong Kong Wild (*F. Hindsii* Swing.), called *chin chü, shan chin kan,* and *chin tou* by the Chinese–native to Hong Kong and adjacent hilly and mountainous regions of Kwantung and Chekiang Provinces of China; nearly round, 5/8 to 3/4 in (1.6-2 cm) wide; peel orange or scarlet when ripe, thin, not very fleshy; pulp in only 3 or 4 small segments; seeds plump. Chinese people flock to the foothills to gather the fruits in season. In the western world, the very thorny shrub is grown only as an ornamental pot plant.

'Marumi', or Round Kumquat *(F. japonica* Swing., syn. *Citrus maduremis* Lour.)–fully described for the first time in 1784; introduced into Florida from Japan by Glen St. Mary and Royal Palm nurseries in 1885; fruit is round, slightly oblate or obovate; to 1 1/4 in (3.2 cm) long; peel is golden-yellow, smooth, with large oil glands, thin, aromatic and spicy; pulp, in 4 to 7 segments, is scant and acid, with 1 to 3 seeds which are smaller than those of 'Nagami'. The tree reaches 9 ft (2.75 m); is otherwise similar to that of 'Nagami' except that it is slightly thorny, has somewhat smaller leaves and is considerably more cold-tolerant; bears at the same season.

'Meiwa', or Large Round Kumquat *(F. crassifolia* Swing.), called *ninpo* or *neiha kinkan* in Japan–possibly a hybrid between 'Nagami' and 'Marumi'; introduced from Japan by the United States Department of Agriculture between 1910 and 1912; short-oblong to round, about 1 1/2 in (4 cm) wide; peel orange-yellow, very thick, sweet; pulp usually in 7 segments, relatively sweet or subacid; often seedless or with few seeds. The tree is a dwarf, frequently thornless or having short, stout spines; the leaves differ from those of other kumquats in being very thick and rigid and partly folded lengthwise; they are pitted with numerous dark-green oil glands. Extensively grown in Chekiang Province, China, and less commonly in Fukuoka Prefecture, Japan. There is an ornamental form with variegated fruits in Japan. This kumquat is the best for eating fresh; is still somewhat rare in the United States.

'Nagami', or Oval, Kumquat (*F. margarita* Swing.)–plants introduced from China into London in 1846 by Robert Fortune, plant explorer for the Royal Horticultural Society; was reported in North America in 1850; introduced into Florida from Japan by Glen St. Mary and Royal Palm nurseries in 1885; obovate or oblong; up to 1 3/4 in (4.5 cm) long and 1 3/16 in (3 cm) wide; pulp divided into 4 or 5 segments, contains 2 to 5 seeds. In season October to January. Tree to 15 ft (4.5 m) tall. A mature specimen on rough lemon rootstock at Oneco, Florida, in 1901, bore a crop of 3,000 to 3,500 fruits. This is the most often cultivated kumquat in the United States.

Climate

Robert Fortune reported that the 'Nagami' kumquat required a hot summer, ranging from 80º to 100º F (26.67º-37.78º C), but could withstand 10 to 15 degrees of frost without injury. It grows in the tea regions of China where the climate is too cold for other citrus fruits, even the Satsuma orange. The trees differ also from other Citrus species in that they enter into a period of winter dormancy so profound that they will remain through several weeks of subsequent warm weather without putting out new shoots or blossoms. Despite their ability to survive low temperatures, as in the vicinity of San Francisco, California, the kumquat trees grow better and produce larger and sweeter fruits in warmer regions.

Propagation

Kumquats are rarely grown from seed as they do not do well on their own roots. In China and Japan they are grafted onto the trifoliate orange (*Poncirus trifoliata*). This has been found the best rootstock for kumquats in northern Florida and California and for dwarfing for pot culture. Sour orange and grapefruit are suitable rootstocks for southern Florida. Rough lemon is unsatisfactory in moist soils and tends to be too vigorous for the slow-growing kumquats.

Culture

In orchard plantings, kumquats on trifoliate orange can be set 8 to 12 ft (2.4-3.65 m) apart, or they may be spaced at 5 ft (1.5 m) in hedged rows 12 ft (3.65 m) apart. For pot culture, they must be dwarfed; must not be allowed to become pot-bound, and need faithful watering to avoid dehydration and also need regular feeding.

Harvesting

For the fresh fruit market, it has been customary to clip the fruits individually with 2 or 3 leaves attached to the stem. For decorating gift packs of other citrus fruits, or for use as table decorations, leafy branches bearing several fruits are clipped. This practice has been common in Florida but in cooler California the tree is not sufficiently vigorous to stand much depletion.

Keeping Quality

Because of the thick peel, the kumquat has good keeping quality and stands handling and shipment well.

Pests and Diseases

Potted kumquats are subject to mealybug infestations. Dooryard and orchard trees may be attacked by most of the common citrus pests. They are highly resistant or even immune to citrus canker. The following diseases are recorded by the Florida Department of Agriculture as observed on kumquats: scab *(Elsinoë fawcetti* and its conidial stage, *Sphaceloma fawcetti;* algal leaf spot, or green scurf *(Cephaleuros virescens);* greasy spot *(Cercospora citri-grisea);* anthracnose (*Colletotrichum gloeosporioides);* fruit rot, melanose (Diaporthe *citri);* stem-end rot and gummosis *(Physalospora rhodina).*

Food Uses

Fresh kumquats, especially the 'Meiwa', can be eaten raw, whole. For preserving, they should be left until they lose some of their moisture and acquire richer flavor. The fruits are easily preserved whole in sugar sirup. Canned kumquats are exported from Taiwan and often served as dessert in Chinese restaurants. For candying, the fruits are soaked in hot water with baking soda, next day cut open and cooked briefly each day for 3 days in heavy sirup, then dried and sugared. Kumquats are excellent for making marmalade, either alone or half-and-half with calamondins. The fruit may be pickled by merely packing in jars of water, vinegar, and salt, partially sealing for 4 to 5 days, changing the brine, sealing and letting stand for 6 to 8 weeks. To make sweet pickles, halved fruits are boiled until tender, drained, boiled again in a mixture of corn sirup, vinegar, water and sugar, with added cloves and cinnamon, and then baked until the product is thick and transparent. Kumquat sauce is made by cooking chopped, seeded fruits with honey, orange juice, salt and butter.

Food Value Per 100 g of Edible Portion *(raw)**

Calories	274
Protein	3.8 g
Fat	0.4g
Carbohydrates	72.1 g
Calcium	266 mg
Phosphorus	97 mg
Iron	1.7 mg
Sodium	30 mg
Potassium	995 mg
Vitamin A	2,530 I.U.
Thiamine	0.35 mg
Riboflavin	0.40 mg
Niacin	
Ascorbic Acid	151 mg

*According to analyses published by the United States Department of Agriculture.

Morton, J. 1987. Sundry Hybrids and Rootstocks. p. 185–186. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sundry Hybrids and Rootstocks

Citrus

Rutaceae

TRIFOLIATE ORANGE (*Poncirus trifoliata* Raf., syn. *Citrus trifoliata* Linn.) grown for thousands of years in central and northern China; from the 8th Century in Japan if not earlier; a small, fast-growing, deciduous tree, with palmate leaves usually having 3 leaflets, rarely 4 or 5; flowers showy, white, 5-petalled; fruits round to pear-shaped, 1 1/4 to 2 in (3.2-5 cm) wide; peel fragrant, dull-yellow, minutely downy, rough, with numerous oil glands, thick; pulp scant, sour, with a little acrid oil in the center; seeds ovoid, plump, numerous. Immature fruits and dried mature fruits used medicinally in China. In southern Germany, fruit juice after 2 weeks' storage used to make a flavoring sirup, the peel is candied and used as a spice, and is a source of pectin. The plant is much grown as an ornamental in cool areas of Europe, Asia and North America. In Brazil, it is valued as a protective hedge against animals and human trespassers. Seedlings are important in most citrus-growing areas as rootstocks for various *Citrus* and related species.

CITRANGE (X *Citroncirus Webberi* J. Ingram & H. E. Moore); a trifoliate orange X sweet orange hybrid created by Dr. Walter Swingle or under his direction, beginning in 1897. Tree is evergreen or semi-deciduous, usually trifoliolate, deciduous; not as cold-resistant as the trifoliate orange. Fruits more or less aromatic, outwardly orange-like; 2 to 3 in (5-7.5 cm) wide; peel yellow to deep-orange, may be hairy or non-hairy, wrinkled, ribbed, or smooth; thin; pulp often very juicy and tender, richly flavored, highly acid, slightly bitter; seedless or with a few, mostly polyembryonic, seeds. Certain cultivars, 'Coleman', 'Morton', 'Rusk' and 'Savage', especially 'Rusk', yield juice valued for ade and mixed drinks. They are also desirable for pie, jams and marmalade. 'Troyer' ('Carrizo'), a 'Washington Navel' X trifoliate orange hybrid created by Dr. Walter Reuther in 1909, named 'Troyer' by Swingle in 1934 and renamed 'Carrizo' in 1938, has become a very important rootstock, particularly in California. When budded onto trifoliate orange, can be grown in Georgia.

In early 1985, citrange hybrids 'C35' and 'C32' ('Ruby' orange X trifoliate orange) were released by the Citrus Research Center, Riverside, California, for trial as rootstocks because of their resistance to the citrus nematode, also to *Phytophthora spp.* and the tristeza virus.

CITRANGEQUAT *(Fortunella* sp. X citrange). The first crosses were made by Dr. Swingle at Eustis, Florida, in 1909. Tree is vigorous, erect, thorny or thornless, with mostly trifoliolate leaves;

highly cold-resistant. Fruit resembles the oval kumquat, mostly very acid. One cultivar, 'Thomasville', becomes edible when fully mature, though it is relatively seedy. It is very juicy, valued for eating out-of-hand, for ade and marmalade. The tree is strongly resistant to citrus canker and is very ornamental. Two other cultivars, 'Swinton' and 'Telfair', have few seeds, but are less desirable; have limited use for juice and as ornamentals.

LIMEQUAT (X *Citrofortunella* spp.)–Mexican lime X kumquat hybrids made by Dr. Swingle in 1909, described and named in 1913. Tree vigorous, evergreen, the single leaflets having narrowly-winged petioles; nearly spineless or with a few short thorns; more cold-tolerant than the lime but not as hardy as the kumquat; very resistant to withertip. Fruit much like the Mexican lime. There are three named cultivars:

'Eustis' (X *C. floridana* J. Ingram & H. E. Moore)–Mexican lime crossed with round kumquat; oval or round, 1 1/8 to 1 1/2 in (2.8-4 cm) wide; peel pale-yellow, smooth, glossy, with prominent oil glands, thin, edible; pulp light greenish in 6 to 9 segments, tender, juicy, very acid, with 5 to 12 small seeds. Of excellent quality, nearly everbearing but mainly in fall-to-winter. Tree has small spines and pure-white buds and flowers; prolific.

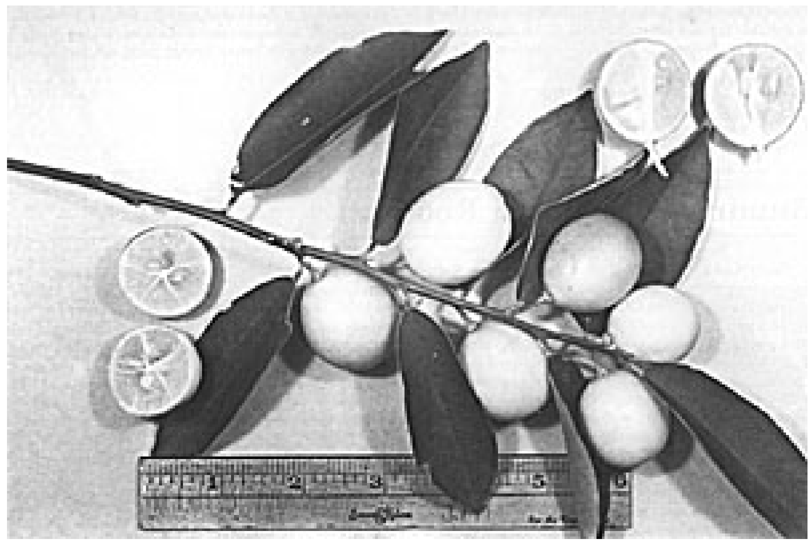


Fig. 46: 'Eustis' limequat (X *Citrafortunella floridana),* a cross between a Mexican lime and the Marumi kumquat.

'Lakeland' (different seed from same hybrid parent)–oval, 1 1/4 to 2 1/4 in (4.5-7 cm) wide; peel bright-yellow, smooth, thin; pulp in 5 to 8 segments, pale-yellow, juicy, pleasantly acid, with 2 to 9 large seeds. Tree nearly spineless; flowers white with pink streaks.

'Tavares' (X *C.* Swinglei J. Ingram & H. E. Moore)–a Mexican lime X oval kumquat hybrid; obovate to oval, about 1 1/4 to 1 7/8 in (3.2-4.75 cm) wide; peel pale orange-yellow, smooth, thin, tender, edible; pulp buff-yellow, in 7 to 8 segments, juicy, very acid, with 6 to 11 large seeds. Tree vigorous with short spines and pink flower buds.

Limequats are cultivated as dooryard trees to a limited extent in central Florida; are more commonly grown in California as potted ornamentals.

VOLKAMER LEMON is described and illustrated in great detail by H. Chapot as *Citrus volkameriana* Pasquale, though the author views it as a hybrid between the lemon and possibly the sour orange. Tanaka and others suggest that it may be a variety of mandarin lime.

The tree is a little smaller than the average lemon tree. Young seedlings bear a few spines 1/2 to 3/5 in (12.5-15 mm) long, but these disappear with age and are produced only occasionally on older specimens. The leaves are short-petioled, ellipsoid, more or less toothed, 3 3/4 to 6 in (9.5-15 cm) long. The flowers, only slightly fragrant, short-stalked, 3-to-6-petalled, 1 3/8 in (3.5 cm) wide, are borne in small clusters all along the branches and at the tips. The fruit, borne profusely, is lemon-shaped, 2 1/4 in (5.7 cm) long, 2 1/8 in (5.4 cm) wide, rough, bright-reddish-orange. The yellow-orange pulp, in 7 to 11 segments, is very juicy, acid, faintly bitter, of agreeable odor and flavor, with few seeds. The fruiting tree is exceptionally ornamental and the fruit can be used as a substitute for the lemon.

The Volkamer lemon has been known for more than 3 centuries. In the mid-1950's, it was reported in Italy to be a promising rootstock for lemon because of its high resistance to *malsecco (Deuterophoma tracheiphila)* and foot-rot *(Phytophthora sp.)*. Trials in Morocco in 1972-1973 with scions of sour orange, sweet orange, mandarin orange, grapefruit, lemon and rough lemon, and inoculated Volkamer rootstock, showed it to be highly susceptible to gummosis caused by *Phytophthora citrophthora* in contrast to 'Carrizo' citrange rootstock's high resistance. The degree of necrosis varied somewhat with the scion. (See Chapot in Bibliography).

During tristeza studies on Reunion, workers noted on several trunks of the Volkamer lemon woody galls associated with a wood-bark-socket stem-pitting, according to Aubert *et al.* Protopapadakis and Zambettakis have reported that, in Crete, Volkamer lemon has proved to be second only to sour orange in resistance to *mal secco.*

Morton, J. 1987. Bael Fruit. p. 187–190. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Bael Fruit

Aegle marmelos Correa

syn. *Feronia pellucida* Roth, *Crataeva marmelos* L.

Though more prized for its medicinal virtues than its edible quality, this interesting member of the family Rutaceae is, nevertheless, of sufficient importance as an edible fruit to be included here. The bael fruit, *Aegle marmelos* Correa (syns. *Feronia pellucida* Roth., *Crataeva marmelos* L.), is also called Bengal quince, Indian quince, golden apple, holy fruit, stone apple, *bel*, *bela*, *sirphal*, *maredoo* and other dialectal names in India; *matum* and *mapin* in Thailand; *phneou* or *pnoi* in Cambodia; *bau nau* in Vietnam; *bilak*, or *maja pahit* in Malaya; *modjo* in Java; *oranger du Malabar* in French; *marmelos* in Portuguese. Sometimes it is called elephant apple, which causes confusion with a related fruit of that name, *Feronia limonia* Swingle (q.v.).

Description

Fig. 47: A hard-shelled bael fruit (*Aegle marmelos),* of the type valued more for medicinal purposes than for eating.

The bael fruit tree is slow-growing, of medium size, up to 40 or 50 ft (12-15 m) tall with short trunk, thick, soft, flaking bark, and spreading, sometimes spiny branches, the lower ones drooping. Young suckers bear many stiff, straight spines. A clear, gummy sap, resembling gum arabic, exudes from wounded branches and hangs down in long strands, becoming gradually solid. It is sweet at first taste and then irritating to the throat. The deciduous, alternate leaves, borne singly or in 2's or 3's, are composed of 3 to 5 oval, pointed, shallowly toothed leaflets, 1 1/2 to 4 in (4-10 cm) long, 3/4 to 2 in (2-5 cm) wide, the terminal one with a long petiole. New foliage is glossy and pinkish-maroon. Mature leaves emit a disagreeable odor when bruised. Fragrant flowers, in clusters of 4 to 7 along the young branchlets, have 4 recurved, fleshy petals, green outside, yellowish inside, and 50 or more greenish-yellow stamens. The fruit, round, pyriform, oval, or oblong, 2 to 8 in (5-20 cm) in diameter, may have a thin, hard, woody shell or a more or less soft rind, gray-green until the fruit is fully ripe, when it turns yellowish. It is dotted with aromatic, minute oil glands. Inside, there is a hard central core and 8 to 20 faintly defined triangular segments, with thin, dark-orange walls, filled with aromatic, pale-orange, pasty, sweet, resinous, more or less astringent, pulp. Embedded in the pulp are 10 to 15 seeds, flattened-oblong, about 3/8 in (1 cm) long, bearing woolly hairs and each enclosed in a sac of adhesive, transparent mucilage that solidifies on drying.

Origin and Distribution

The tree grows wild in dry forests on hills and plains of central and southern India and Burma, Pakistan and Bangladesh, also in mixed deciduous and dry dipterocarp forests of former French Indochina. Mention has been found in writings dating back to 800 B.C. It is cultivated throughout India, mainly in temple gardens, because of its status as a sacred tree; also in Ceylon and northern Malaya, the drier areas of Java, and to a limited extent on northern Luzon in the Philippine Islands where it first fruited in 1914. It is grown in some Egyptian gardens, and in Surinam and Trinidad. Seeds were sent from Lahore to Dr. Walter T. Swingle in 1909 (P.I. No. 24450). Specimens have been maintained in citrus collections in Florida and in agriculture research stations but the tree has never been grown for its fruit in this state except by Dr. David Fairchild at his home, the "Kampong", in Coconut Grove, after he acquired a taste for it, served with jaggery (palm sugar), in Ceylon.

Climate

The bael fruit tree is a subtropical species. In the Punjab, it grows up to an altitude of 4,000 ft (1,200 m) where the temperature rises to 120º F (48.89º C) in the shade in summer and descends to 20º F (-6.67º C) in the winter, and prolonged droughts occur. It will not fruit where there is no long, dry season, as in southern Malaya.

Soil

The bael fruit is said to do best on rich, well-drained soil, but it has grown well and fruited on the oolitic limestone of southern Florida. According to L. B. Singh (1961), it "grows well in swampy, alkaline or stony soils". . . "grows luxuriantly in the soils having pH range from 5 to 8". In India it has the reputation of thriving where other fruit trees cannot survive.

Varieties

One esteemed, large cultivar with thin rind and few seeds is known as **'Kaghzi'**. Dr. L.B. Singh and co-workers at the Horticultural Research Institute, Saharanpur, India, surveyed bael fruit trees in Uttar Padesh, screened about 100 seedlings, selected as the most promising for commercial planting: **'Mitzapuri', 'Darogaji', 'Ojha', 'Rampuri', 'Azamati', 'Khamaria'.** Rated the best was 'Mitzapuri', with very thin rind, breakable with slight pressure of the thumb, pulp of fine texture, free of gum, of excellent flavor, and containing few seeds.

S.K. Roy, in 1975, reported on the extreme variability of 24 cultivars collected in Agra, Calcutta, Delhi and Varanasi. He decided that selections should be made for high sugar content and low levels of mucilage, tannin and other phenolics.

Only the small, hard-shelled type is known in Florida and this has to be sawed open, cracked with a hammer, or flung forcefully against a rock. Fruits of this type are standard for medicinal uses rather than for consuming as normal food.

Propagation

The bael fruit is commonly grown from seed in nurseries and transplanted into the field. Seedlings show great variation in form, size, texture of rind, quantity and quality of pulp and number of seeds. The flavor ranges from disagreeable to pleasant. Therefore, superior types must be multiplied vegetatively. L.B. Singh achieved 80% to 95% success in 1954 when he budded 1-month-old shoots onto 2-year-old seedling bael rootstocks in the month of June. Experimental shield-budding onto related species of *Afraegle* and onto *Swinglea glutinosa* Merr. has been successful. Occasionally, air-layers or root cuttings have been used for propagation.

Culture

The tree has no exacting cultural requirements, doing well with a minimum of fertilizer and irrigation. The spacing in orchards is 25 to 30 ft (6-9 m) between trees. Seedlings begin to bear in 6 to 7 years, vegetatively propagated trees in 5 years. Full production is reached in 15 years. In India flowering occurs in April and May soon after the new leaves appear and the fruit ripens in 10 to 11 months from bloom–March to June of the following year.

Harvesting

Normally, the fruit is harvested when yellowish-green and kept for 8 days while it loses its green tint. Then the stem readily separates from the fruit. The fruits can be harvested in January (2 to 3 months before full maturity) and ripened artificially in 18 to 24 days by treatment with 1,000 to 1,500 ppm ethrel (2-chloroethane phosphonic acid) and storage at 86º F (30º C). Care is needed in harvesting and handling to avoid causing cracks in the rind.

A tree may yield as many as 800 fruits in a season but an average crop is 150 to 200, or, in the better cultivars, up to 400.

Keeping Quality

Normally-harvested bael fruits can be held for 2 weeks at 86º F (30º C), 4 months at 48.2º F (9º C). Thereafter, mold is likely to develop at the stem-end and any crack in the rind.

Pests and Diseases

The bael fruit seems to be relatively free from pests and diseases except for the fungi causing deterioration in storage.

Food Uses

Bael fruits may be cut in half, or the soft types broken open, and the pulp, dressed with palm sugar, eaten for breakfast, as is a common practice in Indonesia. The pulp is often processed as nectar or "squash" (diluted nectar). A popular drink (called "sherbet" in India) is made by beating the seeded pulp together with milk and sugar. A beverage is also made by combining bael fruit pulp with that of tamarind. These drinks are consumed perhaps less as food or refreshment than for their medicinal effects.

Mature but still unripe fruits are made into jam, with the addition of citric acid. The pulp is also converted into marmalade or sirup, likewise for both food and therapeutic use, the marmalade being eaten at breakfast by those convalescing from diarrhea and dysentery. A firm jelly is made from the pulp alone, or, better still, combined with guava to modify the astringent flavor. The pulp is also pickled.

Bael pulp is steeped in water, strained, preserved with 350 ppm $S0_2$, blended with 30% sugar, then dehydrated for 15 hrs at 120º F (48.89º C) and pulverized. The powder is enriched with 66 mg per 100 g ascorbic acid and can be stored for 3 months for use in making cold drinks ("squashes"). A confection, bael fruit toffee, is prepared by combining the pulp with sugar, glucose, skim milk powder and hydrogenated fat. Indian food technologists view the prospects for expanded bael fruit processing as highly promising.

The young leaves and shoots are eaten as a vegetable in Thailand and used to season food in Indonesia. They are said to reduce the appetite. An infusion of the flowers is a cooling drink.

Food Value Per 100 g of Edible Portion*

Water	54.96-61.5 g
Protein	1.8-2.62 g
Fat	0.2-0.39 g
Carbohydrates	28.11-31.8 g
Ash	1.04-1.7 g
Carotene	55 mg
Thiamine	0.13 mg

Riboflavin	1.19 mg
Niacin	1.1 mg
Ascorbic Acid	8-60 mg
Tartaric Acid	2.11 mg

*Fresh bael fruit, as analyzed in India and in the Philippines.

The pulp also contains a balsam-like substance, and 2 furocoumarins-psoralen and marmelosin ($C_{13}H_{12}O_3$), highest in the pulp of the large, cultivated forms.

There is as much as 9% tannin in the pulp of wild fruits, less in the cultivated types. The rind contains up to 20%. Tannin is also present in the leaves, as is skimmianine.

The essential oil of the leaves contains *d*-limonene, 56% *a*-d-phellandrene, cineol, citronellal, citral; 17% p-cyrnene, 5% cumin aldehyde. The leaves contain the alkaloids *O*-(3,3-dimethylallyl)-halfordinol, *N*-2-ethoxy-2-(4-methoxyphenyl) ethylcinnamide, *N*-2-methoxy-2-[4-(3',3'-dimethyalloxy) phenyll]ethylcinnamide, and *N*-2-methoxy-2-(4-methoxyphenyl)-ethylcinnamamide.

Toxicity

The leaves are said to cause abortion and sterility in women. The bark is used as a fish poison in the Celebes. Tannin, ingested frequently and in quantity over a long period of time, is antinutrient and carcinogenic.

Other Uses

Fruit: The fruit pulp has detergent action and has been used for washing clothes. Quisumbing says that bael fruit is employed to eliminate scum in vinegar-making. The gum enveloping the seeds is most abundant in wild fruits and especially when they are unripe. It is commonly used as a household glue and is employed as an adhesive by jewelers. Sometimes it is resorted to as a soap-substitute. It is mixed with lime plaster for waterproofing wells and is added to cement when building walls. Artists add it to their watercolors, and it may be applied as a protective coating on paintings.

The limonene-rich oil has been distilled from the rind for scenting hair oil. The shell of hard fruits has been fashioned into pill- and snuff boxes, sometimes decorated with gold and silver. The rind of the unripe fruit is employed in tanning and also yields a yellow dye for calico and silk fabrics.

Leaves: In the Hindu culture, the leaves are indispensable offerings to the 'Lord Shiva'. The leaves and twigs are lopped for fodder.

Flowers: A cologne is obtained by distillation from the flowers.

Wood: The wood is strongly aromatic when freshly cut. It is gray-white, hard, but not durable; has been used for carts and construction, though it is inclined to warp and crack during curing. It is best utilized for carving, small-scale turnery, tool and knife handles, pestles and combs, taking a fine polish.

Medicinal Uses: The fresh ripe pulp of the higher quality cultivars, and the "sherbet" made from it, are taken for their mild laxative, tonic and digestive effects. A decoction of the unripe fruit, with fennel and ginger, is prescribed in cases of hemorrhoids. It has been surmised that the psoralen in the pulp increases tolerance of sunlight and aids in the maintaining of normal skin color. It is employed in the treatment of leucoderma. Marmelosin derived from the pulp is given as a laxative and diuretic. In large doses, it lowers the rate of respiration, depresses heart action and causes sleepiness.

For medicinal use, the young fruits, while still tender, are commonly sliced horizontally and sun-dried and sold in local markets. They are much exported to Malaya and Europe. Because of the astringency, especially of the wild fruits, the unripe bael is most prized as a means of halting diarrhea and dysentery, which are prevalent in India in the summer months. Bael fruit was resorted to by the Portuguese in the East Indies in the 1500's and by the British colonials in later times.

A bitter, light-yellow oil extracted from the seeds is given in 1.5 g doses as a purgative. It contains 15.6% palmitic acid, 8.3% stearic acid, 28.7% linoleic and 7.6% linolenic acid. The seed residue contains 70% protein.

The bitter, pungent leaf juice, mixed with honey, is given to allay catarrh and fever. With black pepper added, it is taken to relieve jaundice and constipation accompanied by edema. The leaf decoction is said to alleviate asthma. A hot poultice of the leaves is considered an effective treatment for ophthahnia and various inflammations, also febrile delirium and acute bronchitis.

A decoction of the flowers is used as eye lotion and given as an antiemetic. The bark contains tannin and the cournarin, aegelinol; also the furocourmarin, marmesin; umbelliferone, a hydroxy coumarin; and the alkaloids, fagarine and skimmianine. The bark decoction is administered in cases of malaria. Decoctions of the root are taken to relieve palpitations of the heart, indigestion, and bowel inflammations; also to overcome vomiting.

The fruit, roots and leaves have antibiotic activity. The root, leaves and bark are used in treating snakebite. Chemical studies have revealed the following properties in the roots: psoralen, xanthotoxin, *O*-methylscopoletin, scopoletin, tembamide, and skimmin; also decursinol, haplopine and aegelinol, in the root bark.

Morton, J. 1987. Wood-Apple. p. 190–191. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Wood-Apple

Feronia limonia Swingle

Feronia elephantum Correa

Limonia acidissima L.

Schinus limonia L.

The wood-apple, *Feronia limonia* Swingle (syns. *F. elephantum* Correa; *Limonia acidissima* L.; *Schinus limonia* L.) is the only species of its genus, in the family Rutaceae. Besides wood-apple, it may be called elephant apple, monkey fruit, curd fruit, *kath bel* and other dialectal names in India. In Malaya it is *gelinggai* or *belinggai;* in Thailand, *ma-khwit;* in Cambodia, *kramsang;* in Laos, *ma-fit.* In French, it is *pomme d' elephant, pomme de bois*, or *citron des mois.*

Description

The slow-growing tree is erect, with a few upward-reaching branches bending outward near the summit where they are subdivided into slender branchlets drooping at the tips. The bark is ridged, fissured and scaly and there are sharp spines :3/4 to 2 in (2-5 cm) long on some of the zigzag twigs. The deciduous, alternate leaves, 3 to 5 in (7.5-12.5 cm) long, dark-green, leathery, often minutely toothed, blunt or notched at the apex, are dotted with oil glands and slightly lemon-scented when crushed. Dull-red or greenish flowers to 1/2 in (1.25 cm) wide are borne in small, loose, terminal or lateral panicles. They are usually bisexual. The fruit is round to oval, 2 to 5 in (5-12.5 cm) wide, with a hard, woody, grayish-white, scurfy rind about 1/4 in (6 mm) thick. The pulp is brown, mealy, odorous, resinous, astringent, acid or sweetish, with numerous small, white seeds scattered through it.

Origin and Distribution

The wood-apple is native and common in the wild in dry plains of India and Ceylon and cultivated along roads and edges of fields and occasionally in orchards. It is also frequently grown throughout Southeast Asia, in northern Malaya and on Penang Island. In India, the fruit was traditionally a "poor man's food" until processing techniques were developed in the mid-1950's.

Varieties

There are 2 forms, one with large, sweetish fruits; one with small, acid fruits.

Climate

The tree grows up to an elevation of 1,500 ft (450 m) in the western Himalayas. It is said to require a monsoon climate with a distinct dry season.

Soil

Throughout its range there is a diversity of soil types, but it is best adapted to light soils.

Propagation

The wood-apple is generally grown from seeds though seedlings will not bear fruit until at least 15 years old. Multiplication may also be by root cuttings, air-layers, or by budding onto self-seedlings to induce dwarfing and precociousness.

Season

In Malaya, the leaves are shed in January, flowering occurs in February and March, and the fruit matures in October and November. In India, the fruit ripens from early October through March.

Harvesting

The fruit is tested for maturity by dropping onto a hard surface from a height of 1 ft (30 cm). Immature fruits bounce, while mature fruits do not. After harvest, the fruit is kept in the sun for 2 weeks to fully ripen.

Food Uses

The rind must be cracked with a hammer. The scooped-out pulp, though sticky, is eaten raw with or without sugar, or is blended with coconut milk and palm-sugar sirup and drunk as a beverage, or frozen as an ice cream. It is also used in chutneys and for making jelly and jam. The jelly is purple and much like that made from black currants.

A bottled nectar is made by diluting the pulp with water, passing through a pulper to remove seeds and fiber, further diluting, straining, and pasteurizing. A clear juice for blending with other fruit juices, has been obtained by clarifying the nectar with Pectinol R-10. Pulp sweetened with sirup of cane or palm sugar, has been canned and sterilized. The pulp can be freeze-dried for future use but it has not been satisfactorily dried by other methods.

Food Value Per 100 g of Edible Pulp*		
	Pulp (ripe)	*Seeds*
Moisture	74.0%	4.0%
Protein	8.00%	26.18%
Fat	1.45%	27%
Carbohydrates	7.45%	35.49%
Ash	5.0%	5.03%
Calcium	0.17%	1.58%
Phosphorus	0.08%	1.43%
Iron	0.07%	0.03%
Tannins	1.03%	0.08%

*According to analyses made in India.

The pulp represents 36% of the whole fruit. The pectin content of the pulp is 3 to 5% (16% yield on dry-weight basis). The seeds contain a bland, non-bitter, oil high in unsaturated fatty acids.

Other Uses

Pectin: The pectin has potential for multiple uses in pectin-short India, but it is reddish and requires purification.

Rind: The fruit shell is fashioned into snuffboxes and other small containers.

Gum: The trunk and branches exude a white, transparent gum especially following the rainy season. It is utilized as a substitute for, or adulterant of, gum arabic, and is also used in making artists' watercolors, ink, dyes and varnish. It consists of 35.5% arabinose and xylose, 42.7% *d*-galactose, and traces of rhamnose and glucuronic acid.

Wood: The wood is yellow-gray or whitish, hard, heavy, durable, and valued for construction, pattern-making, agricultural implements, rollers for mills, carving, rulers, and other products. It also serves as fuel.

The heartwood contains ursolic acid and a flavanone glycoside, 7-methylporiol-β-D-xylopyranosyl-D-glucopyranoside.

Medicinal Uses: The fruit is much used in India as a liver and cardiac tonic, and, when unripe, as an astringent means of halting diarrhea and dysentery and effective treatment for hiccough, sore throat and diseases of the gums. The pulp is poulticed onto bites and stings of venomous insects, as is the powdered rind.

Juice of young leaves is mixed with milk and sugar candy and given as a remedy for biliousness and intestinal troubles of children. The powdered gum, mixed with honey, is given to overcome dysentery and diarrhea in children.

Oil derived from the crushed leaves is applied on itch and the leaf decoction is given to children as an aid to digestion. Leaves, bark, roots and fruit pulp are all used against snakebite. The spines are crushed with those of other trees and an infusion taken as a remedy for menorrhagia. The bark is chewed with that of *Barringtonia* and applied on venomous wounds.

The unripe fruits contain 0.015% stigmasterol. Leaves contain stigmasterol (0.012%) and bergapten (0.01%). The bark contains 0.016% marmesin. Root bark contains aurapten, bergapten, isopimpinellin and other coumarins.

Morton, J. 1987. White Sapote. p. 191–196. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

White Sapote

Casimiroa edulus Llave.

The genus *Casimiroa* of the family Rutaceae was named in honor of Cardinal Casimiro Gomez de Ortega, a Spanish botanist of the 18th Century. It embraces 5 or 6 species of shrubs or trees. Of these, 3 shrubby species, *C. pubescens* Ramirez, *C. pringlei* Engl. and *C. watsonii* Engl., are apparently confined to Mexico and have received scant attention. An additional species, *C. emarginata* Standl. & Steyerm., was described in 1944, based on a single specimen in Guatemala. It may be merely a form of *C. sapota*, below.

Of the 3 larger-growing forms, the best known is the common white sapote, called *zapote blanco* by Spanish-speaking people, *abché* or *ahache* by Guatemalan Indians, and Mexican apple in South Africa, and widely identified as *C. edulis* Llave & Lex. The *matasano* (or *matazano), C. sapota* Oerst., is often not distinguished from *C. edulis* in the literature and the name *matasano* has been applied to other species in various localities. The woolly-leaved white sapote, known to the Maya as *yuy* and set apart in Guatemala as *matasano de mico,* has been commonly considered a distinct species, *C. tetrameria* Millsp., but it may be only a variant of *C. edulis.*

Description

Fig. 48: A seedless white sapote, natural size, photographed by Dr. David Fairchild at Orange, California, in October 1919. In his notes accompanying the picture in *Inventory of Seeds and Plants Imported,* No. 60, he says: "It is not rare for trees of this species...may often be due to defective pollination." (Bureau of Plant Industry, United States Department of Agriculture)

White sapote trees range from 15 to 20 ft (4.5-6 m) up to 30 to 60 ft (9-18 m) in height. They have light-gray, thick, warty bark and often develop long, drooping branches. The leaves, mostly evergreen are alternate, palmately compound, with 3 to 7 lanceolate leaflets, smooth or hairy on the underside. The odorless flowers, small and greenish-yellow, are 4- or 5-parted, and borne in terminal and axillary panicles. They are hermaphrodite or occasionally unisexual because of aborted stigmas.

The fruit is round, oval or ovoid, symmetrical or irregular, more or less distinctly 5-lobed; 2 1/2 to 4 1/2 in (6.25-11.25 cm) wide and up to 4 3/4 in (12 cm) in length; with thin green, yellowish or golden skin coated with a very thin bloom, tender but inedible; and creamy-white or yellow flesh glinting with many tiny, conspicuous, yellow oil glands. The flavor is sweet with a hint or more of bitterness and sometimes distinctly resinous. There may be 1 to 6 plump, oval, hard, white seeds, 1 to 2 in (2.5-5 cm) long and 1/2 to 1 in (1.25-2.5 cm) thick, but often some seeds are under-developed (aborted) and very thin. The kernels are bitter and narcotic.

C. edulis has leaves that are usually composed of 5 leaflets, glabrous to slightly pubescent on the underside, and 5-parted flowers. The fruit is somewhat apple-like externally, generally smooth, fairly symmetrical and 2 1/2 to 3 in (6.25-7.5 cm) wide. *C. sapota* is very similar but the leaves usually have only 3, somewhat smaller, leaflets. The woolly-leaved white sapote usually has 5 leaflets, larger and thicker than those of *C. edulis* and velvety-white on the underside, and all the parts of the flowers are in 4's. The fruits are usually 4 to 4 1/2 in (10-11.25 cm) wide, ovoid, irregular and knobby, with rough, pitted skin, and there are often gritty particles in the flesh.

Origin and Distribution

The common white sapote occurs both wild and cultivated in central Mexico. It is planted frequently in Guatemala, El Salvador and Costa Rica and is occasionally grown in northern South America, the Bahamas, West Indies, along the Riviera and other parts of the Mediterranean region, India and the East Indies. It is grown commercially in the Gisborne district of New Zealand and to some extent in South Africa. Horticulturists in Israel took serious interest in white sapotes around 1935 and planted a number of varieties. The trees grew well and produced little in the coastal plain; bore good crops in the interior and commercial prospects seemed bright but the fruit did not appeal to consumers and was too attractive to fruit flies. White sapotes have not done well in the

Philippines. The common species was introduced into California by Franciscan monks about 1810, and it is still cultivated on a limited scale in the southern part of that state. In Florida, it was first planted with enthusiasm. Today it is seldom seen outside of fruit tree collections. Of course, many of the trees planted have been seedlings bearing fruits of inferior size and quality, but even the best have never attained popularity in this country.

C. sapota is wild in southern Mexico and Nicaragua, commonly cultivated in Oaxaca and Chiapas. The woolly-leaved white sapote is native from Yucatan to Costa Rica and has not been widely distributed in cultivation. According to Chandler, the fruits are objectionably bitter in California. In southern Florida, the woolly-leaved is sometimes planted in preference to *C. edulis*.

White sapote trees often are grown strictly as ornamentals in California. They are planted as shade for coffee plantations in Central America.

Varieties

Clonal selections were made in California from about 1924 to 1954, and several also in Florida. Some of these may actually be chance hybrids. A surprising number have been named and propagated: 'Blumenthal', 'Chapman', 'Coleman', 'Dade', 'Flournoy', 'Galloway', 'Gillespie', 'Golden' or 'Max Golden', 'Johnston's Golden', 'Harvey', 'Lenz', 'Lomita', 'Maechtlen', 'Maltby' or 'Nancy Maltby', 'Nies', 'Page', 'Parroquia', 'Pike', 'Sarah Jones', 'Suebelle', or 'Hubbell', 'Walton', 'Whatley', 'Wilson', 'Wood', 'Yellow'.

'Coleman'–was one of the first named in California; fruit is oblate, somewhat lobed, furrowed at apex; to 3 in (7.5 cm) wide; skin is yellow-green; flesh of good flavor (22% sugar) but resinous; seeds small. Fruit ripens from late fall to summer. Tree somewhat dwarf; leaflets small and tend to twist. Difficult to propagate.

'Dade'–grown at the Agricultural Research and Education Center, Homestead, Florida from a seed of a selected fruit of a local seedling tree. It was planted in 1935 and fruited in 1939. Round; skin golden-yellow tinged with green, thin; flesh of good, non-bitter flavor. There are 4 to 5 seeds. Ripens in June-July. The tree is low-growing and spreading, with smooth leaflets.

'Gillespie'–originated in California; fruit is round, 3 in (7.5 cm) wide; skin is light-green with russet cheek, fairly tough, rough; flesh is white, of very good flavor. Tree is prolific bearer.

'Golden', or 'Max Golden'–woolly-leaved; fruit conical, depressed at apex; up to 4 1/2 in (11.25 cm) wide; skin yellow-green, fairly tough; flesh has strong flavor, somewhat bitter; few seeds.

'Harvey'–originated in California; round; 3 1/2 in (9 cm) wide; skin smooth, yellow-green with bright orange cheek; flesh cream-colored to pale-yellow; not of the best flavor. Tree is a prolific bearer.

'Maechtlen'–named for the parent, an old tree on property owned by the Maechtlen family in Covina, California. Propagated by budding and sold by nurserymen in the 1940's.

'Maltby', or 'Nancy Maltby'–originated in California; round, faintly furrowed, blunt-pointed at apex, base slightly tapered; large; skin yellow-green, smooth, of good flavor but slightly bitter. Tree bears well.

'Parroquia'–originated in California; oval, 2 1/2 in (6.25 cm) wide, 3 in (7.5 cm) long; skin yellow-green, smooth, thin; flesh ivory, of very good flavor. A fairly prolific bearer.

'Pike'–originated in California; rounded or oblate, slightly 5-lobed; to 4 in (10 cm) wide; skin green, very fragile; flesh white to yellowish, of rich, non-bitter, flavor. The tree bears regularly and heavily in California and South Africa.

'Suebelle', or 'Hubbell'–originated in California; round; medium to small; skin green or yellowish-green; of excellent flavor (22% sugar). Tree is precocious and blooms and fruits all year. Fairly widely planted in California.

'Wilson'–originated in California; round to oblate; medium to large; skin smooth, medium thick; flesh of high quality and excellent flavor. Fruit ripens in fall and winter or more or less all year. Tree bears heavily and has been rather widely planted in California.

'Yellow'–originated in California; oval with pointed apex, furrowed; skin is bright-yellow and fairly tough; flesh is firm. Fruit keeps well. Tree bears regularly and heavily in California.

Pollination

There is a great variation in the amount of pollen produced by seedlings and grafted cultivars. Some flowers bear no pollen grains; others have an abundance. Sterile pollen or lack of cross-pollination are suggested causes of aborted seeds and heavy shedding of immature fruits. In Florida, flowers of some heavy-bearing, double-cropping, trees have been observed so heavily worked by bees that their humming is heard several feet away.

Climate

The white sapotes can be classed as subtropical rather than tropical. *C. edulis is* usually found growing naturally at elevations between 2,000 and 3,000 ft (600-900 m) and occasionally in Guatemala up to a maximum of 9,000 ft (2,700 m) in areas not subject to heavy rainfall.

In California, light frosts cause some leaf shedding but otherwise do not harm the tree. Mature trees have withstood temperature drops to 20º F (-6.67º C) in California and 26º F (-3.33º C) in Florida without injury.

The trees prosper near the coast of southern California where the mean temperature from April to October is about 65º F (18º C). They do poorly and often fail to survive further north near San Francisco where the mean temperature for the same period is 57º to 58º F (13.89º-14.44º C). The woolly-leaved is somewhat less hardy than the common white sapote.

Soil

As long as there is good drainage, the trees will do very well on sandy loam or even on clay. In California, some of the early plantings were on light, decomposed granite soil, and they were fruitful for many years. In Florida, the trees grow and fruit well on deep sand and on oolitic limestone, though, on the latter, they may become chlorotic. They are fairly drought-resistant.

Propagation

White sapotes are commonly grown from seeds and seedlings usually begin to bear in 7 or 8 years.

Grafting is a common practice in California and Florida in midsummer. Seedlings of 'Pike', being vigorous growers, are preferred as rootstock. Shield-budding and side-grafting in spring onto stocks up to 3/4 in (2 cm) thick give good results. Cleft grafts and slot grafts are made on larger rootstocks and when topworking mature trees. Grafted trees will start bearing in 3 or 4 years. Commercial growers in New Zealand have had success with air-layers. Cuttings are very difficult to root.

Culture

In California, the young trees are cut back to 3 ft (0.9 m) when planted out, in order to encourage low-branching. As the branches elongate, some pruning is done to induce lateral growth.

Fertilizer formulas should vary with the nature of the soil, but, in general, the grower is advised to follow procedures suitable for citrus trees. Many white sapote trees have received little or no care and yet have been long-lived. One of the original trees in Santa Barbara, California, was said to be over 100 years old in 1915.

Season

In the Bahamas, the fruits ripen from late May through August. In Mexico, flowering occurs in January and February and the fruits mature from June to October. In Florida there is usually just a spring-summer crop, but a heavy-bearing woolly-leaved tree in Miami blooms in December, fruits in the spring, blooms again and produces a second crop in the fall. In California, 'Pike' and 'Yellow' bloom in the spring and again in late summer and fall, the fruits from late blooms maturing gradually over the winter. 'Suebelle' blooms for 6 to 8 weeks in spring and again in midsummer and fruits ripen in September and October.

Harvesting

Mature fruits must be clipped from the branches leaving a short piece of stem attached. This stub will fall off naturally when the fruits become eating-ripe. If plucked by hand, the fruits will separate from the stem if given a slight twist but they will soon show a soft bruised spot at the stem-end which quickly spreads over much of the fruit, becoming watery and decayed. The fruits must be handled with care even when unripe as they bruise so easily and any bruised skin will blacken and the flesh beneath turns bitter. If picked just a few days before fully ripe and ready to fall, the fruits turn soft quickly but they can be picked several weeks in advance of the failing stage and most will develop full flavor. 'Pike', however, if picked a month early, will take 2 weeks to ripen and will be substandard in flavor. Fruits that have ripened on hand will keep in good condition in the home refrigerator for at least 2 weeks. Fruits from commercial orchards are graded for size, wrapped individually to retard full ripening, packed in wooden boxes, and well-padded for transportation under refrigeration.

Pests and Diseases

The white sapote has few natural enemies but the fruits of some cultivars are attacked by fruit flies. Black scale often occurs on nursery stock and occasionally on mature trees in California.

Food Uses

Within its native range, the white sapote is commonly eaten out-of-hand. The flesh of ripe fruits may be added to fruit cups and salads or served alone as dessert, but it is best cut into sections and served with cream and sugar. Sometimes it is added to ice cream mix or milk shakes, or made into marmalade. Even in their countries of origin, where the fruits may at times appear in markets, their repute is due largely to a belief in their therapeutic value, while, at the same time, there prevails a fear that over-indulgence may be harmful. The epithet "matasano" (interpreted as "kill health") has a sinister connotation. Dr. J.B. Londoño, in his *Frutas de Antioquia*, published in Medellin, Colombia, in 1934, referred to the white sapote as disagreeable and indigestible. Some years ago in Central America there were unsuccessful efforts to manufacture from the pulp an acceptable preserve. In processing trials at the Western Regional Research Laboratory of the United States Department of Agriculture, Albany, California, technologists decided that white sapotes; are not suitable for either canning in sirup or freezing as a puree.

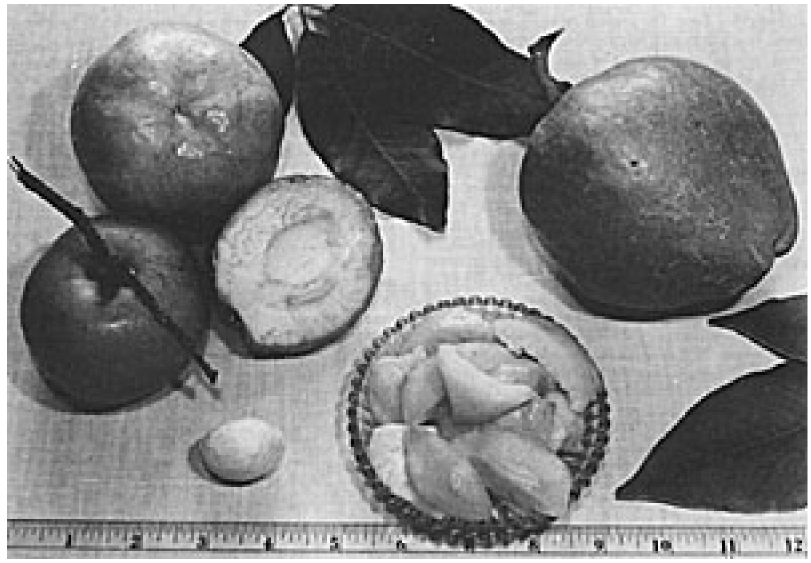


Fig. 49: The common white sapote *(Casimiroa edulis)* (left) and the woolly-leaved white sapote, often called *C. tetrameria* (right). The latter may be only a variant of *C. edulis.*

Food Value Per 100 g of Fresh Pulp*	
Moisture	78.3 g
Protein	0.143 g
Fat	0.03 g
Fiber	0.9g
Ash	0.48g
Calcium	9.9 mg
Phosphorus	20.4 mg
Iron	0.33 mg
Carotene	0.053 mg
Thiamine	0.042 mg
Riboflavin	0.043 mg
Niacin	0.472 mg
Ascorbic Acid	30.3 mg

*According to analyses made in El Salvador.

As bearers of edible fruits, the white sapotes, despite their prolificacy, will doubtless continue to occupy the minor position which they now hold in subtropical horticulture.

Toxicity

The seed is said to be fatally toxic if eaten raw by humans or animals.

Other Uses

Seeds: In 1959, Dr. Everette Burdick, Consulting Chemist, of Coral Gables, Florida, made several extractions from the kernels, securing small amounts of needle-like yellow crystals. From one process, a yellow resinous mass resulted which functioned as an attractive and lethal bait for American cockroaches, having the advantage of killing on the spot rather than at some distance after ingestion of the poison. The United States Department of Agriculture's Agricultural Handbook 154, *Insecticides from Plants,* mentions no experiments with *Casimiroa* seed extracts but reports that extracts from branches and leaves of *C. edulis* are non-toxic to both American and German roaches.

Wood: The wood is yellow, fine-grained, compact, moderately dense and heavy, medium strong and resistant, but not durable for long. It is occasionally employed in carpentry and for domestic furniture in Central America.

Medicinal Uses: The ancient Nahuatl name for the fruits, "cochiztzapotl", is translated "sleepy sapote" or "sleep-producing sapote", and it is widely claimed in Mexico and Central America that consumption of the fruit relieves the pains of arthritis and rheumatism. This belief may stem only from the oft-quoted statement to this effect by Dr. Leopoldo Flores in *Manual Terapeutica de Plantas Mexicanas,* published in 1907, although the Mexican National Commission has received frequent reports of anti-arthritic, anti-rheumatic effects from physicians and their patients.

The eminent Francisco Hernandez, in his writings during the period 1570-1575 (translated and published as *Rerum Medicarum Novae Hispaniae* in 1651), noted that eating the fruit produced drowsiness. He referred to the seeds as "deadly poison" but efficacious, when crushed and roasted, in healing putrid sores. This vulnerary use of the seeds is cited in the obsolete *Farmacopea Mexicana,* where the fruit is mentioned as a vermifuge. For many years, extracts from the leaves, bark, and especially the seeds have been employed in Mexico as sedatives, soporifics and tranquilizers.

The narcotic property of the seeds was first identified as an alkaloid by Dr. Jesus Sanchez of Mexico in his thesis, *Breve estudio sobre la almendra del zapote blanco,* in 1893; and, in 1898, it was made the subject of chemical study by an especially appointed commission. One of the investigators, Alfonso Altimirano, reported the isolation of a glucoside as a pale yellow, amorphous mass, at first sweet but with a prolonged bitter aftertaste. White sapote derivatives were among the medicinal plant products displayed at the St. Louis Exposition in 1904 and explained in the slender book, *Materia Medica Mexicana: A Manual of Mexican Medicinal Herbs,* prepared by the Mexican National Commission for that occasion.

In 1900, a quantity of white sapote seeds was sent from Mexico to F.H. Worlee & Co., in Hamburg, Germany, with an accompanying explanation that both the fruit and the seeds possessed sleep-inducing principles but without the undesirable after-effects of opium. This material came to the attention of W. Bickern. He proceeded to work on the seeds, from which he obtained a substance which he called an alkaloidal glycoside, *casimirin.* In France, several investigators confirmed the narcotic nature of the seeds. Subsequently, Frederick Power and Thomas Callan of the Wellcome Chemical Research Laboratories in London, declared that, though they isolated 6 substances including 2 alkaloids, *casimiroine* and *casimiroedine,* there was "no evidence of the presence of a definite glucoside or a so-called glucoalkaloid ...and physiological tests conducted with animals ...likewise failed to confirm . . . reported hypnotic or toxic properties." Meanwhile, the seed extracts, in liquid, capsule, or tablet form, continued in use in Mexico, one product bearing the trade name "Rutelina".

In 1934, José de Lille proceeded to test the effect on blood pressure of dogs. He found a dose of .20 g per kilo of animal weight to be definitely hypotensive. A large dose (1 g) administered to a dog weighing 11 lbs (5 kg) produced a drastic lowering of blood pressure which persisted even after a brief rise induced by injecting adrenalin. In 1936, M. Mendez described the preparation of a tincture of "a clear yellow color with neither special odor nor taste" which produces "a state of depression in the entire nervous system, especially in the sensory sphere, and sleep." Dr. Faustino Miranda reported that an infusion of the leaves of *Casimiroa sapota is* used for similar purposes, and he assumed that this species has the same properties as *C. edulis.* According to *Materia Medica Mexicana,* the extracts from the leaves and bark are half as strong as those from the seeds and can be safely administered to children. In Costa Rica, the leaf decoction is taken as a treatment for diabetes.

In 1956, four chemists, F. Kinel, J. Rosso, O. Rosenkranz and F. Sondheimer, on the staff of the Mexican branch of the pharmaceutical company, Syntex, undertook chemical studies of the seeds. They did not find the "gluco-alkaloid" casimirin, but isolated 13 substances, 6 of which coincided with those reported by Power and Callan. One of these, *casimirolid,* was later found by F. Sondheimer, A Meisels and F. Kinel, to be identical with *obacunone,* an attribute of citrus oil. Of the 7 additional compounds, one *palmitamide,* had not previously been noted in the plant kingdom. Another, *N-benzoyltyramine,* they suggested might have much to do with the reputed potency of the seed, for *tyramine is* one of the active principles of ergot (is also found in mistletoe and thistle) and is well known for its physiological action. The main alkaloid of the seeds, *casimiroedine*, representing 0.143%, was crystallized in the form of needles.

Investigations of the bark from the trunk and roots of *C. edulis* were undertaken for Syntex by J. Iriarte, F. Kinel, O. Rosenkranz and F. Sondheimer. No *casimiroedine* was found but 12 substances were identified, only 2 of which, *zapotin* and *casimiroin,* occur in the seeds. The root bark contained .22% of the latter, while the seeds yielded only 0.0076%. In 1957, Meisels and Sondheimer announced that one of the bark alkaloids, *edulein,* which they had considered new, is identical with an alkaloid found in the bark and leaves of *Lunaria amara* Blanco, a citrus relative of Malayan origin. In 1958, R.T. Major and F. Dürsch, of the Cobb Chemical Laboratory, University of Virginia, working under a grant from Merck & Co., isolated from *C. edulis* seeds a compound which they identified as N^{a}*, Na-dimethy1histamine,* formerly found in nature only in the sponge, *Geodia gigas.* J.S.L. Ling, S.Y. P'an and F.A. Hockstein, of Chas. Pfizer & Co. Research Laboratories, Brooklyn, New York, in experimental work with this compound in rabbits, dogs and cats, observed strong vasodepressive action. Dr. Hockstein suggested that all of the hypotensive properties and at least part of the sedative and pain-relieving qualities could be attributed to this compound, which "is not considered acceptable in man".

In early July of 1960, the writer furnished approximately 2 bushels of largely overripe, fallen fruits of *C. edulis* and the woolly-leaved white sapote to Delta Pharmaceuticals of Hialeah, Florida. They readily extracted from the seeds a soporific substance, 50 mg of which, taken by humans, induced sound sleep within 2 hours, with no apparent ill effects. The extract also acted as a narcotic on goldfish.

The following statement (translated from Spanish) is made in a communication received in 1961 from the Sección Administrativa, Dirección de Control de Medicamentos, Secretaria de Salubridad y Asistencia, Mexico City: "In Mexico, the white sapote is not used other than in folk medicine and not in any way by pharmacists nor doctors; neither is it an official drug in the Pharmacopoeia".

In India, extensive studies have been made of the seeds, roots and bark, which contain histamine derivatives with strong hypotensive activity, as well as furoquinoline alkaloids and 2-quinolones and 4-quinolones, including *edulein*, *edulitin, edulinine* and *casimiroin.* Also present are coumarins, flavonoids, and limonoids, including *zapoterin, zapotin, zapotinin, casimirolid*, *deacetylnomilin*, and *7-a-obacunol*. Leaves and twigs yield *isoplimpinellin* (diuretic) and *n-hentriacontane* (anti-inflammatory).

Morton, J. 1987. Wampee. p. 197–198. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Wampee

Clausena lansium Skeels

Clausena wampi (Blanco), D. Oliver

Clausena punctata (Sonn.), Rehd. & E.H. Wils.

Cookia punctata Sonn.

Cookia wampi Blanco

Quinaria lansium Lour.

A minor member of the Rutaceae and distant relative of the citrus fruits, the wampee, *Clausena lansium* Skeels (syns. *C. wampi* (Blanco), D. Oliver; *C. punctata* (Sonn.), Rehd. & E.H. Wils.; *Cookia punctata* Sonn.; *Cookia wampi* Blanco; *Quinaria lansium* Lour.), has not traveled sufficiently to acquire many vernacular names and most are derived from the Chinese *huang-p'i-kuo, huang p'i ho, huang p'i kan,* or *huang-p'i-tzu.* In Malaya, it is known as *wampi, wampoi,* or *wang-pei;* in the Philippines, *uampi, uampit, huampit* or *galumpi;* in Vietnam, *hong bi,* or *hoang bi.* In Thailand it is *som-ma-fai.*

Description

Fig. 50: The wampee (*Clausena lansium*) is an attractive tree with somewhat grapelike fruits, but the pulp is scant and the seeds large.

The tree is fairly fast-growing or rather slow, depending on its situation; attractive, reaching 20 ft (6 m), with long, upward-slanting, flexible branches, and gray-brown bark rough to the touch. Its evergreen, spirally-arranged, resinous leaves are 4 to 12 in (10-30 cm) long, pinnate, with 7 to 15 alternate, elliptic or elliptic-ovate leaflets 2 3/4 to 4 in (7-10 cm) long, oblique at the base, wavy-margined and shallowly toothed; thin, minutely hairy on the veins above and with yellow, warty midrib prominent on the underside. The petiole also is warty and hairy. The sweet-scented, 4- to 5-parted flowers are whitish or yellowish-green, about 1/2 in (1.25 cm) wide, and borne in slender, hairy panicles 4 to 20 in (10-50 cm) long. The fruits, on 1/4 to 1/2 in (0.6-1.25 cm) stalks, hang in showy, loose clusters of several strands. The wampee may be round, or conical-oblong, up to 1 in (2.5 cm) long, with 5 faint, pale ridges extending a short distance down from the apex. The thin, pliable but tough rind is light brownish-yellow, minutely hairy and dotted with tiny, raised, brown oil glands. It is easily peeled and too resinous to be eaten. The flesh, faintly divided into 5 segments, is yellowish-white or colorless, grapelike, mucilaginous, juicy, pleasantly sweet, subacid, or sour. There may be 1 to 5 oblong, thickish seeds 1/2 to 5/8 in (1.25-1.6 cm) long, bright-green with one brown tip.

Origin and Distribution

The wampee is native and commonly cultivated in southern China and the northern part of former French Indochina, especially from North to Central Vietnam. It was growing in the Philippines before 1837 and was reintroduced in 1912. It is only occasionally grown in India and Ceylon. Chinese people in southern Malaya, Singapore and elsewhere in the Malaysian Archipelago grow the tree in home gardens. It is cultivated to a limited extent in Queensland, Australia and Hawaii. In 1908, it was said to have been growing in a few Hawaiian gardens for many years but was not in general cultivation. It was brought to Florida as an unidentified species in 1908. The United States Department of Agriculture received seed from Hong Kong in 1914 (P.I. 39176); from Canton in 1917 (P.I. 45328), and from Hawaii in 1922 (P.I. 55598). Dr. David Fairchild was pleased with a wampee tree he grew at his 'Kampong' in Coconut Grove, Miami, and a small cottage near it was named the **'Wamperi'.**

A few other specimens have been growing in southern Florida for some years, mostly in experimental collections, but the fruit is unknown to most residents despite some efforts to arouse interest in it. The wampee was growing in Jamaica in 1913. Two trees were thriving at the Federal Experimental Station, Mayaguez, Puerto Rico, and there were specimens on St. Croix, in the 1920's. Seeds from a Chinese grower in Panama were planted at the Lancetilla Experimental Garden, Tela, Honduras, in 1944. The tree does well in greenhouses in England.

Varieties

A Chinese work translated and published in 1936, mentioned 7 varieties of Foochow, describing and illustrating 6 of them. They vary somewhat in form and size, number of seeds, season of ripening, as well as in flavor:

'Niu Shen' ("cow's kidney")–sour in flavor;

'Yuan Chung' ("globular variety")–sweet-subacid;

'Yeh Sheng' ("wild growing")–sour;

'Suan Tsao' ("sour jujube")–is very sour, of poor quality;

'Hsiao Chi Hsien' ("small chicken heart")–sweet subacid;

'Chi Hsin' ("chicken heart")–sweet; "best flavor of all";

'Kua Pan' ("melon section")–sweet-subacid.

A professor at Sun Yat-sen University in Canton listed 8 varieties of Kwangtung with, as Dr. Swingle stated, long, descriptive names such as "white-hairy-chicken-heart-sweet-wampee" and "long-chicken-heart-sour-wampee".

Climate

The wampee is subtropical to tropical, and young and mature trees have been scarcely hurt by brief exposure to 28º to 30º F (-2.22º to -1.11º C) in Florida, but they have been killed at temperatures of 20º F (-6.667º C) and lower.

Soil

The tree seems quite tolerant of a range of soils, including the deep sand and the oolitic limestone of southern Florida but thrives best in rich loam. It requires watering in dry periods though good drainage is essential.

Propagation

The wampee grows readily from seeds which germinate in a few days. It can also be grown from softwood cuttings and air-layers, and can be veneer-grafted onto wampee seedlings. Dr. Swingle said it could be grafted onto grapefruit. However, trials on various Citrus rootstocks in Florida have shown various degrees of incompatibility and few, if any, can be said to have been really successful in the long run. The wampee is not a first-class fruit and the tree is of only casual interest, even as an ornamental, except in Asia.

Cultivation

No particular cultural requirements have been noted in the literature, except that the wampee is subject to chlorosis on limestone soils and needs applications of manganese and zinc as well as organic fertilizer and mulch to overcome this condition. Sturrock recommends thinning of the crown to avoid overcrowding.

Season and Yield

The fruits ripen in July and August in Florida; from June to October in Southeast Asia; in November and December in Queensland. Seedlings begin to bear when 5 to 8 years of age or sometimes older. Mature trees may yield 100 lbs (45 kg) of fruits in a season.

Food Uses

A fully ripe, peeled wampee, of the sweet or subacid types, is agreeable to eat out-of-hand, discarding the large seed or seeds. The seeded pulp can be added to fruit cups, gelatins or other desserts, or made into pie or jam. Jelly can be made only from the acid types when under-ripe. The Chinese serve the seeded fruits with meat dishes.

In Southeast Asia, a bottled, carbonated beverage resembling champagne is made by fermenting the fruit with sugar and straining off the juice.

Food Value

Florida-grown fruits have shown 28.8 to 29.2 mg/100 g ascorbic acid.

Medicinal Uses

The fruit is said to have stomachic and cooling effects and to act as a vermifuge. The Chinese say that if one has eaten too many lychees, eating the wampee "will counteract the bad effects. Lychees should be eaten when one is hungry, and wampees only on a full stomach".

The halved, sun-dried, immature fruit is a Vietnamese and Chinese remedy for bronchitis. Thin slices of the dried roots are sold in Oriental pharmacies for the same purpose. The leaf decoction is used as a hair wash to remove dandruff and preserve the color of the hair.

Morton, J. 1987. Santol. p. 199–201. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Santol

Sandoricum koetjape Merr.

Sandoricum indicum Cav.

Sandoricum nervosum Blume

Melia koetjape Burm. f.

Perhaps the only important edible fruit in the family Meliaceae, the santol, *Sandoricum koetjape* Merr. (syns. *S. indicum* Cav., *S. nervosum* Blume, *Melia koetjape* Burm. f.), is also known as *sentieh, sentol, setol, sentul, setul, setui, kechapi* or *ketapi*, in Malaya; *saton, satawn, katon*, or *ka-thon* in Thailand; *kompem reach* in Cambodia; *tong* in Laos; *sau chua, sau tia, sau do, mangoustanier sauvage*, or *faux mangoustanier in* North Vietnam. In the Philippines, it is *santor* or *katul;* in Indonesia, *ketjapi* or *sentool;* on Sarawak and Brunei, it is *klampu.* In India, it may be called *sayai, sevai, sevamanu* or *visayan.* In Guam, it is *santor* or wild mangosteen.

Description

The santol is a fast-growing, straight-trunked, pale-barked tree 50 to 150 ft (15-45 m) tall, branched close to the ground and buttressed when old. Young branchlets are densely brown-hairy. The evergreen, or very briefly deciduous, spirally-arranged leaves are compound, with 3 leaflets, elliptic to oblong-ovate, 4 to 10 in (20-25 cm) long, blunt at the base and pointed at the apex. The greenish, yellowish, or pinkish-yellow, 5-petalled flowers, about 3/8 in (1 cm) long are borne on the young branchlets in loose, stalked panicles 6 to 12 in (15-30 cm) in length. The fruit (technically a capsule) is globose or oblate, with wrinkles extending a short distance from the base; 1 1/2 to 3 in (4-7.5 cm) wide; yellowish to golden, sometimes blushed with pink. The downy rind may be thin or thick and contains a thin, milky juice. It is edible, as is the white, translucent, juicy pulp (aril), sweet, subacid or sour, surrounding the 3 to 5 brown, inedible seeds which are up to 3/4 in (2 cm) long, tightly clinging or sometimes free from the pulp.

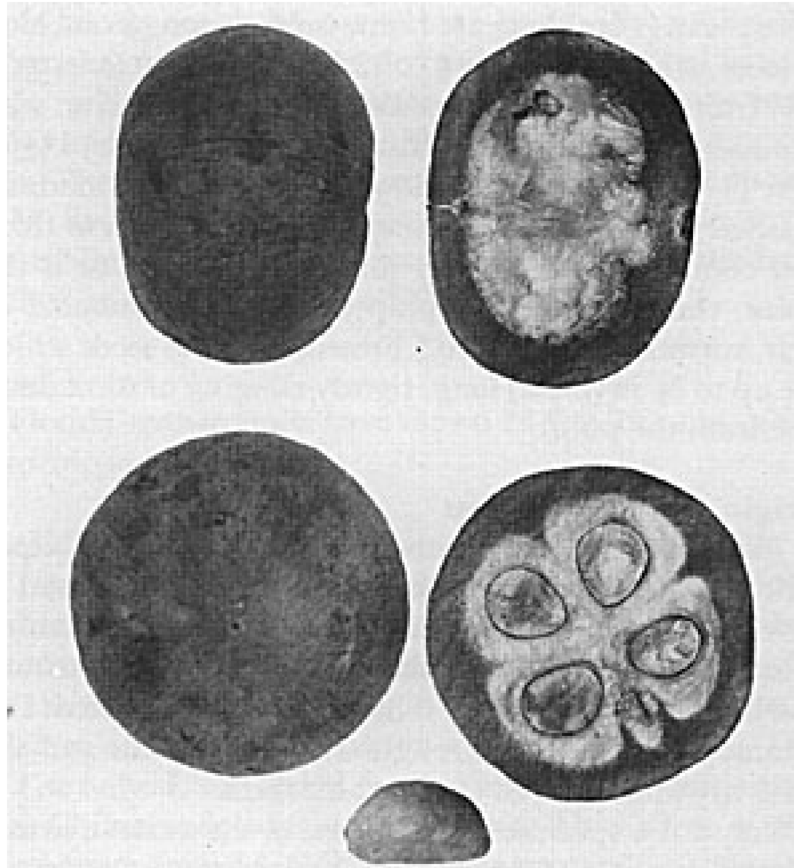


Fig. 52: Santol fruits photographed by Dr. Walter T. Swingle, Plant Explorer for the United States Department of Agriculture.

Origin and Distribution

The santol is believed native to former Indochina (especially Cambodia and southern Laos) and Malaya, and to have been long ago introduced into India, the Andaman Islands, Malaysia, Indonesia, the Moluccas, Mauritius, and the Philippines where it has become naturalized. It is commonly cultivated throughout these regions and the fruits are abundant in the local markets.

Only a few specimens are known in the western hemisphere: one in the Lancetilla Experimental Garden at Tela, Honduras, and one or more in Costa Rica. Seeds have been introduced into Florida several times since 1931. Most of the seedlings have succumbed to cold injury. At least 3 have survived to bearing age in special collections. Grafted plants from the Philippines have fruited well at Fairchild Tropical Garden, Miami.

In Asia and Malaysia, the tree is valued not just for its fruit, but for its timber and as a shade tree for roadsides, being wind-resistant and non-littering.

Varieties

There are two general types of santol: the **Yellow** (formerly *S. indicum* or *S. nervosum);* and the **Red** (formerly *S. koetjape).* The leaflets of the Yellow, to 6 in (15 cm) long, turn yellow when old; the flowers are pinkish-yellow in panicles to 6 in (15 cm) long; the fruit has a thin rind and the pulp is 1/4 to 1/2 in (0.6-1.25 cm) thick around the seeds and typically sweet. The fruit may not fan when ripe. Only the Yellow is now found wild in Malayan forests.

The leaflets of the Red, to 12 in (30 cm) long, velvety beneath, turn red when old; the flowers are greenish or ivory, in panicles to 12 in (30 cm) long; the fruit has a thick rind, frequently to 1/2 in (1.25 cm); there is less pulp around the seeds, and it is sour. The fruit falls when ripe.

However, Corner says that these distinctions are not always clear-cut except as to the dying leaf color, and the fruit may not correspond to the classifications. There are sweet and acid strains of both the Yellow and Red types and much variation in rind thickness.

Plate XXIII: SANTOL, *Sandoricum koetjape*

Climate

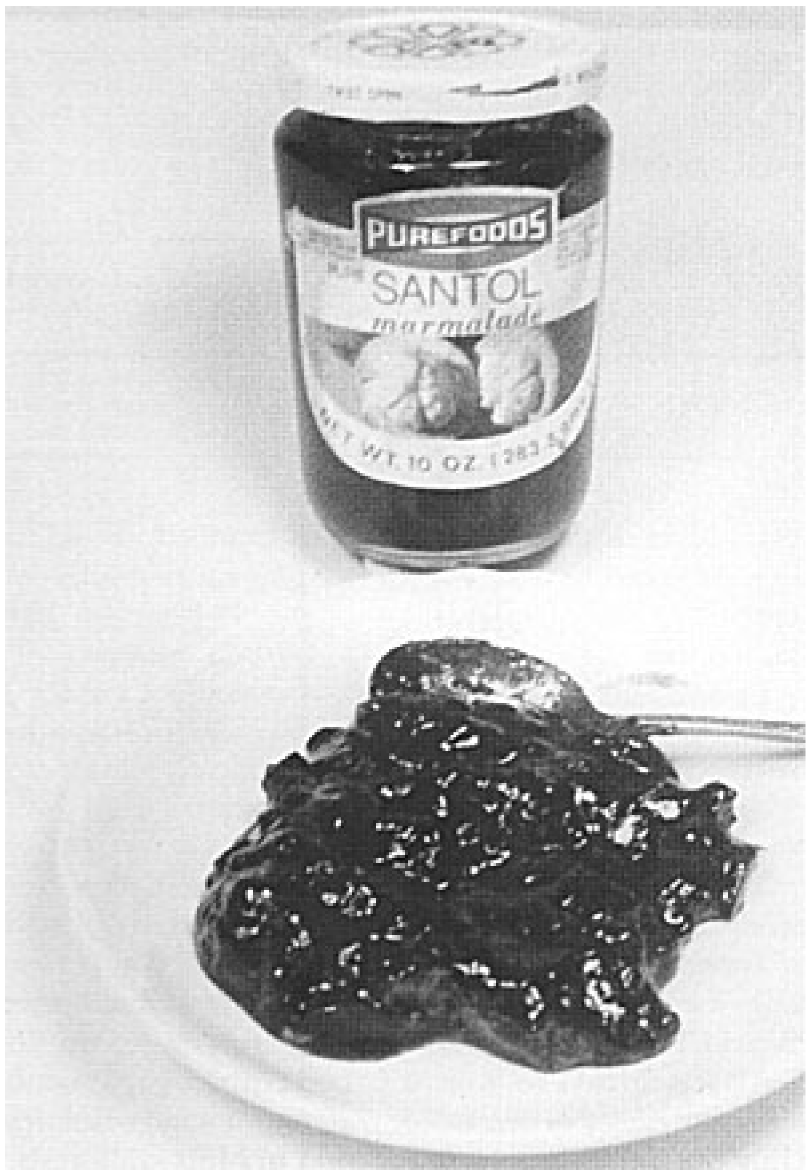
The santol is tropical and cannot be grown above 3,280 ft (1,000 m) in Java. It flourishes in dry as well as moist areas of the Philippine lowlands.

Soil

The tree has grown well in Florida in acid sandy soil and oolitic limestone, but in the latter the foliage becomes chlorotic.

Propagation

The santol is reproduced by seeds, air-layering, inarching, or by budding onto self rootstocks.



Season

The fruit ripens in Malaya in June and July; in Florida, August and September; in the Philippines, from July to October.

Pests

The Caribbean fruit fly *(Anastrepha suspensa)* causes freckle-like blemishes on the surface of the fruit but cannot penetrate the rind.

Food Uses

The fruit is usually consumed raw without peeling. In India, it is eaten with spices. With the seeds removed, it is made into jam or jelly. Pared and quartered, it is cooked in sirup and preserved in jars. Young fruits are candied in Malaysia by paring, removing the seeds, boiling in water, then boiling a second time with sugar. In the Philippines, santols are peeled chemically by dipping in

Fig. 51: Santol *(Sandoricum indicum)* marmalade made in the Philippines is sometimes imported into the United States.

hot water for 2 minutes or more, then into a lye solution at 200º F (93.33º C) for 3 to 5 minutes. Subsequent washing in cool water removes the outer skin. Then the fruits are cut open, seeded and commercially preserved in sirup. Santol marmalade in glass jars is exported from the Philippines to Oriental food dealers in the United States and probably elsewhere. Very ripe fruits are naturally vinous and are fermented with rice to make an alcoholic drink.

Food Value Per 100 g of Edible Pulp

	Yellow*	Red**	Fruits (unspecifiedtype)***
Moisture	87.0 g	83.07-85.50 %	85.4 g
Protein	0.118 g	0.89 %	0.06 g
Carbohydrates		11.43 %	
Fat	0.10 g	1.43 %	0.52 g
Fiber	0.1 g	2.30 %	1.26 g
Ash	0.31 g	0.65-0.88 %	0.39 g
Calcium	4.3 mg	0.01 %	5.38 mg
Phosphorus	17.4 mg	0.03 %	12.57 mg
Iron	0.42 mg	0.002 %	0.86 mg
Carotene	0.003 mg		
Thiamine	0.045 mg	0.037 mg	
Niacin	0.741 mg	0.016 mg	
Ascorbic Acid	86.0 mg	0.78 mg	
Pectin			14.89 mg
			17.01 g

*According to analyses of yellow, thick-skinned, acid fruits in Honduras.

**According to analyses of the red type in the Philippines.

***According to analyses of unspecified type in India. The pericarp contains glucose, sucrose, malic acid, tartaric acid and much pectin.

Other Uses

Wood: The sapwood is gray, merging into the heartwood which is reddish-brown when dry, imparting the color to water. It is fairly hard, moderately heavy, close-grained and polishes well, but is not always of good quality. It is not durable in contact with moisture and is subject to borers. However, it is plentiful, easy to saw and work, and accordingly popular. If carefully seasoned, it can be employed for house-posts, interior construction, light-framing, barrels, cabinetwork, boats, carts, sandals, butcher's blocks, household utensils and carvings. When burned, the wood emits an aromatic scent.

The dried heartwood yields 2 triterpenes–katonic acid and indicic acid–and an acidic resin.

Bark: In the Philippines, the bark is used in tanning fishing lines.

Medicinal Uses: The preserved pulp is employed medicinally as an astringent, as is the quince in Europe. Crushed leaves are poulticed on itching skin.

In cases of fever in the Philippines, fresh leaves are placed on the body to cause sweating and the leaf decoction is used to bathe the patient. The bitter bark, containing the slightly toxic sandoricum acid, an unnamed, toxic alkaloid, and a steroidal sapogenin, is applied on ringworm and also enters into a potion given a woman after childbirth. The aromatic, astringent root also serves the latter purpose, and is a potent remedy for diarrhea. An infusion of the fresh or dried root, or the bark, may be taken to relieve colic and stitch in the side. The root is a stomachic and antispasmodic and prized as a tonic. It may be crushed in a blend of vinegar and water which is then given as a carminative and remedy for diarrhea and dysentery. Mixed with the bark of *Carapa obovata* Blume, it is much used in Java to combat leucorrhea.

Morton, J. 1987. Langsat. p. 201–203. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Langsat

Lansium domesticum Corr.

A somewhat less edible fruit of the family Meliaceae, the langsat, *Lansium domesticum* Corr., is also known as *lansa, langseh, langsep, lanzon, lanzone, lansone*, or *kokosan,* and by various other names in the dialects of the Old World tropics.

Description

The tree is erect, short-trunked, slender or spreading; reaching 35 to 50 ft (10.5 to 15 m) in height, with red-brown or yellow-brown, furrowed bark. Its leaves are pinnate, 9 to 20 in (22.5-50 cm) long, with 5 to 7 alternate leaflets, obovate or elliptic-oblong, pointed at both ends, 2 3/4 to 8 in (7-20 cm) long, slightly leathery, dark-green and glossy on the upper surface, paler and dull beneath, and with prominent midrib. Small, white or pale-yellow, fleshy, mostly bisexual, flowers are home in simple or branched racemes which may be solitary or in hairy clusters on the trunk and oldest branches, at first standing erect and finally pendant, and 4 to 12 in (10-30 cm) in length.

The fruit, borne 2 to 30 in a cluster, is oval, ovoid-oblong or nearly round, 1 to 2 in (2.5-5 cm) in diameter, and has light grayish-yellow to pale brownish or pink, velvety skin, leathery, thin or thick, and containing milky latex. There are 5 or 6 segments of aromatic, white, translucent, juicy flesh (arils), acid to subacid in flavor. Seeds, which adhere more or less to the flesh, are usually present in 1 to 3 of the segments. They are green, relatively large–3/4 to 1 in (2-2.5 cm) long and 1/2 to 3/4 in (1.25-2 cm) wide, very bitter, and sometimes, if the flesh clings tightly to the seed, it may acquire some of its bitterness.

Fig. 53: The langsat, photographed by Dr. Walter T. Swingle, Plant Explorer for the United States Department of Agriculture.

Origin and Distribution

The langsat originated in western Malaysia and is common both wild and cultivated throughout the Archipelago and on the island of Luzon in the Philippines where the fruits are very popular and the tree is being utilized in reforestation of hilly areas. It is much grown, too, in southern Thailand and Vietnam and flourishes in the Nilgiris and other humid areas of South India and the fruits are plentiful on local markets. The langsat was introduced into Hawaii before 1930 and is frequently grown at low elevations. An occasional tree may be found on other Pacific islands.

The species is little known in the American tropics except in Surinam. There it is commercially grown on a small scale. Seeds were sent from Java to the Lancetilla Experimental Garden at Tela, Honduras, in 1926 and plants arrived from the same source in 1927. The trees have grown well but are usually unfruitful, occasionally having a small number of fruits. There are bearing trees in Trinidad, where the langsat was established in 1938, and a few around Mayaguez, Puerto Rico, that have been bearing well for about 60 years. There were young specimens growing on St. Croix in 1930.

Southern Florida does not have climatic and soil conditions favorable to the langsat, but the rare-fruit fancier, William Whitman, has managed to raise two bearing trees in special soil and tented for the first several years. Winter cold has caused complete defoliation and near-girdling at the base of the trunks, but the trees made good recovery. Other specimens have survived on the Lower Keys in pits prepared with non-alkaline soil. There have been attempts to maintain langsats at the University of Florida's Agricultural Research and Education Center in Homestead, but the trees have succumbed either to the limestone terrain or low temperatures.

Varieties

There are two distinct botanical varieties: 1) *L. domesticum* var. *pubescens,* the typical wild langsat which is a rather slender, open tree with hairy branchlets and nearly round, thick-skinned fruits having much milky latex; 2) var. *domesticum,* called the *duku, doekoe,* or *dookoo,* which is a more robust tree, broad-topped and densely foliaged with conspicuously-veined leaflets; the fruits, borne few to a cluster, are oblong-ovoid or ellipsoid, with thin, brownish skin, only faintly aromatic and containing little or no milky latex. The former is often referred to as the "wild" type but both varieties are cultivated and show considerable range of form, size and quality. There are desirable types in both groups. Some small fruits are completely seedless and fairly sweet.

Plate XXIV: LANGSAT, *Lansium domesticum*

'Conception' is a sweet cultivar from the Philippines; **'Uttaradit'** is a popular selection in Thailand; **'Paete'** is a leading cultivar in the Philippines.

Climate

The langsat is ultra-tropical. Even in its native territory it cannot be grown at an altitude over 2,100 to 2,500 ft (650-750 m). It needs a humid atmosphere, plenty of moisture and will not tolerate long dry seasons. Some shade is beneficial especially during the early years.

Soil

The tree does best on deep, rich, well-drained, sandy loam or other soils that are slightly acid to neutral and high in organic matter. It is inclined to do poorly on clay that dries and cracks during rainless periods, and is not at all adapted to alkaline soils. It will not endure even a few days of water-logging.

Propagation

Langsats are commonly grown from seeds which must be planted within 1 or 2 days after removal from the fruit. Viability is totally lost in 8 days unless the seeds are stored in polyethylene bags at 39.2º-42.8º F (4º-6º C) where they will remain viable for 14 days.

Seedlings will bear in 12 to 20 years. Air-layering is discouraging, as the root system is weak and the survival rate is poor after planting out. Shield-budding has a low rate of success. Cleft- and side-grafting and approach-grafting give good results. The budwood should be mature but not old, 2 1/2 to 3 1/2 in (6.5-9 cm) long, 1/4 to 3/4 in (6-20 mm) thick, and it is joined to rootstock of the same diameter about 2 1/2 to 4 in (6.5-10 cm) above the soil. Some preliminary experiments have been conducted in Puerto Rico with hormone-treated cuttings under intermittent mist. Whitman found that a potted cutting 3 to 4 in (7.5-10 cm) long, will root if covered with a clear plastic bag.

Culture

The trees are spaced 25 to 33 ft (8-10 m) apart in orchards. In the Philippines they are frequently planted around the edges of coconut plantations. Generally, the langsat is casually grown in dooryards and on roadsides and receives no cultural attention. Regular irrigation results in better fruit size and heavier crops. Whitman has demonstrated that thrice-yearly applications of a 6-6-6 fertilizer formula with added minor elements result in good growth, productivity and high quality fruits even in an adverse environment.

Season and Harvesting

Langsats in Malaya generally bear twice a year-in June and July and again in December and January or even until February. In India, the fruits ripen from April to September but in the Philippines the season is short and most of the fruits are off the market in less than one month.

Yield

Trees in the Nilgiris average 30 lbs (13.5 kg) of fruits annually. In the Philippines, a productive tree averages 1,000 fruits per year.

Keeping Quality

Langsats are perishable and spoil after 4 days at room temperature. They can be kept in cold storage for 2 weeks at 52º to 55º F (11.11º-12.78º C) and relative humidity of 85-90%. Sugar content increases over this period, while acidity rises only up to the 7th day and then gradually declines.

Fruits treated with fungicide and held at 5% 0 and zero CO_2 and 58º F (14.44º C) with 85% to 90% humidity, have remained in good condition for more than 2 weeks. High C02 promotes browning and elevates acidity.

Waxing reduces weight loss, increases sweetness, but causes browning over at least half the surface within 5 days in storage.

Pests and Diseases

In Puerto Rico, young langsat trees have been defoliated by the sugarcane root borer, *Diaprepes abbreviatus.* Scale insects, especially *Pseudaonidia articulatus* and *Pseudaulacaspis pentagona*, and the red spider mite, *Tetranychus bimaculatus*, are sometimes found attacking the foliage, and sooty mold is apt to develop on the honeydew deposited by the scales. Rats gnaw on the branchlets and branches and the mature fruits.

Anthracnose caused by *Colletotrichum gloeosporioides* is evidenced by brown spots and other blemishes on the fruit and peduncle and leads to premature shedding of fruits.

Canker which makes the bark become rough and corky and flake off has appeared on langsats in Florida, Hawaii and Tahiti. It was believed to be caused by a fungus, *Cephalosporium sp.*, and larvae of a member of the Tineidae have been observed feeding under the loosened bark. However, other fungi, *Nectria sp.* (perfect stage of *Volutella sp.)* and *Phomopsis sp.* are officially recorded as causes of stem gall canker on the langsat in Florida.

Food Uses

The peel of the langsat is easily removed and the flesh is commonly eaten out-of-hand or served as dessert, and may be cooked in various ways.

Varieties with much latex are best dipped into boiling water to eliminate the gumminess before peeling.

The peeled, seedless or seeded fruits are canned in sirup or sometimes candied.

Food Value Per 100 g of Edible Portion*	
Moisture	86.5 g
Protein	0.8 g
Carbohydrates	9.5 g
Fiber	2.3 g
Calcium	20.0 mg
Phosphorus	30.0 mg
Carotene (Vitamin A)	13.0 I.U.
Thiamine	89 mcg
Riboflavin	124 mcg
Ascorbic Acid	1.0 mg
Phytin	1.1 mg (dry weight)

*According to analyses made in India.

The edible flesh may constitute 60% of the fruit.

Toxicity

An arrow poison has been made from the fruit peel and the bark of the tree. Both possess a toxic property, lansium acid, which, on injection, arrests heartbeat in frogs. The peel is reportedly high in tannin. The seed contains a minute amount of an unnamed alkaloid, 1% of an alcohol-soluble resin, and 2 bitter, toxic principles.

Other Uses

Peel: The dried peel is burned in Java, the aromatic smoke serving as a mosquito repellent and as incense in the rooms of sick people.

Wood: The wood is light-brown, medium-hard, fine-grained, tough, elastic and durable and weighs 52.3 lbs/ cu ft. It is utilized in Java for house posts, rafters, tool handles and small utensils. Wood-tar, derived by distillation, is employed to blacken the teeth.

Medicinal Uses: The fresh peel contains 0.2% of a light-yellow volatile oil, a brown resin and reducing acids. From the dried peel, there is obtained a dark, semi-liquid oleoresin composed of 0.17 % volatile oil and 22% resin. The resin is non-toxic and administered to halt diarrhea and intestinal spasms; contracts rabbit intestine *in vitro*.

The pulverized seed is employed as a febrifuge and vermifuge. The bark is poulticed on scorpion stings. An astringent bark decoction is taken as a treatment for dysentery and malaria. Leaves may be combined with the bark in preparing the decoction. The leaf juice is used as eye-drops to dispel inflammation.

Morton, J. 1987. Barbados Cherry. p. 204–207. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Barbados Cherry

Malpighia punicifolia L.

Malpighia glabra Millsp.

The Barbados cherry, a member of the Malpighiaceae, is an interesting example of a fruit that rose, like Cinderella, from relative obscurity about 40 years ago. It was at that time the subject of much taxonomic confusion, having been described and discussed previously under the binomial *Malpighia glabra* L., which properly belongs to a wild relative inhabiting the West Indies, tropical America and the lowlands of Mexico to southern Texas, and having smaller, pointed leaves, smaller flowers in peduncled umbels, styles nearly equal, and smaller fruits. *M. Punicifolia* L. (*M. glabra* Millsp. NOT Linn.) has been generally approved as the correct botanical name for the

Barbados cherry, which is also called West Indian cherry, native cherry, garden cherry, French cherry; in Spanish, *acerola, cereza, cereza colorada, cereza de la sabana,* or *grosella;* in French, *cerisier, cerise de St. Domingue;* in Portuguese, *cerejeira.* The name in Venezuela is *semeruco,* or *cemeruco;* in the Netherlands Antilles, *shimarucu;* in the Philippines, *malpi* (an abbreviation of the generic name).

Description

Plate XXV: BARBADOS CHERRY, *Malpighia punicifolia*

The Barbados cherry is a large, bushy shrub or small tree attaining up to 20 ft (6 m) in height and an equal breadth; with more or less erect or spreading and drooping, minutely hairy branches, and a short trunk to 4 in (10 cm) in diameter. Its evergreen leaves are elliptic, oblong, obovate, or narrowly oblanceolate, somewhat wavy, 3/4 to 2 3/4 in (2-7 cm) long, 3/8 to 1 5/8 in (9.5-40 mm) wide, obtuse or rounded at the apex, acute or cuneate at the base; bearing white, silky, irritating hairs when very young; hairless, dark green, and glossy when mature. The flowers, in sessile or short-peduncled cymes, have 5 pink or lavender, spoon-shaped, fringed petals. The fruits, borne singly or in 2's or 3's in the leaf axils, are oblate to round, cherry-like but more or less obviously 3-lobed; 1/2 to 1 in (1.25-2.5 cm) wide; bright-red, with thin, glossy skin and orange-colored, very juicy, acid to subacid, pulp. The 3 small, rounded seeds each have 2 large and 1 small fluted wings, thus forming what are generally conceived to be 3 triangular, yellowish, leathery-coated, corrugated inedible "stones".

Origin and Distribution

The Barbados cherry is native to the Lesser Antilles from St. Croix to Trinidad, also Curacao and Margarita and neighboring northern South America as far south as Brazil. It has become naturalized in Cuba, Jamaica and Puerto Rico after cultivation, and is commonly grown in dooryards in the Bahamas and Bermuda, and to some extent in Central and South America.

The plant is thought to have been first brought to Florida from Cuba by Pliny Reasoner because it appeared in the catalog of the Royal Palm Nursery for 1887-1888. It was carried abroad rather early for it is known to have borne fruit for the first time in the Philippines in 1916. In 1917, H.M. Curran brought seeds from Curacao to the United States Department of Agriculture. (S.P.I. #44458). The plant was casually grown in southern and central Florida until after World War II when it became more commonly planted. In Puerto Rico, just prior to that war, the Federal Soil Conservation Department planted Barbados cherry trees to control erosion on terraces at the Rio Piedras Experiment Station. During the war, 312 seedlings from the trees with the largest and most agreeably-flavored fruits were distributed to families to raise in their Victory Gardens. Later, several thousand trees were provided for planting in school yards to increase the vitamin intake of children, who are naturally partial to the fruits.

An explosion of interest occurred as a result of some food analyses being conducted at the School of Medicine, University of Puerto Rico, in Rio Piedras in 1945. The emblic *(Emblica officinalis* L.) was found to be extremely high in ascorbic acid. This inspired one of the laboratory assistants to bring in some Barbados cherries which the local people were accustomed to eating when they had colds. These fruits were found to contain far more ascorbic acid than the emblic, and, because of their attractiveness and superior eating quality, interest quickly switched from the emblic to the Barbados cherry. Much publicity ensued, featuring the fruit under the Puerto Rican name of *acerola.* A plantation of 400 trees was established at Rio Piedras in 1947 and, from 1951 to 1953, 238 trees were set out at the Isabela Substation. By 1954, there were 30,000 trees in commercial groves on the island. Several plantings had been made in Florida and a 2,000-acre (833-ha) plantation in Hawaii. There was a great flurry of activity. Horticulturists were busy making selections of high-ascorbic-acid clones and improving methods of vegetative propagation, and agronomists were studying the effects of cultural practices. Smaller plantings were being developed in Jamaica, Venezuela, Guatemala, Ghana, India, the Philippines and Queensland, Australia, and even in Israel. Many so-called "natural food" outlets promoted various "vitamin C" products from the fruits–powder, tablets, capsules, juice, sirup.

At length, enthusiasm subsided when it was realized that a fruit could not become a superstar because of its ascorbic acid content alone; that ascorbic acid from a natural source could not economically compete with the much cheaper synthetic product, inasmuch as research proved that the ascorbic acid of the Barbados cherry is metabolized in a manner identical to the assimilation of crystalline ascorbic acid.

The large plantation of the Hawaiian Acerola Company (a subsidiary of Nutrilite Products Company) was abandoned for this reason, and low fruit yields; and, so it is said, the low ascorbic acid content because of the high copper levels in the soil. Puerto Rican production was directed thereafter mainly to the use of the fruit in specialty baby foods.

Frozen fruits are shipped to the United States for processing.

Varieties

In 1956, workers at the University of Florida's Agricultural Research and Education Center in Homestead, after making preliminary evaluations and selections, chose as superior and named the **'Florida Sweet'**, a clone that was observed to have an upright habit of growth, large fruits, thick skin, apple-like, semi-sweet flavor, and high yield.

The first promising selections in Puerto Rico, on the bases of fruit size, yield and vitamin content, were identified as 'A-l' and 'B-17', but these were later found to be inferior to 'B-15' in ascorbic acid level and productivity. Yields of 10 clones ('A-l', 'A-2', 'A-4', 'A-10', 'A-21', 'B-2', 'B-9', 'B-15', 'B-17', and 'K-7') were compared over a 2-year period (1955-56) in Puerto Rico and 'B-15' far exceeded the others in both years.

A horticultural variety in St. Croix, formerly known as *M. thompsonii* Britton & Small, has displayed unusually large leaves and fruits and more abundant flowers than the common strain of Barbados cherry.

Climate

The Barbados cherry can be classed as tropical and subtropical, for mature trees can survive brief exposure to 28º F (-2.22º C). Young plants are killed by any drop below 30º F (-1.11º C). It is naturally adapted to both medium- and low-rainfall regions; can tolerate long periods of drought, though it may not fruit until the coming of rain.

Soil

The tree does well on limestone, marl and clay, as long as they are well drained. The pH should be at least 5.5. Elevation to 6.5 significantly improves root development. Acid soils require the addition of lime to avoid calcium deficiency and increase yield. The lime should be worked into the soil to a depth of 8 in (20 cm) or more.

Propagation

If seeds are used for planting, they should be selected from desirable clones not exposed to cross-pollination by inferior types. They should be cleaned, dried, and dusted with a fungicide. It should also be realized that the seeds in an individual fruit develop unevenly and only those that are fully developed when the fruit is ripe will germinate satisfactorily. Germination rates may be only 50% or as low as 5%. Seedlings should be transferred from flats to containers when 2 to 3 in (5-7.5 cm) high.

Air-layering (in summer) and side-veneer, cleft, or modified crown grafting are feasible but not popular because it is so much easier to raise the tree from cuttings. Cuttings of branches 1/4 to 1/2 in (6-12.5 mm) thick and 8 to 10 in (20-25 cm) long, with 2 or 3 leaves attached, hormone-treated and set in sand or other suitable media under constant or intermittent mist, will root in 60 days. They are then transplanted to nursery rows or containers and held in shade for 6 months or a year before being set out in the field. Some fruits will be borne a year after planting but a good crop cannot be expected until the 3rd or 4th year. The tree will continue bearing well for about 15 years. There is a lapse of only 22 days between flowering and complete fruit maturity.

Grafting is generally practiced only when cuttings of a desired clone are scarce or if a nematode-resistant rootstock is available on which to graft a preferred cultivar; or when top-working a tree that bears fruits of low quality.

Culture

The Barbados cherry tree will grow and fruit fairly well with little care. For best performance, Puerto Rican agronomists have recommended a fertilizer formula of 8-8-13 twice annually for the first 4 years at the rate of 1/2 to 1 lb (0.22-0.45 kg). Older trees should have 3 to 5 lbs (1.35-2.25 kg) per tree. In addition, organic material should be worked into the planting hole and also supplied in amounts of 10 to 20 lbs (4.5-9 kg) per tree. Under Florida conditions, a 10-10-10 formula is given in February, 1 lb (0.22 kg) for each year of growth. In May, July and September, a 4-7-5-3 formula is recommended, 1 lb (0.22 kg) for each year of age up to the 10th year. Thereafter, a 6-4-6-3 mixture is given–5 lbs (2.25 kg) per tree in late winter and 10 lbs (4.5 kg) per tree for each of the summer feedings. On limestone soils, sprays of minor elements–copper, zinc, and sometimes manganese–will enhance growth and productivity. Young trees need regular irrigation until well established; older trees require watering only during droughts. Mature plants will bear better if thinned out by judicious pruning after the late crop and then fertilized once more.

Pollination and Fruit Set

In Florida, bees visit Barbados cherry flowers in great numbers and are the principal pollinators. Maintenance of hives near Barbados cherry trees substantially improves fruit set. In Hawaii, there was found to be very little transport of pollen by wind, and insect pollination is inadequate. Consequently, fruits are often seedless. Investigations have shown that growth regulators (IBA at 100 ppm; PCA at 50 ppm) induce much higher fruit set but these chemicals may be too costly to buy and apply.

Season

In Florida, the Bahamas, Puerto Rico and Hawaii the fruiting season varies with the weather. There may be a spring crop ripening in May and then successive small crops off and on until December, but sometimes, if spring rains are lacking, there may be no fruits at all until December and then a heavy crop. In Zanzibar, the bearing season is said to be just the months of December and January.

Harvesting

For home use, as dessert, the fruits are picked when fully ripe. For processing or preserving, they can be harvested when slightly immature, when they are turning from yellow to red. As there is continuous fruiting over long periods, picking is done every day, every other day, or every 3 days to avoid loss by falling.

The fruits are usually picked manually in the cool of the early morning, and must be handled with care. For immediate processing, some growers shake the tree and allow the ripe fruits to fall onto sheets spread on the ground. Harvested fruits should be kept in the shade until transferred from the field, which ought to be done within 3 hours, and collecting lugs are best covered with heavy canvas to retard loss of ascorbic acid.

Yield

There is great variation in productivity. Individual trees may yield 30 to 62 lbs (13.5-28 kg) in Puerto Rico. In Jamaica, maximum yield in the 6th year is about 80 lbs (36 kg) per tree; 24,000 lbs/acre (24,000 kg/ha). Venezuelan growers have reported 10 to 15 tons/ha; the average in Puerto Rico is 25 tons/ha/yr. 'Florida Sweet' in Florida has yielded 65 tons/ha. A plot of 300 trees of 'Florida Sweet' has borne crops of 6,300 to 51,300 lbs (2,858-23,270 kg) of fruit from March to November, in Homestead, Florida.

In Puerto Rico, a planting of 200 trees may be expected to produce 3,600 to 5,400 lbs (1,636-2,455 kg) of juice. From the juice there can be extracted at least 120 lbs (54.5 kg) of vitamin C expressed as dehydroascorbic and ascorbic acid, providing the content is determined to be 2%. In Puerto Rico, it is calculated that 10 tons of fruit should yield 435 lbs (197 kg) ascorbic acid. In a commercial operation using ion-exchange resins, the yield of ascorbic acid from Barbados cherry juice is expected to be about 88%.

Keeping Quality

Ripe Barbados cherries bruise easily and are highly perishable. Processors store them for no more than 3 days at 45º F (7.22º C). Half-ripe fruits can be maintained for a few more days. If longer storage is necessary, the fruits must be frozen and kept at 10º F (-12.22º C) and later thawed for use. At one time it was believed that the fruits could be transported to processing plants in water tanks (as is done with true cherries) but it was discovered that they lose their color and ascorbic acid content in water.

At room temperature–85º F (29.44º C) in Puerto Rico–canned Barbados cherries and also the juice lose color and fresh flavor and 53% to 80% of their ascorbic acid content in one month, and metal cans swell because of the development of CO_2. Refrigeration at 44.6º F (7º C) considerably reduces such deterioration. Juice in the home refrigerator will lose 20% of its ascorbic acid in 18 days. Therefore, the juice and the puree should be kept no longer than one week.

Pests and Diseases

One of the major obstacles to successful cultivation of the Barbados cherry is the tree's susceptibility to the root-knot nematode, *Meloidogyne incognita* var. *acrita,* especially in sandy acid soils. Soil fumigation, mulching and regular irrigation will help to keep this problem under control. The burrowing nematode, *Radopholus similis,* is also a cause of decline in otherwise healthy trees.

In Florida, the foliage is attacked by wax scale, Florida mango scale, and other scale insects, whiteflies, a leaf roller, and aphids. In Guatemala, the aphid, *Aphis spiraecola,* attacks the leaves and young, tender branches. This pest and the Hesperid caterpillar, *Ephyriades arcas,* require chemical control. In Puerto Rico, the tree is often damaged by the blue chrysomelid of acerola, *Leucocera laevicollis.* Some fruits may be malformed but not otherwise affected by the sting of stinkbugs. None of these predators is of any great importance.

The major pest in Florida is the Caribbean fruit fly, *Anastrepha suspensa,* which seems to attack all but very sour fruits and the larvae are commonly found inside. In Guatemala, a fruit worm, *Anthonomus florus,* deposits its eggs in the floral ovary and also in the fruits; the larvae feed in the fruits causing deformity and total ruin. Drastic control measures have been employed against this predator, including the incineration of all fallen, infested fruits and the elimination of all related species that serve as hosts.

Few diseases have been reported. However, in Florida, there are cases of anthracnose caused by *Colletotrichum gloeosporioides,* and leafspotting by the fungus, *Cercospora bunchosiae, is* a serious malady in Florida, Puerto Rico and Hawaii. Green scurf, identified with the alga, *Cephaleuros virescens,* occurs in Puerto Rico.

Food Uses

Barbados cherries are eaten out-of-hand, mainly by children. For dessert use, they are delicious merely stewed with whatever amount of sugar is desired to modify the acidity of the particular type available. The seeds must be separated from the pulp in the mouth and returned by spoon to the dish. Many may feel that the nuisance is compensated for by the pleasure of enjoying the flavorful pulp and juice. Other-wise, the cooked fruits must be strained to remove the seeds and the resulting sauce or puree can be utilized as a topping on cake, pudding, ice cream or sliced bananas, or used in other culinary products. Commercially prepared puree may be dried or frozen for future use. The fresh juice will prevent darkening of bananas sliced for fruit cups or salads. It can be used for gelatin desserts, punch or sherbet, and has been added as an ascorbic acid supplement to other fruit juices. The juice was dried and powdered commercially in Puerto Rico for a decade until the cost of production caused the factory to be closed down.

The fruits may be made into sirup or, with added pectin, excellent jelly, jam, and other preserves. Cooking causes the bright-red color to change to brownish-red. The pasteurization process in the canning of the juice changes the color to orange-red or yellow, and packing in tin cans brings on further color deterioration. Enamel-lined cans preserve the color better.

Wine made from Barbados cherries in Hawaii was found to retain 60% of the ascorbic acid.

Food Value Per 100 g of Edible Portion*	
Calories	59
Moisture	81.9-91.10 g
Protein	0.68-1.8 g
Ether Extract	0.19-0.09 g
Fiber	0.60-1.2 g
Fat	0.18-0.1 g
Carbohydrates	6.98-14.0 g
Ash	0.77-0.82 g
Calcium	8.2-34.6 mg
Phosphorus	16.2-37.5 mg
Iron	0.17-1.11 mg
Carotene	0.003-0.408 mg
(Vitamin A)	408-1000 I.U.
Thiamine	0.024-0.040 mg
Riboflavin	0.038-0.079 mg
Niacin	0.34-0.526 mg
Ascorbic Acid**	

*According to analyses made in Hawaii, Guatemala, and elsewhere.

**According to analyses at the Massachusetts Institute of Technology of fruits grown in Barbados: 4,500 mg (green), 3,300 mg (medium-ripe), 2,000 mg (very ripe). The ascorbic acid level of unripe fruits can range up to 4,676 mg and such ratings are exceeded only by the fruits (rose hips) of *Rosa rugosa* Thunb., which may have as much as 6,977 mg/100 g. This constituent varies as much as 25% with the clone, the locale, cultural methods and degree of exposure to sunlight during developmental stages and after harvesting. At INCAP (Instituto de Nutricion de Central America and Panama), in Guatemala assays in 1950-1955 showed distressingly low levels–an average of 17 mg/100 g, whereas fruits sent to INCAP by air and in dry ice from Florida were analyzed and contained 1,420 mg/100 g. In field experiments, treatment of young fruits on the tree with 200 ppm gibberellic acid has brought about a marked increase in the ascorbic acid content of the mature fruits.

The ascorbic acid is not totally destroyed by heat, for the jelly may contain 499-1,900 mg/100 g. Of the total ascorbic acid in Barbados cherry juice, 0.18% is in the bound form. Other constituents include dextrose, levulose, and a little sucrose.

Harmful Effects

Physicians in Curacao report that children often require treatment for intestinal inflammation and obstruction caused by eating quantities of the entire fruits, including seeds, from the wild Barbados cherries which abound on the island.

People who pick Barbados cherries without gloves and long sleeves may suffer skin irritation from contact with the minute stinging hairs on the leaves and petioles.

Other Uses

Bark: The bark of the tree contains 20-25% tannin and has been utilized in the leather industry.

Wood: The wood is surprisingly hard and heavy. Trials have demonstrated that it refuses to ignite even when treated with flammable fluid unless perfectly dry.

Medicinal Uses: The fruits are considered beneficial to patients with liver ailments, diarrhea and dysentery, as well as those with coughs or colds. The juice may be gargled to relieve sore throat.

Morton, J. 1987. Nance. p. 207–209. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Nance

Byrsonima crassifolia HBK.

Byrsonima cubensis Juss.

Malpighia crassifolia L.

The fruits of a number of species of *Byrsonima* have been consumed by the Indians of Central America and northern South America. The best-known of these is the nance, *B. crassifolia* HBK. (syns. *B. cubensis Juss.; Malpighia crassifolia* L.), which has acquired many alternate vernacular names: *changugu, chi, nance agrio, nanche, nanchi, nancen, nanche de perro, nananche,* and *nantzin* in Mexico; *nance verde* in El Salvador; *nancito* or *crabo* in Honduras; *craboo, crapoo* and wild *craboo* in Belize; *doncela* and *maricao* in the Dominican Republic; *maricao cimaroon, maricao verde, peralejo* and *peralejo blanco* in Puerto Rico; *peralejo de sabana* in Cuba; *tapal* in Guatemala; *chaparro, chaparro manteca, maache, mantequera, nanzi, noro, peraleja hembra, yaca* or *yuco* in Colombia; *chaparro de chinche, chaparro de sabana, manero manteco, manteco merey* or *manteco sabanero* in Venezuela; *murici, mirixi, murici-do-campo,* and *muruci-da-praia* in Brazil; *hori, sabana kwari moeleidan,* and *sabana mango* in Surinam; *huria* in Guyana; *quinquina des savannes* in Guateloupe; *savanna serrette* in Trinidad; sometimes wild cherry in Panama; golden spoon in the former British West Indies.

Description

The nance is a slow-growing large shrub or tree to 33 ft (10 m) high, or, in certain situations, even reaching 66 ft (20 m); varying in form from round-topped and spreading to narrow and compact;

the trunk short or tall, crooked or straight. Young branches are densely coated with russet hairs. The opposite leaves, ovate to elliptic or oblong-elliptic, may be 1 1/4 to 6 1/2 in (3.2-17 cm) long and 1 1/2 to 2 3/4 in (4-7 cm) wide, rounded or pointed at the apex, blunt or pointed at the base; leathery, usually glossy on the upper surface and more or less brown- or gray-hairy on the underside. The flowers, borne in thinly or conspicuously red-hairy, erect racemes 4 to 8 in (10-20 cm) long, are 1/2 to 3/4 in (1.25-2 cm) wide; the 5 petals yellow at first, changing to dull orange-red. The fruit is peculiarly odorous, orange-yellow, round, 5/16 to 7/16 in (8-12 cm) wide, with thin skin and white, juicy, oily pulp varying in flavor from insipid to sweet, acid, or cheese-like. There is a single, fairly large, stone containing 1 to 3 white seeds.

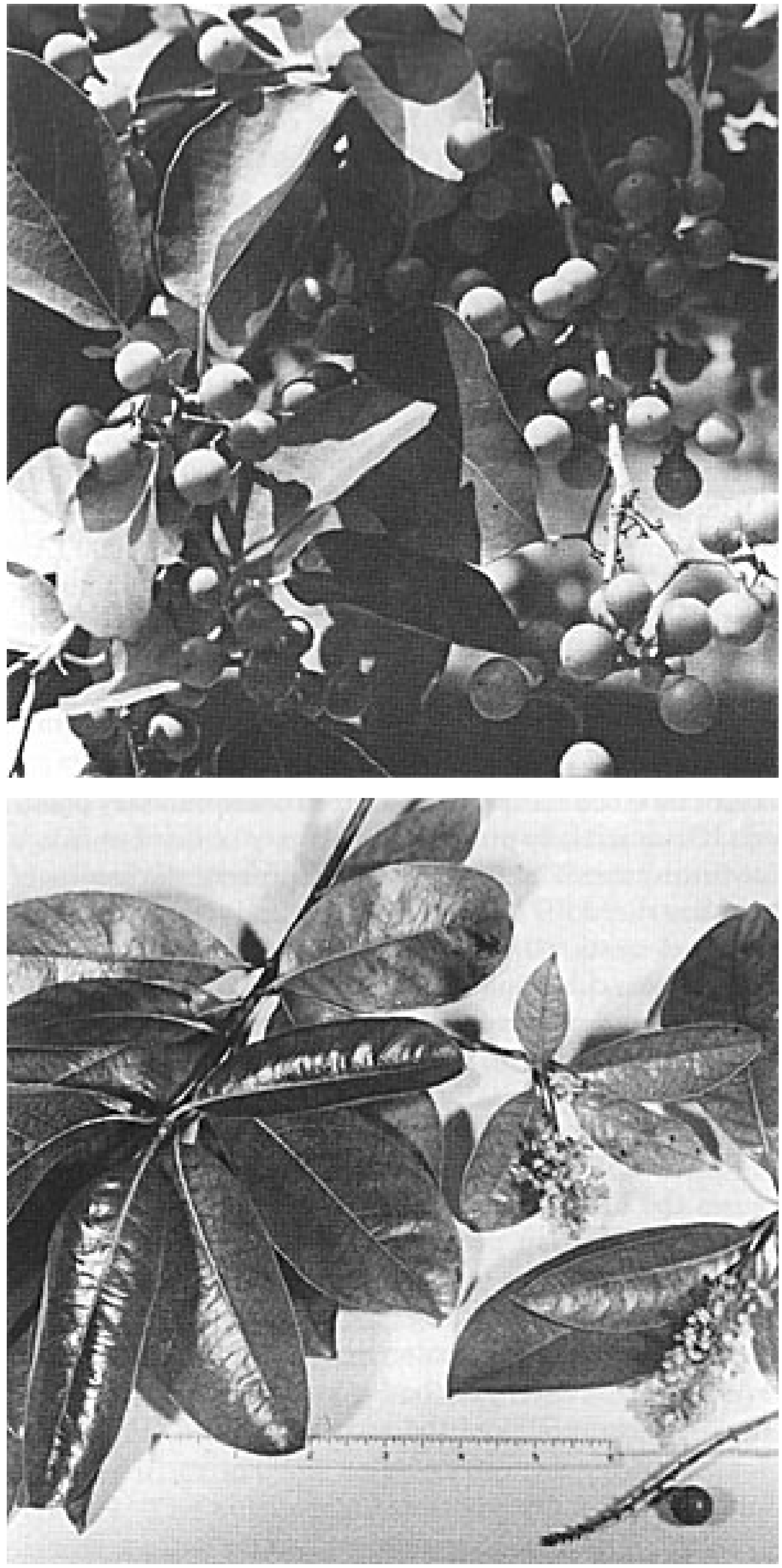


Fig. 54: The nance *(Byrsonima crassifolia),* though a minor fruit, has culinary and beverage uses in tropical America. The flowers furnish nectar for honeybees.

Origin and Distribution

The tree is native and abundant in the wild, sometimes in extensive stands, in open pine forests and grassy savannas, from southern Mexico, through the Pacific side of Central America, to Peru and Brazil; also occurs in Trinidad, Barbados, Curacao, St. Martin, Dominica, Guadeloupe, Puerto Rico, Haiti, the Dominican Republic and throughout Cuba and the Isle of Pines.

Dr. David Fairchild brought seeds from Panama to the United States Department of Agriculture in 1899 (S.P.I. #2944). A few specimens exist in special collections in southern Florida. The species was introduced into the Philippines in 1918.

Throughout its natural range, the nance is mainly consumed by children, birds, and wild and domesticated animals. In some regions, large quantities are sold in native markets at very low prices. There is some cultivation of the tree for its fruits in Mexico and parts of Central America.

Climate

The nance is limited to tropical and subtropical climates. In Central and South America, the tree ranges from sea-level to an altitude of 6,000 ft (1,800 m). It is highly drought-tolerant.

Soil

In Mexico, the tree is often found on rocky ground. It grows well in sandy and alkaline-sandy soils. It is well suited for restoration of infertile and burned-over land.

Season

In Mexico, the tree blooms from April through July and the fruits are marketed in September and October. In Puerto Rico, the tree blooms and fruits continuously from spring to fall; in Brazil from December to April.

Keeping Quality

The fruits fall to the ground when fully ripe and are very perishable. However, they can be stored in good condition for several months by merely keeping them submerged in water.

Food Uses

The fruits are eaten raw or cooked as dessert, or may be included in soup or in stuffing for meats. J.N. Rose in 1899 wrote that he saw nances, olives and rice cooked with stewed chicken in Mexico.

The fruits are often used to prepare carbonated beverages, or an acid, oily, fermented beverage known by the standard term *chicha* applied to assorted beer-like drinks made of fruits or maize. By distillation, there is produced in Costa Rica, a rum-like liquor called *Crema de nance*.

In Magdalena, Colombia, an edible fat is extracted from the fruits with boiling water.

Food Value Per 100 g of Edible Portion*	
Moisture	79.3-83.2 g
Protein	0.109-0.124 g
Fat	0.21-1.83 g
Fiber	2.5-5.8 g
Ash	0.58-0.69 g
Calcium	23.0-36.8 mg
Phosphorus	12.6-15.7 mg
Iron	0.62-1.01 mg
Carotene	0.002-0.060 mg
Thiamine	0.009-0.014 mg
Riboflavin	0.015-0.039 mg
Niacin	0.266-0.327 mg
Ascorbic Acid	90.0-192.0 mg

*According to analyses made in Guatemala and El Salvador. The fruit is high in tannin, especially when unripe.

Other Uses

Fruit: Green fruits are sometimes used in dyeing. The fruit skin imparts a light-brown hue to cotton cloth.

Bark: The bark yields a strong fiber, and is employed in tanning, giving the leather a light-yellow tone. The bark contains 17.25-28.26% tannin and 2.73% oxalic acid.

Branches: Fresh branches are cut into small pieces and thrown into streams to stupefy fish; or they are crushed at the edge of shallow waters so that the juice spills into the water, for the same effect.

Wood: The sapwood is grayish; the heartwood reddish-brown, heavy, coarse-textured, tough, and highly prized for boat ribs though it is brittle and only medium-durable. Usually available only in small sizes, it serves for tool handles, turnery, cabinetwork and furniture and small-scale construction. In Brazil, the wood is chosen for the hot fire over which the people smoke the stimulant paste of guaraná *(Paullinia cupana* HBK.) because the burning wood has a pleasant odor. In some areas it is used for making charcoal.

Nectar: In Costa Rica, the nance provides one of the few sources of nectar for honeybees in the month of June.

Medicinal Uses: The astringent bark infusion is taken to halt diarrhea; also as a febrifuge. It is considered beneficial in pulmonary complaints, cases of leucorrhea, and allegedly tightens the teeth where the gums are diseased. In Belize, it is taken as an antidote for snakebite. In Guyana, the pounded bark is poulticed on wounds. Mexicans apply the pulverized bark on ulcers.

Morton, J. 1987. Emblic. p. 213–217. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Emblic

Phyllanthus emblica L.

Emblica officinalis Gaertn.

This member of the Euphorbiaceae, *Phyllanthus emblica* L. (syn. *Emblica officinalis* Gaertn.) ranges in status from insignificant in the western world to highly prized in tropical Asia. Alternative English names include emblic myrobalan, Malacca tree and Indian gooseberry, though the last term is more frequently applied to the related but dissimilar Otaheite gooseberry, q.v. In Malaya the emblic is called *melaka, Asam melaka*, or *amlaka;* in Thailand, it is *ma-kham-pom;* in Laos, *mak-kham-pom;* in Cambodia, *kam lam* or *kam lam ko;* in southern Vietnam, *bong ngot;* in North Vietnam, *chu me.* In the Philippines, it is called *nelli.*

Description

The tree is a graceful ornamental, normally reaching a height of 60 ft (18 m) and, in rare instances, 100 ft (30 m). Its fairly smooth bark is a pale grayish-brown and peels off in thin flakes like that of the guava. While actually deciduous, shedding its branchlets as well as its leaves, it is seldom entirely bare and is therefore often cited as an evergreen. The miniature, oblong leaves, only 1/8 in

(3 mm) wide and 1/2 to 3/4 in (1.25-2 cm) long, distichously disposed on very slender branchlets, give a misleading impression of finely pinnate foliage. Small, inconspicuous, greenish-yellow flowers are borne in compact clusters in the axils of the lower leaves. Usually, male flowers occur at the lower end of a growing branchlet, with the female flowers above them, but occasional trees are dioecious.

Fig. 56: The marble-like emblic *(Phyllanthus emblica),* hard and sour, is valued in Asia as a thirst-quencher and for its ascorbic acid content.

The nearly stemless fruit is round or oblate, indented at the base, and smooth, though 6 to 8 pale lines, sometimes faintly evident as ridges, extending from the base to the apex, give it the appearance of being divided into segments or lobes. Light-green at first, the fruit becomes whitish or a dull, greenish-yellow, or, more rarely, brick-red as it matures. It is hard and unyielding to the touch. The skin is thin, translucent and adherent to the very crisp, juicy, concolorous flesh. Tightly embedded in the center of the flesh is a slightly hexagonal stone containing 6 small seeds. Fruits collected in South Florida vary from 1 to 1 1/4 in (2.5-3.2 cm) in diameter but choice types in India approach 2 in (5 cm) in width. Ripe fruits are astringent, extremely acid, and some are distinctly bitter.

Origin and Distribution

The emblic tree is native to tropical southeastern Asia, particularly in central and southern India, Pakistan, Bangladesh, Ceylon, Malaya, southern China and the Mascarene Islands. It is commonly cultivated in home gardens throughout India and grown commercially in Uttar Pradesh. Many trees have been planted in southern Malaya, Singapore, and throughout Malaysia. In India, and to a lesser extent in Malaya, the emblic is important and esteemed, raw as well as preserved, and it is prominent in folk medicine. Fruits from both wild and dooryard trees and from orchards are gathered for home use and for market. In southern Thailand, fruits from wild trees are gathered for marketing.

In 1901, the United States Department of Agriculture received seeds from the Reasoner Brothers, noted nurserymen and plant importers of Oneco, Florida. Seeds were distributed to early settlers in Florida and to public gardens and experimental stations in Bermuda, Cuba, Puerto Rico, Trinidad, Panama, Hawaii and the Philippines. The fruits of these seedlings aroused no enthusiasm until 1945 when Mr. Claud Horn of the Office of Foreign Agricultural Relations in Washington, D.C., inspired by Indian ratings of the emblic as the "richest known natural source of vitamin C", asked that analyses be made in Puerto Rico. A high level of ascorbic acid was found and confirmed in Florida but interest quickly switched to the Barbados cherry (q.v.) which was casually assayed and found to be as rich or richer when underripe. The emblic was soon forgotten. Some old trees still exist in southern Florida; others have been removed in favor of housing or other developments. In 1954, the Campbell Soup Company in Camden, New Jersey, requested 5 lbs (2.25 kg) of the fruits for study. They were sent, but no further interest was evidenced. In 1982, several individuals asked for and were given seeds for planting in Australia. They did not reveal whether the tree was desired for its own sake or for its fruits.

Varieties

In India there are 3 named cultivars grown commercially:

'Banarsi'–originated in Banarsi district of Uttar Pradesh; medium to large, the 6 segments paired, giving the appearance of only 3; 1 1/2 in (4 cm) long, 1 3/4 in (4.5 cm) wide; skin thin and translucent, light-green, turning whitish as the fruit ripens; flesh slightly fibrous, medium juicy, moderately astringent. Earliest in season. Tree is semi-spreading; not a heavy cropper; tends to alternate bearing unless interplanted.

'Chakaiya'–flattened at base and apex; may have 6, 7, or 8 segments; of medium size, 1 1/4 in (3.2 cm) long, 3 1/4 in (8.25 cm) wide; flesh fibrous. Tree is spreading; prolific. This cultivar is now preferred over the others because of its yield.

'Francis' ('Hathijhool')–rounded-oval, bulged at the apex; has 6 segments; large, 1 5/8 in (4.3 cm) long and 2 in (5 cm) wide. The tree is a regular producer of good crops, but prone to fruit necrosis.

The ordinary small fruits–5/8 to 1 in (1.5-2.5 cm) wide, with reddish skin, rarely grown commercially, are mainly used for medicinal purposes.

Pollination

Cross-pollination is desirable. 'Banarsi' bears better when interplanted with other varieties. Growers in India are beginning to scatter a few seedling trees around in their groves. Honeybees work the flowers in the morning and late evening. It is now known that lack of pollination is the cause of up to 70% shedding of flowers in the first 3 weeks after onset of blooming.

Climate

The emblic is subtropical rather than strictly tropical. In India, it flourishes from sea-level up to an altitude of 5,000 ft (1,800 m). Seeds were planted at the Agricultural Research and Education Center in Homestead, Florida, in 1955 and the seedlings were set out in the field in 1956. They survived unusually cold weather in the winter of 1957-58. That freeze damaged a tree with a trunk 1 ft (30 cm) thick at Laurel, Florida. It was set back again by cold in December 1962. It put out many shoots which, by October 2, 1963 were 10 ft (3 m) high, showing a remarkable ability to recover from cold injury. On the other hand, it is intolerant of excessive heat. In India, mature trees can stand temperatures up to 115º F (46º C) in the summer but young plants must be shaded.

Soil

The emblic seems to grow equally well under both and and humid conditions. It is noted for being able to thrive in regions too dry and soil too poor for most other fruit crops. For maximum productivity, the tree requires deep soil ranging from sandy loam to clay, light or heavy, slightly acidic to slightly alkaline. At high pH (as much as 8.0), nutritional deficiencies are evident. Limestone is considered unsuitable but the large, old trees in southern Florida are all in oolitic limestone. Good drainage is essential. A low degree of salinity seems to be fairly well tolerated.

Propagation

The tree is often propagated by seeds taken from overripe fruits sun-dried to facilitate removal of the stone, or cut in half right through the stone. The extracted seeds are given the float test and 100% of those that sink will germinate. In 4 months, seedlings will have a stem diameter of 1/3 in (8 mm) and can be budded or grafted from June to September and in February and March in India. The Forkert and patch techniques have given 85% to 100% success. Chip-budding, using seedlings 1 1/2 years old as rootstocks, is easier and 60% to 80% successful in September and October and February and March. Inarching is sometimes practiced in India but survival rate may be only 25% to 30% after separation from the stock and further losses may occur in the field. At the Experimental Farm of the University of Miami in 1955, air-layers and cuttings were unsuccessful but root sprouts grew well.

Emblic trees bearing fruits of inferior quality may be top-worked by cutting back to a height of 4 ft (1.2 m) and applying coal tar to the cut surfaces. Trials at Saharanpur showed that this is best done in March when the trees are not in active growth. Budding of the new shoots can be done successfully any time from June to September.

Culture

While the emblic has long been established as an important and remunerative crop in India, the systematic culture of high-quality fruit is a modern development actively promoted by the Indian Government. It is recommended that the trees be spaced 30 to 40 ft (9-12 m) apart and planted in well-prepared holes enriched with a composted manure and soil mixture, and well-watered. Thereafter, watering is done only in the dry season. Seedlings in Florida have attained 8 to 9 ft (2.4-2.7 m) in height in 5 years. They usually begin to bear when 5 to 6 years old and normally bear for about 50 years.

There are no standard practices for fertilizing the emblic but 1 to 1 1/2 oz (28-42 g) of nitrogen per tree for each year of age up to 10 years has been suggested. After 10 years the nitrogen is increased and potash and superphosphate are added. Half of the fertilizer should be given after fruit-set and the other half 4 months later.

The branches are brittle and judicious pruning to develop a strong framework is advocated to avoid branch breakage from heavy loads of fruit.

Season and Harvesting

The emblic is sensitive to day-length. In northern India, flowering takes place from March to May. In Madras, the tree blooms in June-July and again in February-March, the second flowering producing only a small crop. In Florida flowering occurs during the summer months, the main crop maturing during the winter and early spring. A few fruits developed from late blooms are found in summer and fall.

In India, people shake down the fruits that are ready to fall and gather from the ground those that have already fallen, and take them to market. They stand handling well. The yield varies a great deal as many young fruits are shed throughout the period of fruit development, and there is considerable difference in the productivity of seedlings and cultivars. P.N. Bajpai, in a study of the fruiting habits of four 15-year-old emblic trees, found an average yield of 415 fruits, which weighed approximately 24 1/2 lbs (11 kg). 'Banarsi' trees 10 years old have yielded 35.2 lbs (16 kg). 'Chakaiya' trees of the same age have yielded 39.6 lbs (18 kg). Mature 'Chakaiya' trees may bear 55 lbs (25 kg) per year.

Pests and Diseases

The chief pest of this tree in India is the bark-eating caterpillar, *Indarbela* sp., which tunnels into the branches and trunk. A secondary enemy produces shoot galls. A non-pathogenic problem, especially in 'Francis', is called "fruit necrosis" in India. It is evidenced by internal browning which gradually extends to the surface where dark spots become corky and gummy. It can be overcome by bi-monthly sprays of borax in September and October. There are few serious diseases but the fungi, *Bestonea stylophora*, *Phakospora phyllanthi* and *Ravenelia emblicae,* cause ring rust, leaf rust and fruit rot.

Fresh emblics on the market or in storage are subject to blue mold and rotting caused by *Penicillium islandicum.* Rinsing with very dilute borax or sodium chloride solutions helps retard such spoilage. Emblic preserves on the market have been found contaminated with yeasts, molds and bacteria. Pre-processing treatment with 0.01% sulfur dioxide or sodium benzoate prolongs keeping quality.

Food Uses

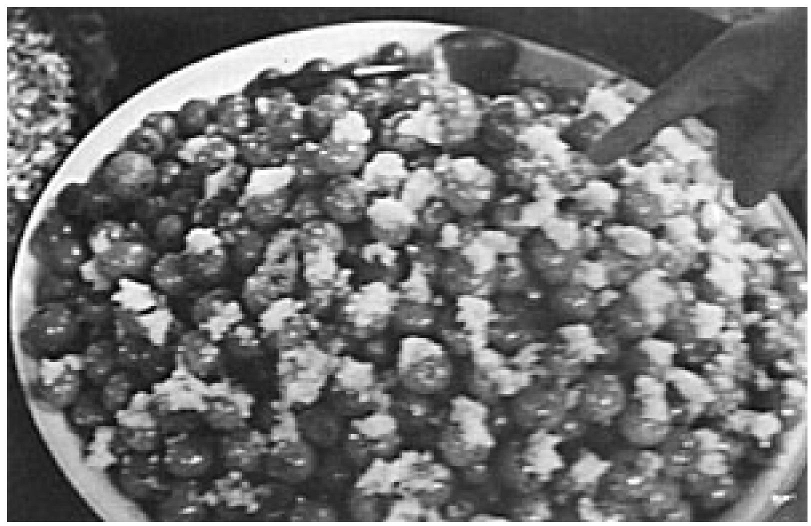


Fig. 57: Emblics, heavily sugared, are sold in the native markets of Southeast Asia.

Rural folk in India claim that the highly acid, fresh, raw fruit, followed by water, produces a sweet and refreshing aftertaste. Wood-cutters in Southeast Asia eat the emblic to avoid thirst, as the fruit stimulates the flow of saliva. This is the one tree left standing when forests are clear-cut in Thailand, and busses stop along highways to let thirsty travelers run to the tree to get the fruits. The emblic is regarded as sacred by many Hindus and the Hindu religion prescribes that ripe fruits be eaten for 40 days after a fast in order to restore health and vitality. It is a common practice in Indian homes to cook the fruits whole with sugar and saffron and give one or two to a child every morning.

Fresh emblics are baked in tarts, added to other foods as seasoning during cooking, and the juice is used to flavor vinegar. Both ripe and half-ripe fruits are candied whole and also made into jam and other preserves, sweetmeats, pickles and relishes. They are combined with other fruits in making chutney. In Indonesia, emblics; are added to impart acidity to many dishes, often as a substitute for tamarinds.

When necessary, bitterness is overcome by soaking the fruits in a salt solution or by adding citrus fruit, unripe mango or tamarind. In preserving emblics; whole, the fruit is first brined, washed and pricked, blanched in an alum solution, layered with sugar until a sirup is formed, and then boiled. It is finally packed in enameled cans or crystallized as a confection. In India, a sauce is made from the dried, chipped flesh. In its preparation, the chips are cooked in water, mashed in a mortar with caraway seeds, and further seasoned with salt and yogurt. This, also, is commonly eaten after fasting. During World War II, emblic powder, tablets and candies were issued to Indian military personnel as vitamin C rations. Drs. Rama Rao, Balakushnan and Rajagopalan, of the Institute of Science at Bangalore, describe a method of spray-drying emblic juice to produce a special powder for fortifying salt as a means of increasing vitamin C intake.

In Thailand, where the tree is common in the forests, the fruits are favored by deer, especially the tiny barking deer.

Food Value Per 100 g of Edible Portion*	
Moisture	77.1 g
Protein	0.07 g
Fat	0.2 g
Carbohydrates	21.8 g
Fiber	1.9 g
Ash	0.5 g
Calcium	12.5 mg
Phosphorus	26.0 mg
Iron	0.48 mg
Carotene	0.01 mg
Thiamine	0.03 mg
Riboflavin	0.05 mg
Niacin	0.18 mg
Tryptophan	3.0 mg
Methionine	2.1 mg
Lysine	17.0 mg
Ascorbic Acid**	625 mg

*As reported by the Finlay Institute Laboratory, Havana.

**The ascorbic acid ratings vary immensely. Analyses in Puerto Rico, showed 625 mg; fruits from one tree in Avon Park, Florida, showed only 467 mg, while 2 adjacent trees in Homestead, Florida, showed 1,130 and 1,325 mg; and Dr. Margaret Mustard reported an average of 1,561.0 and a high of 1,814 mg in 7 samples analyzed.

The ascorbic acid in the emblic is considered highly stable, apparently protected by tannins (or leucoanthocyanins) which retard oxidation. Biochemical studies at the Central Drug Research Institute, Lucknow, India, show 13 tannins plus 3 or 4 colloidal complexes. In juice extracted from the fresh fruit, the ascorbic acid is stable for at least a week. Fresh juice stored at 35.6º F (2º C) loses only 14% ascorbic acid after 45 days. Only 30% is lost in evaporation over open flame at 149º F (65º C), but the product loses 40% during a week in a refrigerator and 100% in 20 days.

Efforts in India to prepare a stable ascorbic acid concentrate from the dried fruit have been frustrating because sun-drying loses 65% ascorbic acid. Artificial drying at 185º F (85º C) loses

34%; and at 212º F (100º C), 72%. Once dried, there is negligible loss. However, vacuum-drying (27 in. Hg) at 140-176º F (60-80º C) retains the original ascorbic acid levels, the dried product containing 2,000 to 3,500 mg per 100 g, depending on the content of the fresh fruit. Even after 14 months of refrigerated storage, there is a loss of only 15 to 20%.

Separation of tannins from expressed juice by precipitation with neutral lead acetate and ion exchange chromatographic purification has yielded crystalline ascorbic acid amounting to 70-72% of that in the juice.

The dry, powdered fruit contains 6.3% phyllembic acid, 6% fatty matter, 5% gallic acid, ellagic acid, emblicol (a crystalline phenolic product) and other constituents. Phyllemblin (ethyl gallate) isolated from dried fruit, acts as a mild CNS depressant and has spasmolytic activity.

Other Uses

Other uses of the fruit and parts of the tree are numerous:

Fruit: The dried fruit yields ink and hair-dye and, having detergent properties, is sometimes used as a shampoo. A fixed oil derived from the fruit allegedly acts as a hair-restorer and is used in shampoos in India. This oil is the main ingredient in an "Amla Conditioner" currently sold by Shikai Products of Santa Rosa, California, by mail and through "health food" stores and other "natural" product outlets. A most curious custom is the making of simulated pottery jars from a paste of the boiled fruit, the surface being decorated with impressed colored seeds. Dyes from the fruit and leaves impart an appealing light-brown or yellow-brown hue to silk and wool. When sulfate of iron is added as a mordant, the color becomes black.

Bark: The tannin-rich bark, as well as the fruit and leaves, is highly valued and widely employed in conjunction with other so-called myrobalans, especially fruits of various species of *Terminalia.* The twig bark is particularly esteemed for tanning leather and is often used with leaves of *Carissa spinarum* A. DC. and *Anogeissus latifolia* Wall.

Leaves: The foliage furnishes fodder for cattle and branches are lopped for green manure. They are said to correct excessively alkaline soils.

Wood: The hard but flexible red wood, though highly subject to warping and splitting, is used for minor construction, furniture, implements, gunstocks, hookas and ordinary pipes. Durable when submerged and believed to clarify water, it is utilized for crude aqueducts and inner braces for wells, and branches and chips of the wood are thrown into muddy streams for clarification and to impart a pleasant flavor. The wood serves also as fuel and a source of charcoal.

Medicinal Uses: The emblic is of great importance in Asiatic medicine, not only as an antiscorbutic, but in the treatment of diverse ailments, especially those associated with the digestive organs. For such use, the fruit juice is prepared in the form of a sherbet or is fermented. In the latter state, it is prescribed in jaundice, dyspepsia and coughs. The dried chips of flesh are dispensed by apothecaries and often are mixed with grape juice and honey for dosage. The fruit is considered diuretic and laxative. *Triphala*, a decoction of emblic with *Terminalia chebula* Retz. and *T. bellerica* Roxb. is given for chronic dysentery, biliousness, hemorrhoids, enlarged liver, and other disorders. A powder prepared from the dried fruit is an effective expectorant as it stimulates the bronchial glands. The juice that exudes when the fruit is scored while still on the tree is valued as an eyewash and an application for inflamed eyes. An infusion made by steeping dried fruit overnight in water also serves as an eyewash, as does an infusion of the seeds. A liquor made from the fermented fruits is prescribed as a treatment for indigestion, anemia, jaundice, some cardiac problems, nasal congestion and retention of urine.

Emblic leaves, too, are taken internally for indigestion and diarrhea or dysentery, especially in combination with buttermilk, sour milk or fenugreek. The milky sap of the tree is applied on foul sores. The plant is considered an effective antiseptic in cleaning wounds, and it is also one of the many plant palliatives for snakebite and scorpion stings. A decoction of the leaves is used as a mouthwash and as a lotion for sore eyes.

The flowers, considered refrigerant and aperient, and roots, emetic, are also variously employed. The root bark, mixed with honey, is applied to inflammations of the mouth. The bark is strongly astringent and used in the treatment of diarrhea and as a stomachic for elephants. The juice of the fresh bark is mixed with honey and turmeric and given in cases of gonorrhea. It is clear that the majority of the applications of the fruit and other parts are based on the astringent action of the tannins they contain. The short-term effects of tannins appear beneficial, but habitual indulgence can be highly detrimental, inasmuch as tannin is antinutrient and carcinogenic.

An ointment made from the burnt seeds and oil is applied to skin afflictions. The seeds are used in treating asthma, bronchitis, diabetes and fevers. They contain proteolytic and lipolytic enzymes, phosphatides and a small amount of essential oil. Approximately 16% consists of a brownish-yellow fixed oil.

Morton, J. 1987. Otaheite Gooseberry. p. 217–219. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Otaheite Gooseberry

Phyllanthus acidus Skeels

Phyllanthus distichus Muell. Arg.

Cicca acida Merr.

Cicca disticha L.

Totally unlike a gooseberry except for its acidity, the Otaheite gooseberry, *Phyllanthus acidus* Skeels (syns. *P. distichus* Muell. Arg.; *Cicca acida* Merr.; *C. disticha* L.), is another of the few members of the family Euphorbiaceae having edible fruit. It has been widely distributed and is variously known as Malay gooseberry, country gooseberry, *cheremai, chermela, chamin-chamin,* or *kemangor* (Malaya); *cherme, tjerme,* or *tjareme* (Java); *cherimbillier, tam duot, chum ruot* (Vietnam); *mayom* (Thailand); *mak-nhom* (Laos); star gooseberry, West India gooseberry, *jimbling, chalmeri, harpharori* (India.); *iba* (Philippines); *ciruela corteña, manzana estrella* (Mexico), *pimienta* or *guinda* (El Salvador); *grosella* (Costa Rica, Cuba, Guatemala, Nicaragua); *groselha* (Brazil); *groseillier des Antilles* (French West Indies); *cereza amarilla, cerezo comun, cerezo de la tierra* (Puerto Rico); *cerezo agrio* (Venezuela); *cerezo occidental* (Cuba); wild plum (Belize, Yucatan); *cheramina, jimbling,* short *jimbelin* (Jamaica).

Description

Fig. 58: No fruit is borne in greater abundance than the crisp, sour, pale-yellow Otaheite gooseberry *(Phyllanthus acidus).* When cooked in sugar, the fruit and juice turn ruby-red. In: K. & J. Morton, *Fifty Tropical Fruits of Nassau,* 1946.

This is a curious and ornamental shrub or tree, 6 1/2 to 30 ft (2-9 m) high, with spreading, dense, bushy crown of thickish, rough, main branches, in general aspect resembling the **Bilimbi** (q.v.). At the branch tips are clusters of deciduous, greenish or pinkish branchlets 6 to 12 in (15-30 cm) long, bearing alternate, short-petioled, ovate or ovate-lanceolate, pointed leaves 3/4 to 3 in (2-7.5 cm) long, thin, green and smooth on the upper surface, blue-green with a bloom on the underside; altogether giving the impression of pinnate leaves with numerous leaflets. There are 2 tiny, pointed stipules at the base of each leaf. Small, male, female, and some hermaphrodite, 4-parted, rosy flowers, are borne together in little clusters arranged in panicles 2 to 5 in (5-12.5 cm) long, hanging directly from leafless lengths of the main branches and the upper trunk, and the fruits develop so densely that they form spectacular masses. The fruit is oblate with 6 to 8 ribs; is 3/8 to 1 in (1-2.5 cm) wide; pale-yellow to nearly white when fully ripe; waxy, fleshy, crisp, juicy and highly acid. Tightly embedded in the center is a hard, ribbed stone containing 4 to 6 seeds.

Origin and Distribution

This species is believed to have originated in Madagascar and to have been carried to the East Indies. Quisumbing says that it was introduced, into the Philippines in prehistoric times and is cultivated throughout those islands but not extensively. It is more commonly grown in Indonesia, South Vietnam and Laos, and frequently in northern Malaya, and in India in home gardens. The tree is a familiar one in villages and on farms in Guam, where the fruit is favored by children, and occurs in Hawaii and some other Pacific Islands.

It was introduced into Jamaica from Timor in 1793 and has been casually spread throughout the Caribbean islands and to the Bahamas and Bermuda. It has long been naturalized in southern Mexico and the lowlands of Central America, and is occasionally grown in Colombia, Venezuela, Surinam, Peru and Brazil. Formerly an escape from cultivation in South Florida, there are now only scattered specimens remaining here as curiosities.

Climate

The Otaheite gooseberry is subtropical to tropical, being sufficiently hardy to survive and fruit in Tampa, Florida, where cold spells are more severe than in the southeastern part of the state. It thrives up to an elevation of 3,000 ft (914 m) in El Salvador.

Soil

The tree grows on a wide range of soils but prefers rather moist sites.

Propagation

The tree is generally grown from seed but may also be multiplied by budding, greenwood cuttings, or air-layers. Seedlings will produce a substantial crop in 4 years.

Pests

The Otaheite gooseberry is prone to attack by the phyllanthus caterpiller in Florida. This pest eats the bark and also the young leaves, causing total defoliation in a few days if not controlled by pesticides.

Season

The tree often bears two crops a year in South India, the first in April and May, and the second in August and September. In other areas, the main crop is in January with scattered fruiting throughout the year.

Food Uses

The flesh must be sliced from the stone, or the fruits must be cooked and then pressed through a sieve to separate the stones. The sliced raw flesh can be covered with sugar and let stand in the refrigerator for a day. The sugar draws out the juice and modifies the acidity so that the flesh and juice can be used as a sauce. If left longer, the flesh shrivels and the juice can be strained off as a clear, pale-yellow sirup. In Indonesia, the tart flesh is added to many dishes as a flavoring. The juice is used in cold drinks in the Philippines. Bahamian cooks soak the whole fruits in salty water overnight to reduce the acidity, then rinse, boil once or twice, discarding the water, then boil with equal amount of sugar until thick, and put up in sterilized jars without removing seeds. The repeated processing results in considerable loss of flavor. Fully ripe fruits do not really require this treatment. If cooked long enough with plenty of sugar, the fruit and juice turn ruby-red and yield a sprightly jelly. In Malaya, the ripe or unripe Otaheite gooseberry is cooked and served as a relish, or made into a thick sirup or sweet preserve. It is also combined with other fruits in making chutney and jam because it helps these products to "set". Often, the fruits are candied, or pickled in salt. In the Philippines, they are used to make vinegar.

The young leaves are cooked as greens in India and Indonesia.

Food Value Per 100 g of Edible Portion*

Moisture	91.9 g
Protein	0.155 g
Fat	0.52 g
Fiber	0.8 g
Ash	0.51 g
Calcium	5.4 mg
Phosphorus	17.9 mg
Iron	3.25 mg
Carotene	0.019 mg
Thiamine	0.025 mg

Riboflavin	0.013 mg
Niacin	0.292 mg
Ascorbic Acid	4.6 mg

*According to analyses made in El Salvador.

Other Uses

Wood: The wood is light-brown, fine-grained, attractive, fairly hard, strong, tough, durable if seasoned, but scarce, as the tree is seldom cut down.

Root bark: The root bark has limited use in tanning in India.

Medicinal Uses: In India, the fruits are taken as liver tonic, to enrich the blood. The sirup is prescribed as a stomachic; and the seeds are cathartic. The leaves, with added pepper, are poulticed on sciatica, lumbago or rheumatism. A decoction of the leaves is given as a sudorific. Because of the mucilaginous nature of the leaves, they are taken as a demulcent in cases of gonorrhea.

The root is drastically purgative and regarded as toxic in Malaya but is boiled and the steam inhaled to relieve coughs and headache. The root infusion is taken in very small doses to alleviate asthma. Externally, the root is used to treat psoriasis of the soles of feet. The juice of the root bark, which contains saponin, gallic acid, tannin and a crystalline substance which may be lupeol, has been employed in criminal poisoning.

The acrid latex of various parts of the tree is emetic and purgative.

Morton, J. 1987. Mango. p. 221–239. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mango

Mangifera indica L.

It is a matter of astonishment to many that the luscious mango, *Mangifera indica L.,* one of the most celebrated of tropical fruits, is a member of the family Anacardiaceae–notorious for embracing a number of highly poisonous plants. The extent to which the mango tree shares some of the characteristics of its relatives will be explained further on. The universality of its renown is attested by the wide usage of the name, mango in English and Spanish and, with only slight variations in French *(mangot, mangue, manguier),* Portuguese *(manga, mangueira),* and Dutch *(manja)*. In some parts, of Africa, it is called *mangou,* or *mangoro.* There are dissimilar terms only in certain tribal dialects.

Description

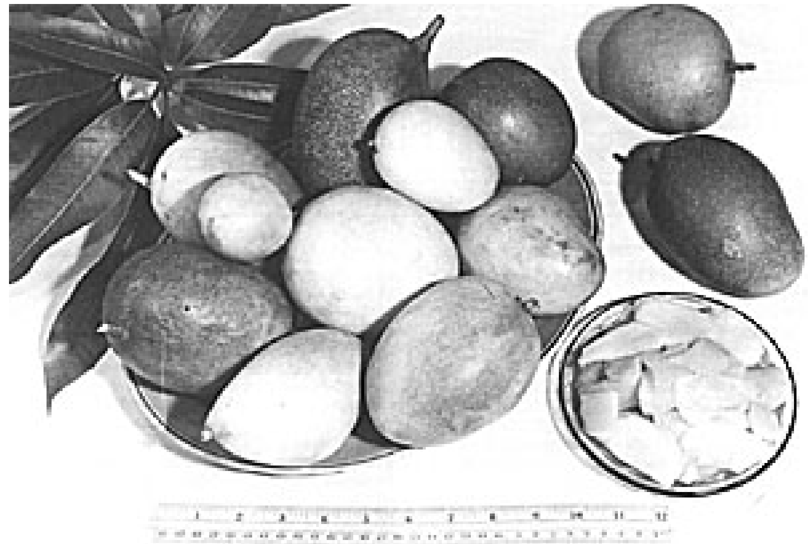


Fig. 59: Some mangoes *(Mangifera indica)* more or less commonly grown in dooryards of southern Florida in the mid-1940's.

The mango tree is erect, 30 to 100 ft (roughly 10-30 m) high, with a broad, rounded canopy which may, with age, attain 100 to 125 ft (30-38 m) in width, or a more upright, oval, relatively slender crown. In deep soil, the taproot descends to a depth of 20 ft (6 in), the profuse, wide-spreading, feeder root system also sends down many anchor roots which penetrate for several feet. The tree is long-lived, some specimens being known to be 300 years old and still fruiting.

Nearly evergreen, alternate leaves are borne mainly in rosettes at the tips of the branches and numerous twigs from which they droop like ribbons on slender petioles 1 to 4 in (2.5-10 cm) long. The new leaves, appearing periodically and irregularly on a few branches at a time, are yellowish, pink, deep-rose or wine-red, becoming dark-green and glossy above, lighter beneath. The midrib is pale and conspicuous and the many horizontal veins distinct. Full-grown leaves may be 4 to 12.5 in (10-32 cm) long and 3/4 to 2 1/8 in (2-5.4 cm) wide. Hundreds and even as many as 3,000 to 4,000 small, yellowish or reddish flowers, 25% to 98% male, the rest hermaphroditic, are borne in profuse, showy, erect, pyramidal, branched clusters 2 1/2 to 15 1/2 in (6-40 cm) high. There is great variation in the form, size, color and quality of the fruits. They may be nearly round, oval, ovoid-oblong, or somewhat kidney-shaped, often with a break at the apex, and are usually more or less lop-sided. They range from 2 1/2 to 10 in (6.25-25 cm) in length and from a few ounces to 4 to 5 lbs (1.8-2.26 kg). The skin is leathery, waxy, smooth, fairly thick, aromatic and ranges from light-or dark-green to clear yellow, yellow-orange, yellow and reddish-pink, or more or less blushed with bright-or dark-red or purple-red, with fine yellow, greenish or reddish dots, and thin or thick whitish, gray or purplish bloom, when fully ripe. Some have a "turpentine" odor and flavor, while others are richly and pleasantly fragrant. The flesh ranges from pale-yellow to deep-orange. It is essentially peach-like but much more fibrous (in some seedlings excessively so-actually "stringy"); is extremely juicy, with a flavor range from very sweet to subacid to tart.

There is a single, longitudinally ribbed, pale yellowish-white, somewhat woody stone, flattened, oval or kidney-shaped, sometimes rather elongated. It may have along one side a beard of short or long fibers clinging to the flesh cavity, or it may be nearly fiberless and free. Within the stone is the starchy seed, monoembryonic (usually single-sprouting) or polyembryonic (usually producing more than one seedling).

Origin and Distribution

Native to southern Asia, especially eastern India, Burma, and the Andaman Islands, the mango has been cultivated, praised and even revered in its homeland since Ancient times. Buddhist monks are believed to have taken the mango on voyages to Malaya and eastern Asia in the 4th and 5th Centuries B.C. The Persians are said to have carried it to East Africa about the 10th Century A.D. It was commonly grown in the East Indies before the earliest visits of the Portuguese who apparently introduced it to West Africa early in the 16th Century and also into Brazil. After becoming established in Brazil, the mango was carried to the West Indies, being first planted in Barbados about 1742 and later in the Dominican Republic. It reached Jamaica about 1782 and, early in the 19th Century, reached Mexico from the Philippines and the West Indies.

In 1833, Dr. Henry Perrine shipped seedling mango plants from Yucatan to Cape Sable at the southern tip of mainland Florida but these died after he was killed by Indians. Seeds were imported into Miami from the West Indies by a Dr. Fletcher in 1862 or 1863. From these, two trees grew to large size and one was still fruiting in 1910 and is believed to have been the parent of the 'No. 11' which was commonly planted for many years thereafter. In 1868 or 1869, seeds were planted south of Coconut Grove and the resultant trees prospered at least until 1909, producing the so-called 'Peach' or 'Turpentine' mango which became fairly common. In 1872, a seedling of 'No. 11' from Cuba was planted in Bradenton. In 1877 and 1879, W.P. Neeld made successful plantings on the west coast but these and most others north of Ft. Myers were killed in the January freeze of 1886.

In 1885, seeds of the excellent 'Bombay' mango of India were brought from Key West to Miami and resulted in two trees which flourished until 1909. Plants of grafted varieties were brought in from India by a west coast resident, Rev. D.G. Watt, in 1885 but only two survived the trip and they were soon frozen in a cold spell. Another unsuccessful importation of inarched trees from Calcutta was made in 1888. Of six grafted trees that arrived from Bombay in 1889, through the efforts of the United States Department of Agriculture, only one lived to fruit nine years later. The tree shipped is believed to have been a 'Mulgoa' (erroneously labeled 'Mulgoba', a name unknown in India except as originating in Florida). However, the fruit produced did not correspond to 'Mulgoa' descriptions. It was beautiful, crimson-blushed, just under 1 lb (454 g) with golden-yellow flesh. No Indian visitor has recognized it as matching any Indian variety. Some suggest that it was the fruit of the rootstock if the scion had been frozen in the freeze of 1894-95. At any rate, it continued to be known as 'Mulgoba', and it fostered many off-spring along the southeastern coast of the State and in Cuba and Puerto Rico, though it proved to be very susceptible to the disease, anthracnose, in this climate. Seeds from this tree were obtained and planted by a Captain Haden in Miami. The trees fruited some years after his death and his widow gave the name 'Haden' to the tree that bore the best fruit. This variety was regarded as the standard of excellence locally for many decades thereafter and was popular for shipping because of its tough skin.

George B. Cellon started extensive vegetative propagation (patch-budding) of the 'Haden' in 1900 and shipped the fruits to northern markets. P.J. Wester conducted many experiments in budding, grafting and inarching from 1904 to 1908 with less success. Shield-budding on a commercial scale was achieved by Mr. Orange Pound of Coconut Grove in 1909 and this was a pioneer breakthrough which gave strong impetus to mango growing, breeding, and dissemination.

Enthusiastic introduction of other varieties by the U.S. Department of Agriculture's Bureau of Plant Industry, by nurserymen, and other individuals followed, and the mango grew steadily in popularity and importance. The Reasoner Brothers Nursery, on the west coast, imported many mango varieties and was largely responsible for the ultimate establishment of the mango in that area, together with a Mr. J.W. Barney of Palma Sola who had a large collection of varieties and had worked out a feasible technique of propagation which he called "slot grafting".

Dr. Wilson Popenoe, one of the early Plant Explorers of the U.S. Department of Agriculture, became Director of the Escuela Agricola Panamericana, Tegucigalpa, Honduras. For more than a quarter of a century, he was a leader in the introduction and propagation of outstanding mangos from India and the East Indies, had them planted at the school and at the Lancetilla Experiment Station at Tela, Honduras, and distributed around tropical America.

In time, the mango became one of the most familiar domesticated trees in dooryards or in small or large commercial plantings throughout the humid and semi-arid lowlands of the tropical world and in certain areas of the near-tropics such as the Mediterranean area (Madeira and the Canary Islands), Egypt, southern Africa, and southern Florida. Local markets throughout its range are heaped high with the fragrant fruits in season and large quantities are exported to non-producing countries.

Altogether, the U.S. Department of Agriculture made 528 introductions from India, the Philippines, the West Indies and other sources from 1899 to 1937. Selection, naming and propagation of new varieties by government agencies and individual growers has been going on ever since. The Mango Form was created in 1938 through the joint efforts of the Broward County Home Demonstration Office of the University of Florida's Cooperative Extension Service and the Fort Lauderdale Garden Club, with encouragement and direction from the University of Florida's Subtropical Experiment Station (now the Agricultural Research and Education Center) in Homestead, and Mrs. William J. Krome, a pioneer tropical fruit grower. Meetings were held annually, whenever possible, for the exhibiting and judging of promising seedlings, and exchanging and publication of descriptions and cultural information.

Meanwhile, a reverse flow of varieties was going on. Improved mangos developed in Florida have been of great value in upgrading the mango industry in tropical America and elsewhere.

With such intense interest in this crop, mango acreage advanced in Florida despite occasional setbacks from cold spells and hurricanes. But with the expanding population, increased land values and cost and shortage of agricultural labor after World War II, a number of large groves were subdivided into real estate developments given names such as "Mango Heights" and "Mango Terrace". There were estimated to be 7,000 acres (2,917 ha) in 27 Florida counties in 1954, over half in commercial groves. There were 4,000 acres (1,619 ha) in 1961. Today, mango production in Florida, on approximately 1,700 acres (688 ha), is about 8,818 tons (8,000 MT) annually in "good" years, and valued at $3 million. Fruits are shipped not only to northern markets but also to the United Kingdom, Netherlands, France and Saudi Arabia. In advance of the local season, quantities are imported into the USA from Haiti and the Dominican Republic, and, throughout the summer, Mexican sources supply mangos to the Pacific Coast consumer. Supplies also come in from India and Taiwan.

A mango seed from Guatemala was planted in California about 1880 and a few trees have borne fruit in the warmest locations of that state, with careful protection when extremely low temperatures occur.

Mangos have been grown in Puerto Rico since about 1750 but mostly of indifferent quality. A program of mango improvement began in 1948 with the introduction and testing of over 150 superior cultivars by the University of Puerto Rico. The south coast of the island, having a dry atmosphere, is best suited for mango culture and substantial quantities of mangos are produced there without the need to spray for anthracnose control. The fruits are plentiful on local markets and shipments are made to New York City where there are many Puerto Rican residents. A study of 16 cultivars was undertaken in 1960 to determine those best suited to more intense commercial production. Productivity evaluations started in 1965 and continued to 1972.

The earliest record of the mango in Hawaii is the introduction of several small plants from Manila in 1824. Three plants were brought from Chile in 1825. In 1899, grafted trees of a number of Indian varieties, including 'Pairi', were imported. Seedlings became widely distributed over the six major islands. In 1930, the 'Haden' was introduced from Florida and became established in commercial plantations. The local industry began to develop seriously after the importation of a series of monoembryonic cultivars from Florida. But Hawaiian mangos are prohibited from entry into mainland USA, Australia, Japan and some other countries, because of the prevalence of the mango seed weevil in the islands.

In Brazil, most mangos are produced in the state of Minas, Gerais where the crop amounts to 243,018 tons (22,000 MT) annually on 24,710 acres (10,000 ha). These are mainly seedlings, as are those of the other states with major mango crops–Ceará, Paraibá, Goias, Pernambuco, and Maranhao. Sao Paulo raises about 63,382 tons (57,500 MT) per year on 9,884 acres (4,000 ha). The bulk of the crop is for domestic consumption. In 1973, Brazil exported 47.4 tons (43 MT) of mangos to Europe.

Mango growing began with the earliest settlers in North Queensland, Australia, with seeds brought casually from India, Ceylon, the East Indies and the Philippines. In 1875, 40 varieties from India were set out in a single plantation. Over the years, selections have been made for commercial production and culture has extended to subtropical Western Australia.

There is no record of the introduction of the mango into South Africa but a plantation was set out in Durban about 1860. Production today probably has reached about 16,535 tons (15,000 MT) annually, and South Africa exports fresh mangos by air to Europe.

Kenya exports mature mangos to France and Germany and both mature and immature to the United Kingdom, the latter for chutney-making. Egypt produces 110,230 tons (100,000 MT) of mangos annually and exports moderate amounts to 20 countries in the Near East and Europe. Mango culture in the Sudan occupies about 24,710 acres (10,000 ha) producing a total of 66,138 tons (60,000 MT) per year.

India, with 2,471,000 acres (1,000,000 ha) of mangos (70% of its fruit-growing area) produces 65% of the world's mango crop–9,920,700 tons (9,000,000 MT). In 1985, mango growers around Hyderabad sought government protection against terrorists who cut down mango orchards unless the owners paid ransom (50,000 rupees in one case). India far outranks all other countries as an exporter of processed mangos, shipping 2/3 of the total 22,046 tons (20,000 MT). Mango preserves go to the same countries receiving the fresh fruit and also to Hong Kong, Iraq, Canada and the United States. Following India in volume of exports are Thailand, 774,365 tons (702,500 MT), Pakistan and Bangladesh, followed by Brazil. Mexico ranks 5th with about 100,800 acres (42,000 ha) and an annual yield of approximately 640,000 tons (580,000 MT). The Philippines have risen to 6th place. Tanzania is 7th, the Dominican Republic, 8th and Colombia, 9th.

Leading exporters of fresh mangos are: the Philippines, shipping to Hong Kong, Singapore and Japan; Thailand, shipping to Singapore and Malaysia; Mexico, shipping mostly 'Haden' to the United States, 2,204 tons (2,000 MT), annually, also to Japan and Paris; India, shipping mainly 'Alphonso' and 'Bombay' to Europe, Malaya, Saudi Arabia and Kuwait; Indonesia, shipping to Hong Kong and Singapore; and South Africa shipping (60% 'Haden' and 'Kent') by air to Europe and London in mid-winter.

Chief importers are England and France, absorbing 82% of all mango shipments. Mango consumers in England are mostly residents of Indian origin, or English people who formerly lived in India.

The first International *Symposium on Mango and Mango Culture*, of the International Society for Horticultural Science, was held in New Delhi, India, in 1969 with a view to assembling a collection of germplasm from around the world and encouraging cooperative research on rootstocks and bearing behavior, hybridization, disease, storage and transport problems, and other areas of study.

Varieties

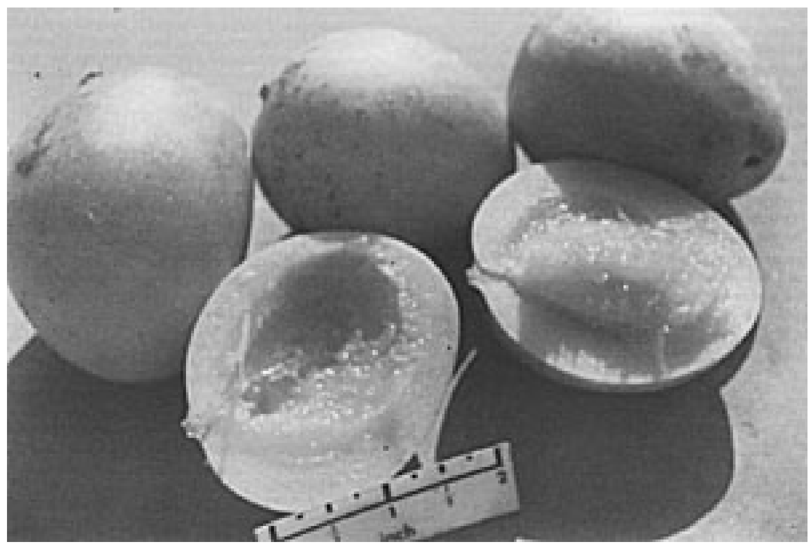


Fig. 60: The tiny, colorful 'Azucar' mango of Santa Marta and Baranquilla, Colombia, is sweet and freestone.

The original wild mangos were small fruits with scant, fibrous flesh, and it is believed that natural hybridization has taken place between *M. indica* and *M. sylvatica* Roxb. in Southeast Asia. Selection for higher quality has been carried on for 4,000 to 6,000 years and vegetative propagation for 400 years.

Over 500 named varieties (some say 1,000) have evolved and have been described in India. Perhaps some are duplicates by different names, but at least 350 are propagated in commercial nurseries. In 1949, K.C. Naik described 82 varieties grown in South India. L.B. and R.N. Singh presented and illustrated 150 in their monograph on the mangos of Uttar Pradesh (1956). In 1958, 24 were described as among the important commercial types in India as a whole, though in the various climatic zones other cultivars may be prominent locally. Of the 24, the majority are classed as early or mid-season:

Early:

'Bombay Yellow' ('Bombai')–high quality

'Malda' ('Bombay Green')

'01our' (polyembryonic)–a heavy bearer.

'Pairi' ('Paheri', 'Pirie', 'Peter', 'Nadusalai', 'grape', 'Raspuri', 'Goha bunder')

'Safdar Pasand'

'Suvarnarekha' ('Sundri')

Early to Mid-Season:

'Langra'

'Rajapuri'

Mid-Season:

'Alampur Baneshan'–high quality but shy bearer

'Alphonso' ('Badami', 'gundu', 'appas', 'khader')–high quality

'Bangalora'('Totapuri', 'collection', 'kili-mukku', abu Samada' in the Sudan)–of highest quality, best keeping, regular bearer, but most susceptible to seed weevil.

'Banganapally' ('Baneshan', 'chaptai', 'Safeda')–of high quality but shy bearer

'Dusehri' ('Dashehari aman', 'nirali aman', 'kamyab')–high quality

'Gulab Khas'

'Zardalu'

'K.O. 11'

Mid- to Late-Season:

'Rumani' (often bearing an off-season crop)

'Samarbehist' ('Chowsa', 'Chausa', 'Khajri')–high quality

'Vanraj'

'K.O. 7/5' ('Himayuddin' ´ 'Neelum')

Late:

'Fazli' ('Fazli malda')–high quality

'Safeda Lucknow'

Often Late:

'Mulgoa'–high quality but a shy bearer

'Neelum' (sometimes twice a year)–somewhat dwarf, of indifferent quality, and anthracnose-susceptible.

Most of the leading Indian cultivars are seedling selections. Over 50,000 crosses were made over a period of 20 years in India and 750 hybrids were raised and screened. Of these, **'Mallika',** a cross of 'Neelum' (female parent) with **'Dashehari'** (male parent) was released for cultivation in 1972.

The hybrid tends toward regular bearing, the fruits are showier and are thicker of flesh than either parent, the flavor is superior and keeping quality better. The season is nearly a month later than 'Dashehari'. Another new hybrid, **'Amrapali',** of which 'Dashehari' was the female parent and 'Neelum' the male, is definitely dwarf, precocious, a regular and heavy bearer, and late in the season. The fruit is only medium in size; flesh is rich orange, fiberless, sweet and 2 to 3 times as high in carotene as either parent.

The Central Food Technological Research Institute Experiment Station in Hyderabad has evaluated 9 "table varieties" (firm-fleshed), 4 "juicy" varieties, and 5 hybrids as to suitability for processing. **'Baneshan', 'Suvarnarekha' and '5/5 Rajapuri' ´ 'Langra'** were deemed suitable for slicing and canning. **'Baneshan', 'Navaneetam', 'Goabunder', 'Royal Special', 'Hydersaheb'** and **'9/4 Neelum Baneshan',** for canned juice; and 'Baneshan', 'Navaneetam', 'Goabunder', 'K.O. 7'and 'Sharbatgadi' for canned nectar.

It is interesting to note that all but four of the leading Indian cultivars are yellow-skinned. The exceptions are: two yellow with a red blush on shoulders, one red-yellow with a blush of red, and one green. In Thailand, there is a popular mango called **'Tong dum'** ('Black Gold') marketed when the skin is very dark-green and usually displayed with the skin at the stem end cut into points and spread outward to show the golden flesh in the manner that red radishes are fashioned into "radish roses" in American culinary art.

Fig. 63: 'Black Cold' mangoes, dark-green externally when ripe, are partly peeled like "radish roses" on the Bangkok market to show their yellow, fiberless flesh.

European consumers prefer a deep-yellow mango that develops a reddish-pink tinge. In Florida, the color of the mango is an important factor and everyone admires a handsome mango more or less generously overlaid with red. Red skin is considered a necessity in mangos shipped to northern markets, even though the quality may be inferior to that of non-showy cultivars. Also, dependable bearing and shippability are rated above internal qualities for practical reasons. And a shipping mango must be one that can be picked 2 weeks before full maturity without appreciable loss of flavor. Too, there must be several varieties to extend the season over at least 3 months.

Florida mangos are classed in 4 groups:

1–Indian varieties, mainly monoembryonic, introduced in the past and maintained mostly in collections; typically of somewhat "turpentine" character.

2–Philippine and Indo-Chinese types, largely polyembryonic, non-turpentiney, fiberless, fairly anthracnose-resistant. Scattered in dooryard plantings.

3–West Indian/South American mangos, especially 'Turpentine' and 'No.11' and the superior 'Julie' from Trinidad, 'Madame Francis' from Haiti, 'Itamaraca' from Brazil. These are non-commercial.

4–Florida-originated selections or cultivars, of which many have risen and declined over the decades.

In general, mangos from the Philippines ('Carabao') and Thailand ('Saigon', 'Cambodiana') behave better in Florida's humidity than the Indian varieties.

The much-prized 'Haden' was being recognized in the late 1930's and early 1940's as anthracnose-prone, a light and irregular bearer, and was being replaced by more disease-resistant and prolific cultivars. The present-day leaders for commercial production and shipping are 'Tommy Atkins', 'Keitt', 'Kent', 'Van Dyke' and Jubilee'. The first 2 represent 50% of the commercial crop.

'Tommy Atkins' (from a seed planted early in the 1920's at Fort Lauderdale, Florida; commercially adopted in the late 1950's); oblong-oval; medium to large; skin thick, orange-yellow, largely overlaid with bright- to dark-red and heavy purplish bloom, and dotted with many large, yellow-green lenticels. Flesh medium- to dark-yellow, firm, juicy, with medium fiber, of fair to good quality; flavor poor if over-fertilized and irrigated. Seed small. Season: mid-May to early July, or late June through July, depending on spring weather; can be picked early, developing good color and usually has long shelf-life. Sometimes there is an open space in the flesh at the stem-end. Interior softening near the seed occurs in some years. Anthracnose-resistant.

Plate XXVIII: MANGO, *Mangifera indica*–'Kent', 'Tommy Atkins', and 'Irwin'

'Keitt'–rounded-oval to ovate; large; skin medium-thick, yellow with light-red blush and a lavender bloom; the many lenticels small, yellow to red. Flesh orange-yellow, firm, fiberless except near the seed; of rich, sweet flavor; very good quality. Seed small, or medium to large. Season: early July through August or August and September, depending on spring weather. Tree small to medium, erect, open, rather scraggly but very productive. For market acceptance, requires post-harvest ethylene treatment to enhance color.

'Kent'–ovate, thick; large; skin greenish-yellow with dark-red blush and gray bloom; many small, yellow lenticels. Flesh fiberless, juicy, sweet; very good to excellent. Seed small. Season: July and August and often into September, but if left on too long the seed tends to sprout in the fruit–a condition called ovipary. Subject to black spot. Tree is of erect, slender habit, of moderate size, precocious; bears very well and fruit ships well, but, for the market, needs ethylene treatment to enrich color.

'Van Dyke' and **'Jubilee'** are relatively new cultivars maturing from late June through July. 'Van Dyke' is of superior color and excellent quality but subject to anthracnose and may not hold its place for long.

Two cultivars that have stood the test of time and have been shipped north on a lesser scale are:

'Sensation' (originated in North Miami; tree moved to Carmichael grove near Perrine and propagated and grown commercially since 1949). Oval, oblique, and faintly beaked; medium to medium-small; skin thin, adherent; basically yellow to yellow-orange overlaid with dark plum-red, and with tiny, pale-yellow lenticels. Flesh pale-yellow, firm, with very little fiber, faintly aromatic, of mild, slightly sweet flavor; of good quality. Monoembryonic. Tree bears heavily in August.

'Palmer'–oblong-ovate, plump; large; skin medium-thick, orange-yellow with red blush and pale bloom and many large lenticels. Flesh dull-yellow, firm, with very little or no fiber; of fair to good quality. Seed long, of medium size. Season: July and August, sometimes into September. Tree is medium to large; precocious; usually bears well.

The leading cultivar for local market at present is:

'Irwin' (a seedling of 'Lippens', planted by F.D. Irwin of Miami in 1939; bore its first fruits in 1945); oblong-ovate, one shoulder oblique; of medium size; skin orange to pink with extensive dark-red blush and small, white lenticels. Seed of medium size. Flesh yellow, almost fiberless, with mild, sweet flavor; good to very good quality. Seed small. Season: mid-May to early July; or June through July. Tree somewhat dwarf; bears heavy crops of fruits in clusters. Fruit no longer shipped because if picked before full maturity ripens with a mottled appearance which is not acceptable on the market.

Non-colorful or not high-yielding cultivars of excellent quality recommended for Florida homeowners include:

'Carrie' (somewhat dwarf); **'Edward'** ('Haden' seedling); **'Florigon'**; **'Jacquelin'**; **'Cambodiana'**; **'Cecil'**; **'Saigon'**.

Among cultivars formerly commercial but largely top-worked to others favored for various reasons: **'Davis-Haden'** (a 'Haden' seedling); **'Fascell'**; **'Lippens'** (a 'Haden' seedling); **'Smith'** (a 'Haden' seedling); **'Spring-fels'; 'Dixon'; 'Sunset'; 'Zill'** (a 'Haden' seedling).

Many cultivars that have lost popularity in Florida have become of importance elsewhere. 'Sandersha', for example, has proved remarkably resistant to most mango fruit diseases in South Africa.

Plate XXVII: MANGO, *Mangifera indica*–'Cambodiana'

The histories and descriptions of 46 cultivars growing in Brazil were published in 1955. These included **'Brooks', 'Cacipura', 'Cambodiana', 'Goa-Alphonso', 'Haden', 'Mulgoba', 'Pairi', 'Pico', 'Sandersha', 'Singapore', 'White Langra',** all brought in from Florida. The rest are mostly local seedlings. 'Haden' was introduced from Florida in 1931 and has been widely cultivated. It is still included among the cultivars of major importance, the others being **'Extrema'**, **'Non-Plus-Ultra'**. **'Carlota'**; but in 1977 the leading cultivar in Brazil was reported to be

'Bourbon', also known as 'Espada'. It is found especially in northeastern Brazil but is recommended for all other mango areas. A collection of 53 cultivars is maintained at Piricicaba and another of 82 at Bahia.

Of Mexican mangos, 65% are Florida selections; 35% are of the type commonly grown in the Philippines. Over a period of 3 years detailed studies have been made of the commercial cultivars in Culiacan, Sinaloa, Mexico, with a view to determining the most profitable for export. Results indicated that propagation of **'Purple Irwin', 'Red Irwin',** 'Sensation' and 'Zill' should be discontinued, and that 'Haden', 'Kent' and 'Keitt' will continue to be planted, the first two because, of their color and quality, and the third in spite of its deficiency in color.

'Manila', a Philippine mango, early-ripening, is much grown in Veracruz. '**Manzanillo-Nunez'**, a chance seedling first noticed in 1972, is gaining in popularity because of its regular bearing, skin color (75% red), nearly fiberless flesh, good quality, high yield and resistance to anthracnose.

'Julie' is the main mango exported from the West Indies to Europe. The fruit is somewhat flattened on one side, of medium size; the flesh is not completely fiberless but is of good flavor. It came to Florida from Trinidad but has long been popular in Jamaica. The tree is somewhat dwarf, has 30% to 50% hermaphrodite flowers; bears well and regularly. It is adaptable to humid environments and disease-resistant and the fruit is resistant to the fruit fly. 'Julie' has been grown in Ghana since the early 1920's. From 'Julie', the well-known mango breeder, Lawrence Zill, developed 'Carrie', but 'Julie' has not been planted in Florida for many years.

Grafted plants of the 'Bombay Green', so popular in Jamaica, were brought there from India in 1869 by the then governor, Sir John Peter Grant, but were planted in Castleton gardens where the trees flourished but failed to fruit in the humid atmosphere. Years later, a Director of Agriculture had budwood from these trees transferred to rootstocks at Hope Gardens. The results were so successful that the 'Bombay Green' became commonly planted on the island. The author brought six grafted trees from Jamaica to Miami in 1951 and, after they were released from quarantine, distributed them to the Subtropical Experiment Station in Homestead, the Newcomb Nursery, and a private grower, but all succumbed to the cold in succeeding winters. The fruit is completely fiberless and freestone so that it is frequently served cut in half and eaten with a spoon. The seed is pierced with a mango fork and served also so that the luscious flesh that adheres to it may be enjoyed as well.

One of the best-known mangos peculiar to the West Indies is 'Madame Francis' which is produced abundantly in Haiti. It is a large, flattened, kidney-shaped mango, light-green, slightly yellowish when ripe, with orange, low-fiber, richly flavored flesh. This mango has been regularly exported to Florida in late spring after fumigation against the fruit fly.

Ghana received more than a dozen cultivars back in the early 1920's. In 1973, it was found that only three of these–'Julie', 'Jaffna' and 'Rupee'–could be recognized with certainty. More than a dozen other cultivars were brought in much later from Florida and India. An effort was begun in 1967 to classify the seedlings (from 10 to 50 years of age) in the Ejura district, the Ejura Agricultural Station, and the plantation of the Faculty of Agriculture, University of Science and Technology, Kumasi, in order to eliminate confusion and have identifiable cultivars marked for future research. After checking with available published material on other cultivars for possible resemblances, descriptions and photographs of 21 newly named cultivars were published in 1973.

Of these, 12 are fibrous and 9 fiberless. (See Godfrey-Sam-Aggrey and Arbutiste in the Bibliography). One of the fibrous cultivars, named 'Tee-Vee-Dee', is so well flavored and aromatic that it is locally extremely popular.

Until the mid-1960's mangos were grown only in dooryards in Surinam and the few varieties were largely polyembryonic types from Indonesia, and these have given rise to many chance seedlings. In order to discover the best for commercial planting, mango exhibits were sponsored and budwood of the best selections has been grafted onto various rootstocks at the Paramaribo Agricultural Experiment Station. The two most important local mangos are:

'Golek' (from Java; also grown in Queensland) long-oblong; skin dull-green or yellowish-green even when ripe, leathery; flesh pale yellow, thick, fiberless, sweet, rich, of excellent quality. Keeps well in cold storage for 3 weeks. Season: early (December in Queensland). Tree bears moderately to heavily. This cultivar is considered the most promising for large-scale culture and export. In Queensland it tends to crack longitudinally as it matures.

'Roodborstje'–medium to large; skin deep-red; flesh sweet, juicy, with very little fiber. Not a good keeper. Season: early to midseason. Tree is a heavy bearer.

In Venezuela, eleven cultivars were evaluated by food technologists for processing suitability–'Blackman', 'Glenn', 'Irwin', 'Kent', 'Lippens', 'Martinica', 'Sensation', 'Smith', 'Selection 80', 'Selection 85', and 'Zill'. The most appropriate, because of physicochemical characteristics and productivity were determined to be: 'Glenn', 'Irwin', 'Kent' and 'Zill'.

In Hawaii, **'Haden'** has represented 90% of all commercial production. 'Pairi' is more prized for home use but is a shy bearer, a poor keeper, not as colorful as 'Haden', so it never attained commercial status. In a search for earlier and later varieties of commercial potential, over 125 varieties were collected and tested between 1934 and 1969. In 1956, one of the winning entries in a mango contest attracted much attention. After propagation and due observation it was named 'Gouveia' in 1969 and described as: ovate-oblong, of medium size, with medium-thick, ochre-yellow skin blushed with blood-red over 2/3 of the surface. Flesh is orange, nearly fiberless, sweet, juicy. Seed is small, slender, monoembryonic. Season: late. Tree is of medium size, a consistent but not heavy bearer. In quality tests 'Gouveia' received top scoring over 'Haden', 'Pairi', and several other cultivars. Florida mangos rated as promising for Hawaii were 'Pope', 'Kent', 'Keitt' and 'Brooks' (later than 'Haden') and 'Earlygold' and 'Zill' (earlier than 'Haden').

In Queensland, **'Kensington Pride'** is the leading commercial cultivar in the drier areas. In humid regions it is anthracnose-prone and requires spraying. It is thought to have been introduced by traders in Bowen who were shipping horses for military use in India. It may be called 'Kensington', 'Bowen', or, because of its color, 'Apple' or 'Strawberry'. The fruit is distinctly beaked when immature, with a groove extending from the stem to the beak. It is medium-large; the skin is bright orange-yellow with red-pink blush overlying areas exposed to the sun. Flesh is orange, thick, nearly fiberless, juicy, of rich flavor. This cultivar is classified as mid-season. The fruit matures from early to mid-November at latitude 13°S; 6 weeks later at Bowen (20°S) and 1 week later for each degree of latitude from Bowen to Brisbane. But at 17°S and an altitude of 1,148 ft (350 m) peak maturity is in mid- to late-January. Polyembryonic. The fruit ships well but the tree is not a dependable nor heavy bearer. It has an oval crown and unusually sweet-scented leaves.

In 1981, after evaluating 43 accessions seeking to lengthen the mango season in Queensland, 9 that mature between 2 weeks earlier and 4 weeks later than 'Kensington Pride' were chosen for commercial testing. Only one, 'Banana-1', was a Queensland selection. The other 8 were introductions from Florida–'Smith', 'Palmer', 'Haden', 'Zill', 'Carrie', 'Irwin', 'Kent', 'Keitt'. 'Kent' and 'Haden' have proved to be highly susceptible to blackspot in Queensland; 'Keitt', 'Smith', and 'Zill' less so; and 'Palmer' and 'Kensington Pride' resistant.

In the Philippines, the **'Carabao'** constitutes 66% of the crop and **'Pico'** 26%. These cultivars, apparently of Southeast Asian origin have remained the most commonly grown and exported for many years.

In Israel, 'Haden' has been popular for a long time though it is sensitive to low temperatures in spring. An Egyptian introduction, **'Mabroka'** is later in season and escapes the early frosts. **'Maya'**, a local seedling of 'Haden' has done well. Perhaps the most promising today is **'Nimrod',** a seedling of 'Maya', open pollinated, perhaps by 'Haden', planted in 1943, observed for 20 years and budded progeny for another 9 years; named and released in 1970. The fruit is round-ovate, large; skin is fairly thin, olive-green to yellow-green, blushed with red; attractive. Flesh is deep-yellow, nearly fiberless, of fair flavor. Seed is large, monoembryonic. Matures in mid-season (all August to mid-September in Israel). Tree is large, upright, very cold-resistant. Average yield is 480 lbs (218 kg) per tree over 10 years.

It is impressive to see how the early favorite, 'Haden', has influenced mango culture in many parts of the world. Today, the Subtropical Horticulture Research Unit of the U.S. Department of Agriculture and the Agricultural Research and Education Center of the University of Florida, together maintain 125 mango cultivars as a resource for mango growers and breeders in many countries.

Blooming and Pollination

Mango trees less than 10 years old may flower and fruit regularly every year. Thereafter, most mangos tend toward alternate, or biennial, bearing. A great deal of research has been done on this problem which may involve the entire tree or only a portion of the branches. Branches that fruit one year may rest the next, while branches on the other side of the tree will bear.

Blooming is strongly affected by weather, dryness stimulating flowering and rainy weather discouraging it. In most of India, flowering occurs in December and January; in northern India, in January and February or as late as March. There are some varieties called "Baramasi" that flower and fruit irregularly throughout the year. The cultivar **'Sam Ru Du'** of Thailand bears 3 crops a year–in January, June and October. In the drier islands of the Lesser Antilles, there are mango trees that flower and fruit more or less continuously all year around but never heavily at any time. Some of these are cultivars introduced from Florida where they flower and fruit only once a year. In southern Florida, mango trees begin to bloom in late November and continue until February or March, inasmuch as there are early, medium, and late varieties. During exceptionally warm winters, mango trees have been known to bloom 3 times in succession, each time setting and maturing fruit.

Fig. 65: Mango trees produce massive sprays of reddish or yellowish flowers but only a few fruits develop from each spray.

In the Philippines, various methods are employed to promote flowering: smudging (smoking), exposing the roots, pruning, girdling, withholding nitrogen and irrigation, and even applying salt. In the West Indies, there is a common folk practice of slashing the trunk with a machete to make the tree bloom and bear in "off" years. Deblos-soming (removing half the flower clusters) in an "on" year will induce at least a small crop in the next "off" year. Almost any treatment or condition that retards vegetative growth will have this effect. Spraying with growth-retardant chemicals has been tried, with inconsistent results. Potassium nitrate has been effective in the Philippines.

In India, the cultivar 'Dasheri', which is self incompatible, tends to begin blooming very early (December and January) when no other cultivars are in flower. And the early particles show a low percentage of hermaphrodite flowers and a high incidence of floral malformation. Furthermore, early blooms are often damaged by frost. It has been found that a single mechanical deblossoming in the first bud-burst stage, induces subsequent development of particles with less malformation, more hermaphrodite flowers, and, as a result, a much higher yield of fruits.

There is one cultivar, 'Neelum', in South India that bears heavily every year, apparently because of its high rate (16%) of hermaphrodite flowers. (The average for 'Alphonso' is 10%.) However, Indian horticulturists report great tree-to-tree variation in seedlings of this cultivar; in some surveys as much as 84% of the trees were rated as poor bearers. Over 92% of 'Bangalora' seedlings have been found bearing light crops.

Mango flowers are visited by fruit bats, flies, wasps, wild bees, butterflies, moths, beetles, ants and various bugs seeking the nectar and some transfer the pollen but a certain amount of self-pollination also occurs. Honeybees do not especially favor mango flowers and it has been found that effective pollination by honeybees would require 3 to 6 colonies per acre (6-12 per ha). Many of the unpollinated flowers are shed or fail to set fruit, or the fruit is set but is shed when very young. Heavy rains wash off pollen and thus prevent fruit setting. Some cultivars tend to produce a high percentage of small fruits without a fully developed seed because of unfavorable weather during the fruit-setting period.

Shy-bearing cultivars of otherwise desirable characteristics are hybridized with heavy bearers in order to obtain better crops. For example: shy-bearing 'Himayuddin' ´ heavy-bearing 'Neelum'. Breeders usually hand-pollinate all the flowers that are open in a cluster, remove the rest, and cover the inflorescence with a plastic bag. But researchers in India have found that there is very little chance of contamination and that omitting the covering gives as much as 3.85% fruit set in place of 0.23% to 1.57% when bagged. Thus large populations of hybrids may be raised for study. One of the latest techniques involves grafting the male and female parents onto a chosen tree, then covering the panicles with a polyethylene bag, and introducing house flies as pollinators.

Indian scientists have found that pollen for crossbreeding can be stored at 32° F (0° C) for 10 hours. If not separated from the flowers, it remains viable for 50 hours in a humid atmosphere at 65° to 75° F (18.33° -23.09° C). The stigma is receptive 18 hours before full flower opening and, some say, for 72 hours after.

Climate

The mango is naturally adapted to tropical lowlands between 25°N and 25°S of the Equator and up to elevations of 3,000 ft (915 m). It is grown as a dooryard tree at slightly cooler altitudes but is apt to suffer cold damage. The *amount* of rainfall is not as critical as *when it occurs*. The best climate for mango has rainfall of 30 to 100 in (75-250 cm) in the four summer months (June to September) followed by 8 months of dry season. This crop is well suited to irrigated regions bordering the desert frontier in Egypt. Nevertheless, the tree flourishes in southern Florida's approximately 5 months of intermittent, scattered rains (October to February), 3 months of drought (usually March to May) and 4 months of frequently heavy rains (June to September).

Rain, heavy dews or fog during the blooming season (November to March in Florida) are deleterious, stimulating tree growth but interfering with flower production and encouraging fungus diseases of the inflorescence and fruit. In Queensland, dry areas with rainfall of 40 in (100 cm), 75% of which occurs from January to March, are favored for mango growing because vegetative growth is inhibited and the fruits are well exposed to the sun from August to December, become well colored, and are relatively free of disease. Strong winds during the fruiting season cause many fruits to fall prematurely.

Soil

The mango tree is not too particular as to soil type, providing it has good drainage. Rich, deep loam certainly contributes to maximum growth, but if the soil is too rich and moist and too well fertilized, the tree will respond vegetatively but will be deficient in flowering and fruiting. The mango performs very well in sand, gravel, and even oolitic limestone (as in southern Florida and the Bahamas)

A polyembryonic seedling, 'No. 13-1', introduced into Israel from Egypt in 1931, has been tested since the early 1960's in various regions of the country for tolerance of calcareous soils and saline conditions. It has done so well in sand with a medium (15%) lime content and highly saline irrigation water (over 600 ppm) that it has been adopted as the standard rootstock in commercial plantings in salty, limestone districts of Israel. Where the lime content is above 30%, iron chelates are added.

Propagation

Mango trees grow readily from seed. Germination rate and vigor of seedlings are highest when seeds are taken from fruits that are fully ripe, not still firm. Also, the seed should be fresh, not dried. If the seed cannot be planted within a few days after its removal from the fruit, it can be covered with moist earth, sand, or sawdust in a container until it can be planted, or kept in charcoal dust in a dessicator with 50% relative humidity. Seeds stored in the latter manner have shown 80% viability even after 70 days. High rates of germination are obtained if seeds are stored in polyethylene bags but the seedling behavior may be poor. Inclusion of sphagnum moss in the sack has no benefit and shows inferior rates of germination over 2- to 4-week periods, and none at all at

6 weeks.

The flesh should be completely removed. Then the husk is opened by carefully paring around the convex edge with a sharp knife and taking care not to cut the kernel, which will readily slide out. Husk removal speeds germination and avoids cramping of roots, and also permits discovery and removal of the larva of the seed weevil in areas where this pest is prevalent. Finally, the husked kernels are treated with fungicide and planted without delay. The beds must have solid bottoms to prevent excessive taproot growth, otherwise the taproot will become 18 to 24 in (45-60 cm) long while the top will be only one third to a half as high, and the seedling will be difficult to transplant with any assurance of survival. The seed is placed on its ventral (concave) edge with 1/4 protruding above the sand. Sprouting occurs in 8 to 14 days in a warm, tropical climate; 3 weeks in cooler climates. Seedlings generally take 6 years to fruit and 15 years to attain optimum yield for evaluation.

However, the fruits of seedlings may not resemble those of the parent tree. Most Indian mangos are monoembryonic; that is, the embryo usually produces a single sprout, a natural hybrid from accidental crossing, and the resulting fruit may be inferior, superior, or equal to that of the tree from which the seed came. Mangos of Southeast Asia are mostly polyembryonic. In these, generally, one of the embryos in the seed is a hybrid; the others (up to 4) are vegetative growths which faithfully reproduce the characteristics of the parent. The distinction is not absolute, and occasionally a seed supposedly of one class may behave like the other.

Seeds of polyembryonic mangos are most convenient for local and international distribution of desirable varieties. However, in order to reproduce and share the superior monoembryonic selections, vegetative propagation is necessary. Inarching and approach-grafting are traditional in India. Tongue-, saddle-, and root-grafting (stooling) are also common Indian practices. Shield- and patch-grafting have given up to 70% success but the Forkert system of budding has been found even more practical. After many systems were tried, veneer grafting was adopted in Florida in the mid-1950's. Choice of rootstock is important. Use of seedlings of unknown parentage has resulted in great variability in a single cultivar. Some have believed that polyembryonic rootstocks are better than monoembryonic, but this is not necessarily so. In trials at Tamil Nadu Agricultural University, 10-year-old trees of 'Neelum' grafted on polyembryonic 'Bapakkai' showed vigor and spread of tree and productivity far superior to those grafted on 'Olour' which is also polyembryonic. Those grafted on monoembryonic rootstock also showed better growth and yield than those on 'Olour'. In 1981, experimenters at Lucknow, India, reported the economic advantage of "stone-grafting", which requires less space in the nursery and results in greater uniformity. Scions from the spring flush of selected cultivars are defoliated and, after a 10-day delay, are cleft-grafted on 5-day-old seedlings which must thereafter be kept in the shade and protected from drastic changes in the weather.

Old trees of inferior types are top-worked to better cultivars by either side-grafting or crown-grafting the beheaded trunk or beheaded main branches. Such trees need protection from sunburn until the graft affords shade. In South Africa, the trunks are whitewashed and bunches of dry grass are tied onto cut branch ends. The trees will bear in 2 to 3 years. Attempts to grow 3 or 4 varieties on one rootstock may appear to succeed for a while but the strongest always outgrows the others.

Cuttings, even when treated with growth regulators, are only 40% successful. Best results are obtained with cuttings of mature trees, ringed 40 days before detachment, treated, and rooted under mist. But neither cuttings nor air layers develop good root systems and are not practical for establishing plantations. Clonal propagation through tissue culture is in the experimental stage.

In spite of vegetative propagation, mutations arise in the form of bud sports. The fruit may differ radically from the others on a grafted tree-perhaps larger and superior-and the foliage on the branch may be quite unlike that on other branches.

Dwarfing

Reduction in the size of mango trees would be a most desirable goal for the commercial and private planter. It would greatly assist harvesting and also would make it possible for the homeowner to maintain trees of different fruiting seasons in limited space.

In India, double-grafting has been found to dwarf mango trees and induce early fruiting. Naturally dwarf hybrids such as 'Julie' have been developed. The polyembryonic Indian cultivars, 'Olour' and 'Vellai Colamban', when used as rootstocks, have a dwarfing effect; so has the polyembryonic 'Sabre' in experiments in Israel and South Africa.

In Peru, the polyembryonic 'Manzo de Ica', is used as rootstock; in Colombia, 'Hilaza' and 'Puerco'. 'Kaew' is utilized in Thailand.

Culture

About 6 weeks before transplanting either a seedling or a grafted tree, the taproot should be cut back to about 12 in (30 cm). This encourages feeder-root development in the field. For a week before setting out, the plants should be exposed to full morning sun.

Inasmuch as mango trees vary in lateral dimensions, spacing depends on the habit of the cultivar and the type of soil, and may vary from 34 to 60 ft (10.5-18 m) between trees. Closer planting will ultimately reduce the crop. A spacing of 34 x 34 ft (10.5 x l0.5 m) allows 35 trees per acre (86 per ha); 50 x 50 ft (15.2 x l5.2 m) allows only 18 trees per acre (44.5 per ha). In Florida's limestone, one commercial grower maintains 100 trees per acre (247 per ha), controlling size by hedging and topping.

The young trees should be placed in prepared and enriched holes at least 2 ft (60 cm) deep and wide, and 3/4 of the top should be cut off. In commercial groves in southern Florida, the trees are set at the intersection of cross trenches mechanically cut through the limestone.

Mangos require high nitrogen fertilization in the early years but after they begin to bear, the fertilizer should be higher in phosphate and potash. A 5-8-10 fertilizer mix is recommended and applied 2 or 3, or possibly even 4, times a year at the rate of 1 lb (454 g) per year of age at each dressing, Fertilizer formulas will vary with the type of soil. In sandy acid soils, excess nitrogen contributes to "soft nose" breakdown of the fruits. This can be counteracted by adding calcium. On organic soils (muck and peat), nitrogen may be omitted entirely. In India, fertilizer is applied at an increasing rate until the tree is rather old, and then it is discontinued. Ground fertilizers are supplemented by foliar nutrients including zinc, manganese and copper. Iron deficiency is corrected by small applications of chelated iron.

Indian growers generally irrigate the trees only the first 3 or 4 years while the taproot is developing and before it has reached the water table. However, in commercial plantations, irrigation of bearing trees is withheld only for the 2 or 3 months prior to flowering. When the blooms appear, the tree is given a heavy watering and this is repeated monthly until the rains begin. In Florida groves, irrigation is by means of overhead sprinklers which also provide frost protection when needed.

Usually no pruning is done until the 4th year, and then only to improve the form and this is done right after the fruiting season. If topping is practiced, the trees are cut at 14 ft (4.25 m) to facilitate both spraying and harvesting. Grafted mangos may set fruit within a year or two from planting. The trees are then too weak to bear a full crop and the fruits should be thinned or completely removed.

Harvesting

Mangos normally reach maturity in 4 to 5 months from flowering. Fruits of "smudged" trees ripen several months before those of untreated trees. Experts in the Philippines have demonstrated that 'Carabao' mangos sprayed with ethephon (200 ppm) 54 days after full bloom can be harvested 2 weeks later at recommended minimum maturity. The fruits will be larger and heavier even though harvested 2 weeks before untreated fruits. If sprayed at 68 days after full bloom and harvested 2 weeks after spraying, there will be an improvement in quality in regard to soluble solids and titratable acidity.

When the mango is full-grown and ready for picking, the stem will snap easily with a slight pull. If a strong pull is necessary, the fruit is still somewhat immature and should not be harvested. In the more or less red types of mangos, an additional indication of maturity is the development of a purplish-red blush at the base of the fruit. A long-poled picking bag which holds no more than 4 fruits is commonly used by pickers. Falling causes bruising and later spoiling. When low fruits are harvested with clippers, it is desirable to leave a 4-inch (10 cm) stem to avoid the spurt of milky/resinous sap that exudes if the stem is initially cut close. Before packing, the stem is cut off 1/4 in (6 mm) from the base of the fruit. In Queensland, after final clipping of the stem, the fruits are placed stem-end-down to drain.

In a sophisticated Florida operation, harvested fruits are put into tubs of water on trucks in order to wash off the sap that exudes from the stem end. At the packing house, the fruits are transferred from the tubs to bins, graded and sized and packed in cartons ("lugs") of 8 to 20 each depending on size. The cartons are made mechanically at the packing house and hold 14 lbs (6.35 kg) of fruit. The filled cartons are stacked on pallets and fork-lifted into refrigerated trucks with temperature set at no less than 55° F (12.78° C) for transport to distribution centers in major cities throughout the USA and Canada.

Yield

The yield varies with the cultivar and the age of the tree. At 10 to 20 years, a good annual crop may be 200 to 300 fruits per tree. At twice that age and over, the crop will be doubled. In Java,, old trees have been known to bear 1,000 to 1,500 fruits in a season. Some cultivars in India bear 800 to 3,000 fruits in "on" years and, with good cultural attention, yields of 5,000 fruits have been reported. There is a famous mango, 'Pane Ka Aam' of Maharashtra and Khamgaon, India, with "paper-thin" skin and fiberless flesh. One of the oldest of these trees, well over 100 years of age, bears heavily 5 years out of 10 with 2 years of low yield. Average annual yield is 6,500 fruits; the highest record is 29,000.

Reported annual yields for 6 cultivars in Puerto Rico are:

'Lippens'	67,079 lbs per acre
'Keitt'	45,608 lbs per acre
'Earlygold'	42,310 lbs per acre
'Parvin'	38,369 lbs per acre
'Haden'	32,732 lbs per acre
'Palmer'	28,868 lbs per acre

The number of lbs per acre is roughly the equivalent of kg per hectare.

Average mango yield in Florida is said to be about 30,000 lbs/acre. One leading commercial grower has reported his annual crop as 22,000 to 27,500 lbs/acre. One grower who has hedged and topped trees close-planted at the rate of 100 per acre (41/ha) averages 14,000 to 19.000 lbs/acre.

Ripening

In India, mangos are picked quite green to avoid bird damage and the dealers layer them with rice straw in ventilated storage rooms over a period of one week. Quality is improved by controlled temperatures between 60° and 70° F (15° -21° C). In ripening trials in Puerto Rico, the 'Edward' mango was harvested while deep-green, dipped in hot water at 124° F (51° C) to control anthracnose, sorted as to size, then stored for 15 days at 70° F (21° C) with relative humidity of 85% to 90%. Those picked when more than 3 in (7.5 cm) in diameter ripened satisfactorily and were of excellent quality.

Ethylene treatment causes green mangos to develop full color in 7 to 10 days depending on the degree of maturity, whereas untreated fruits require 10 to 15 days. One of the advantages is that there can be fewer pickings and the fruit color after treatment is more uniform. Therefore, ethylene treatment is a common practice in Israel for ripening fruits for the local market. Some growers in Florida depend on ethylene treatment. Generally, 24 hours of exposure is sufficient if the fruits are picked at the proper stage. It has been determined that mangos have been picked prematurely if they require more than 48 hours of ethylene treatment and are not fit for market.

Keeping Quality and Storage

Washing the fruits immediately after harvest is essential, as the sap which leaks from the stem bums the skin of the fruit making black lesions which lead to rotting.

Some cultivars, especially 'Bangalora', 'Alphonso', and 'Neelum' in India, have much better keeping quality than others. In Bombay, 'Alphonso' has kept well for 4 weeks at 52° F (11.11° C); 6 to 7 weeks at 45° F (7.22° C). Storage at lower temperatures is detrimental inasmuch as mangos are very susceptible to chilling injury. Any temperature below 55.4° F (13° C) is damaging to 'Kent'. In Florida, this is regarded as the optimum for 2 to 3 weeks storage. The best ripening temperatures are 70° to 75° F (21.11°-23.89° C).

Experiments in Florida have demonstrated that 'Irwin', 'Tommy Atkins' and 'Kent' mangos, held for 3 weeks at storage temperature of 55.4° F (13° C), 98% to 100% relative humidity and atmospheric pressure of 76 or 152 mmHg, ripened thereafter with less decay at 69.8° F (21° C) under normal atmospheric pressure, as compared with fruits stored at the same temperature with normal atmospheric pressure. Those stored at 152 mmHg took 3 to 5 days longer to ripen than those stored at 76 mmHg. Decay rates were 20% for 'Tommy Atkins' and 40% for 'Irwin'. Spoilage from anthracnose has been reduced by immersion for 15 min in water at 125° F (51.67° C) or for 5 min at 132° F (55.56° C). Dipping in 500 ppm maleic hydrazide for 1 min and storing at 89.6° F (32° C) also retards decay but not loss of moisture. In South Africa, mangos are submerged immediately after picking in a suspension of benomyl for 5 min at 131° F (55° C) to control soft brown rot.

In Australia, mature-green 'Kensington Pride' mangos have been dipped in a 4% solution of calcium chloride under reduced pressure (250 mm Hg) and then stored in containers at 77° F (25° C) in ethylene-free atmosphere. Ripening was retarded by a week; that is, the treated fruits ripened in 20 to 22 days whereas controls ripened in 12 to 14 days. Eating quality was equal except that the calcium-treated fruits were found slightly higher in ascorbic acid.

Wrapping fruits individually in heat-shrinkable plastic film has not retarded decay in storage. The only benefit has been 3% less weight loss. Coating with paraffin wax or fungicidal wax and storing at 68° to 89.6° F (20° -32° C) delays ripening 1 to 2 weeks and prevents shriveling but interferes with full development of color.

Gamma irradiation (30 Krad) causes ripening delay of 7 days in mangos stored at room temperature. The irradiated fruits ripen normally and show no adverse effect on quality. Irradiation has not yet been approved for this purpose.

In India, large quantities of mangos are transported to distant markets by rail. To avoid excessive heat buildup and consequent spoilage, the fruits, padded with paper shavings, are packed in ventilated wooden crates and loaded into ventilated wooden boxcars. Relative humidity varies from 24% to 85% and temperature from 88° to 115° F (31.6°-46.6° C). These improved conditions have proved superior to the conventional packing of the fruits in *Phoenix*-palm-midrib or bamboo, or the newer pigeonpea-stem, baskets padded with rice straw and mango leaves and transported in steel boxcars, which has resulted in 20% to 30% losses from shriveling, unshapeliness and spoilage.

Green seedling mangos, harvested in India for commercial preparation of chutneys and pickles as well as for table use, are stored for as long as 40 days at 42° to 45° F (5.56°-7.22° C) with relative humidity of 85% to 99%. Some of these may be diverted for table use after a 2-week ripening period at 62° to 65° F (16.67° -18.13° C).

Pests and Diseases

The fruit flies, *Dacus ferrugineus* and *D. zonatus*, attack the mango in India; *D. tryoni* (now *Strumeta tryoni)* in Queensland, and *D. dorsalis* in the Philippines; *Pardalaspis cosyra* in Kenya; and the fruit fly is the greatest enemy of the mango in Central America. Because of the presence of the Caribbean fruit fly, *Anastrepha suspensa*, in Florida, all Florida mangos for interstate shipment or for export must be fumigated or immersed in hot water at 115° F (46.11° C) for 65 minutes.

In India, South Africa and Hawaii, mango seed weevils, *Sternochetus (Cryptorhynchus) mangiferae* and *S. gravis,* are major pests, undetectable until the larvae tunnel their way out. The leading predators of the tree in India are jassid hoppers *(Idiocerus* spp.) variously attacking trunk and branches or foliage and flowers, and causing shedding of young fruits. The honeydew they excrete on leaves and flowers gives rise to sooty mold.

The mango-leaf webber, or "tent caterpillar", *Orthaga euadrusalis,* has become a major problem in North India, especially in old, crowded orchards where there is excessive shade. Around Lucknow, 'Dashehari' is heavily infested by this pest; 'Samarbehist' ('Chausa') less. In South Africa, 11 species of scales have been recorded on the fruits. *Coccus mangiferae* and *C. acuminatus* are the most common scale insects giving rise to the sooty mold that grows on the honeydew excreted by the pests. In some areas, there are occasional outbreaks of the scales, *Pulvinaria psidii, P. polygonata, Aulacaspis cinnamoni, A. tubercularis, Aspidiotus destructor* and *Leucaspis indica.* In Florida, pyriform scale, *Protopulvinaria Pyrformis,* and Florida wax scale, *Ceroplastes floridensis,* are common, and the lesser snow scale, *Pinnaspis strachani,* infests the trunks of small trees and lower branches of large trees. Heavy attacks may result in cracking of the bark and oozing of sap.

The citrus thrips, *Scirtothrips aurantii,* blemishes the fruit in some mango-growing areas. The red-banded thrips, *Selenothrips rubrocinctus,* at times heavily infests mango foliage in Florida, killing young leaves and causing shedding of mature leaves. Mealybugs, *Phenacoccus citri* and *P. mangiferae,* and *Drosicha stebbingi* and *D. mangiferae* may infest young leaves, shoots and fruits. The mango stem borer, *Batocera rufomaculata* invades the trunk. Leaves and shoots are preyed on by the caterpillars of *Parasa lepida, Chlumetia transversa* and *Orthaga exvinacea.* Mites feed on mango leaves, flowers and young fruits. In Florida, the most common is the avocado red mite, *Paratetranychus yothersii.*

Mistletoe *(Loranthus* and *Viscum* spp.) parasitizes and kills mango branches in India and tropical America. Dr. B. Reddy, Regional Plant Production and Protection Officer, FAO, Bangkok, compiled an extensive roster of insects, mites, nematodes, other pests, fungi, bacteria and phanerogamic parasites in Southeast Asia and the Pacific Region (1975).

One of the most serious diseases of the mango is powdery mildew *(Oidium mangiferae),* which is common in most growing areas of India, occurs mostly in March and April in Florida. The fungus affects the flowers and causes young fruits to dehydrate and fall, and 20% of the crop may be lost. It is controllable by regular spraying. In humid climates, anthracnose caused by *Colletotrichum gloeosporioides (Glomerella cingulata)* affects flowers, leaves, twigs, fruits, both young and mature. The latter show black spots externally and the corresponding flesh area is affected. Control measures must be taken in advance of flowering and regularly during dry spells. In Florida, mango growers apply up to 20 sprayings up to the cut-off point before harvesting. The black spots are similar to those produced by *AIternaria sp.* often associated with anthracnose in cold storage in India. Inside the fruits attacked by *AIternaria* there are corresponding areas of hard, corky, spongy lesions. Inasmuch as the fungus enters the stem-end of the fruit, it is combatted by applying Fungicopper paste in linseed oil to the cut stem and also by sterilizing the storage compartment with Formalin 1:20. A pre-harvest dry stem-end rot was first noticed on 'Tommy Atkins' in Mexico in 1973, and it has spread to all Mexican plantings of this cultivar causing losses of 10-80%

especially in wet weather. *Fusarium, Alternaria* and *Cladosporium spp.* were prominent among associated fungi.

Malformation of inflorescence and vegetative buds is attributed to the combined action of *Fusarium moniliforme* and any of the mites, *Aceria mangifera, Eriophyes sp., Tyrophagus castellanii,* or *Typhlodromus asiaticus.* This grave problem occurs in Pakistan, India, South Africa and Egypt, El Salvador, Nicaragua, Mexico, Brazil and Venezuela, but not as yet in the Philippines. It is on the increase in India. Removing and burning the inflorescence has been the only remedy, but it has been found that malformation can be reduced by a single spray of NAA (200 mg in 50 ml alcohol with water added to make 1 liter) in October, and deblooming in early January.

There are 14 types of mango galls in India, 12 occurring on the leaves. The most serious is the axillary bud gall caused by *Apsylla cistellata* of the family Psyllidae.

In Florida, leaf spot is caused by *Pestalotia mangiferae, Phyllosticta mortoni,* and *Septoria sp.;* algal leaf spot, or green scurf by *Cephaleuros virescens.* In 1983, a new disease, crusty leaf spot, caused by the fungus, *Zimmermaniella trispora,* was reported as common on neglected mango trees in Malaya. Twig dieback and dieback are from infection by *Phomopsis sp., Physalospora abdita,* and *P. rhodina.* Wilt is caused by *Verticillium alboatrum;* brown felt by *Septobasidium pilosum* and *S. pseudopedicellatum;* wood rot, by *Polyporus sanguineus;* and scab by *Elsinoe mangiferae (Sphaceloma mangiferae). Cercospora mangiferae* attacks the fruits in the Congo.

A number of organisms in India cause white sap, heart rot, gray blight, leaf blight, white pocket rot, white spongy rot, sap rot, black bark and red rust. In South Africa, *Asbergillus* attacks young shoots and fruit rot is caused by A. *niger. Gloeosporium mangiferae* causes black spotting of fruits. *Erwinia mangiferae* and *Pseudomonas mangiferaeindicae* are sources of bacterial black spot in South Africa and Queensland. *Bacterium carotovorus is* a source of soft rot. Stem-end rot is a major problem in India and Puerto Rico from infection by *Physalospora rhodina (Diplodia natalensis).* Soft brown rot develops during prolonged cold storage in South Africa.

Leaf tip burn may be a sign of excess chlorides. Manganese deficiency is indicated by paleness and limpness of foliage followed by yellowing, with distinct green veins and midrib, fine brown spots and browning of leaf tips. Inadequate zinc is evident in less noticeable paleness of foliage, distortion of new shoots, small leaves, necrosis, and stunting of the tree and its roots. In boron deficiency, there is reduced size and distortion of new leaves and browning of the midrib. Copper deficiency is seen in paleness of foliage and severe tip-bum with gray-brown patches on old leaves; abnormally large leaves; also die-back of terminal shoots; sometimes gummosis of twigs and branches. Magnesium is needed when young trees are stunted and pale, new leaves have yellow-white areas between the main veins and prominent yellow specks on both sides of the midrib. There may also be browning of the leaf tips and margins. Lack of iron produces chlorosis in young trees.

Food Uses

Mangos should always be washed to remove any sap residue, before handling. Some seedling mangos are so fibrous that they cannot be sliced; instead, they are massaged, the stem-end is cut off, and the juice squeezed from the fruit into the mouth. Non-fibrous mangos may be cut in half to the stone, the two halves twisted in opposite directions to free the stone which is then removed, and the halves served for eating as appetizers or dessert. Or the two "cheeks" may be cut off, following the contour of the stone, for similar use; then the remaining side "fingers" of flesh are cut off for use in fruit cups, etc.

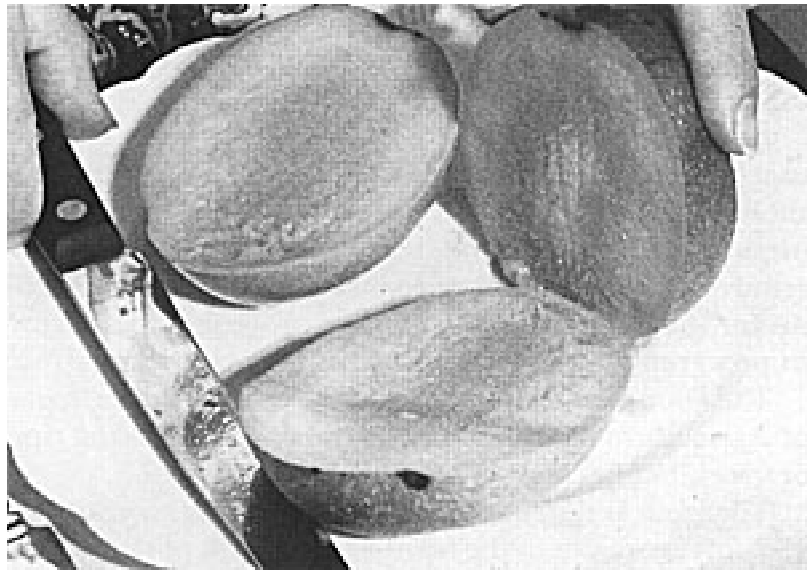


Fig. 61: Low-fiber mangoes are easily prepared for the table by first cutting off the "cheeks" which can then be served for eating by spooning the flesh from the "shell".

Most people enjoy eating the residual flesh from the seed and this is done most neatly by piercing the stem-end of the seed with the long central tine of a mango fork, commonly sold in Mexico, and holding the seed upright like a lollypop. Small mangos can be peeled and mounted on the fork and eaten in the same manner. If the fruit is slightly fibrous especially near the stone, it is best to peel and slice the flesh and serve it as dessert, in fruit salad, on dry cereal, or in gelatin or custards, or on ice cream. The ripe flesh may be spiced and preserved in jars. Surplus ripe mangos are peeled, sliced and canned in sirup, or made into jam, marmalade, jelly or nectar. The extracted pulpy juice of fibrous types is used for making mango halva and mango leather. Sometimes corn flour and tamarind seed jellose are mixed in. Mango juice may be spray-dried and powdered and used in infant and invalid foods, or reconstituted and drunk as a beverage. The dried juice, blended with wheat flour has been made into "cereal" flakes, A dehydrated mango custard powder has also been developed in India, especially for use in baby foods.

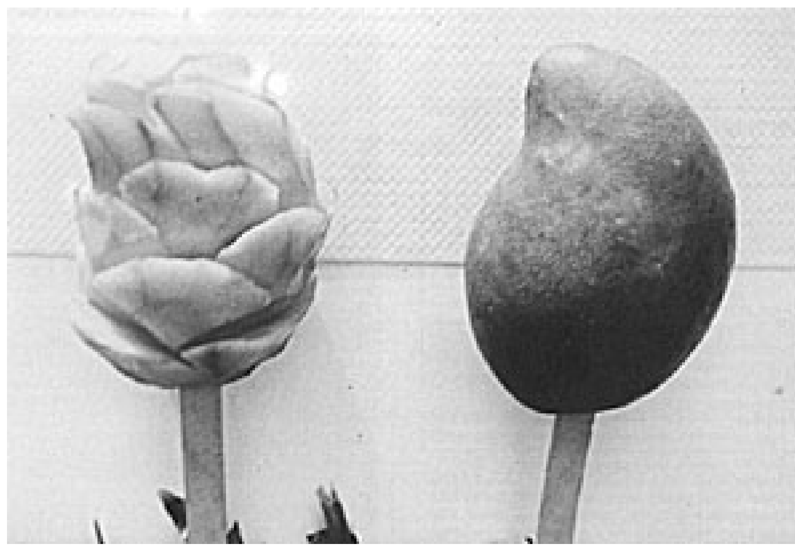


Fig. 64: A low-fiber, green-skinned mango on the market in Merida, Yucatan, is mounted on a lollipop stick. The fruit may be peeled and the flesh deeply cut to resemble the petals of a flower.

Ripe mangos may be frozen whole or peeled, sliced and packed in sugar (1 part sugar to 10 parts mango by weight) and quick-frozen in moisture-proof containers. The diced flesh of ripe mangos, bathed in sweetened or unsweetened lime juice, to prevent discoloration, can be quick-frozen, as can sweetened ripe or green mango puree. Immature mangos are often blown down by spring winds. Half-ripe or green mangos are peeled and sliced as filling for pie, used for jelly, or made into sauce which, with added milk and egg whites, can be converted into mango sherbet. Green mangos are peeled, sliced, parboiled, then combined with sugar, salt, various spices and cooked, sometimes with raisins or other fruits, to make chutney; or they may be salted, sun-dried and kept for use in chutney and pickles. Thin slices, seasoned with turmeric, are dried, and sometimes powdered, and used to impart an acid flavor to chutneys, vegetables and soup. Green or ripe mangos may be used to make relish.

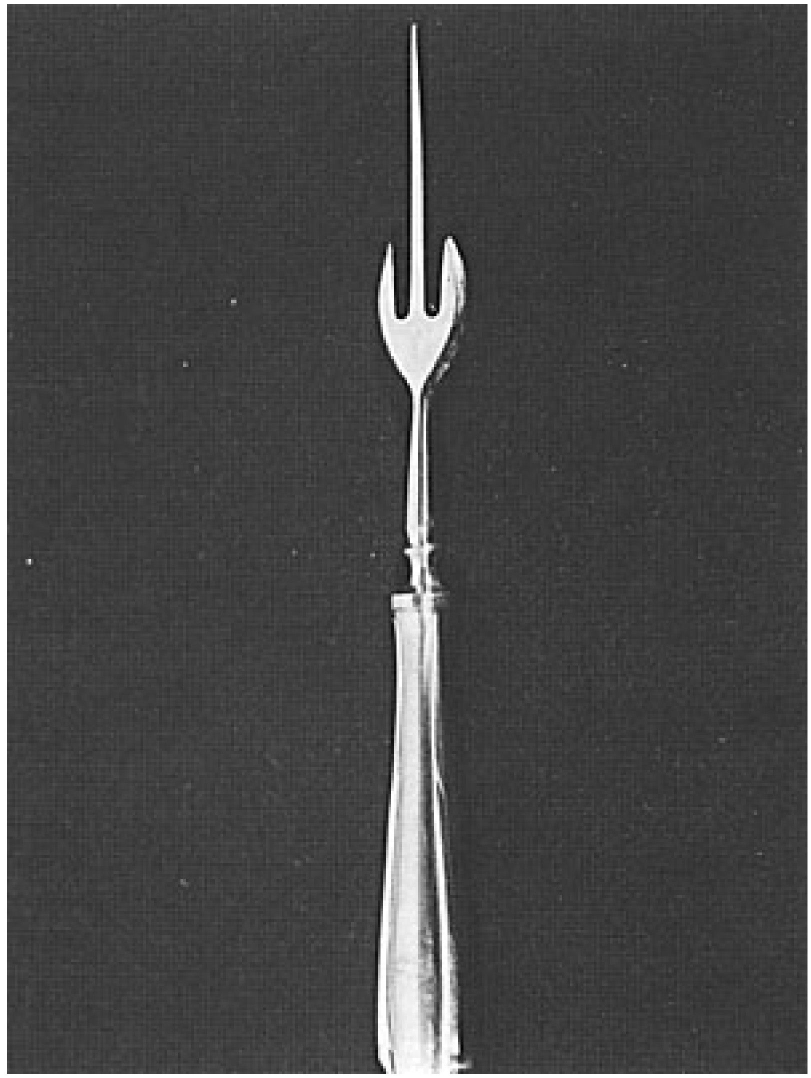


Fig. 62: The long center tine of the mango fork is designed for piercing the base of the center section and right through the seed. With the strip of peel removed, the most flavorful flesh around the seed can be enjoyed like a lollipop.

In Thailand, green-skinned mangos of a class called "keo", with sweet, nearly fiberless flesh and very commonly grown and inexpensive on the market, are soaked whole for 15 days in salted water before peeling, slicing and serving with sugar.

Processing of mangos for export is of great importance in Hawaii in view of the restrictions on exporting the fresh fruits. Hawaiian technologists have developed methods for steam- and lye-peeling, also devices for removing peel from unpeeled fruits in the preparation of nectar. Choice of suitable cultivars is an essential factor in processing mangos for different purposes.

The Food Research Institute of the Canada Department of Agriculture has developed methods of preserving ripe or green mango slices by osmotic dehydration,

The fresh kernel of the mango seed (stone) constitutes 13% of the weight of the fruit, 55% to 65% of the weight of the stone. The kernel is a major by-product of the mango-processing industry. In times of food scarcity in India, the kernels are roasted or boiled and eaten. After soaking to dispel the astringency (tannins), the kernels are dried and ground to flour which is mixed with wheat or rice flour to make bread and it is also used in puddings.

The fat extracted from the kernel is white, solid like cocoa butter and tallow, edible, and has been proposed as a substitute for cocoa butter in chocolate.

The peel constitutes 20% to 25% of the total weight of the fruit. Researchers in India have shown that the peel can be utilized as a source of pectin. Average yield on a dry-weight basis is 13%.

Immature mango leaves are cooked and eaten in Indonesia and the Philippines.

Food Value Per 100 g of Ripe Mango Flesh*

Fruit	
Calories	62.1-63.7
Moisture	78.9-82.8 g
Protein	0.36-0.40 g

Fat	0.30-0.53 g
Carbohydrates	16.20-17.18 g
Fiber	0.85-1.06 g
Ash	0.34-0.52 g
Calcium	6.1-12.8 mg
Phosphorus	5.5-17.9 mg
Iron	0.20-0.63 mg
Vitamin A (carotene)	0.135-1.872 mg
Thiamine	0.020-0.073 mg
Riboflavin	0.025-0.068 mg
Niacin	0.025-0.707 mg
Ascorbic Acid	7.8-172.0 mg
Tryptophan	3-6 mg
Methionine	4 mg
Lysine	32-37 mg

*Minimum and maximum levels of food constituents derived from various analyses made in Cuba, Central America, Africa and India.

Puerto Rican analyses of 30 cultivars showed b-carotene as ranging from a low of 4,171 I.U./100 g in 'Stringless Peach' to a high of 7,900 I.U. in 'Carrie'. Ascorbic acid ranged from 3.43 mg/100 g in 'Keitt' to 62.96 in 'Julie'.

*Seed Kernel***	
Moisture	10.55-11.35%
Protein	4.76-8.5%
Fat	6-15%
Starch	40-72%
Sugar	1.07%
Fiber	1.17-2.6%
Ash	1.72-3.66%
Silica	0.41%
Iron	0.03%
Calcium	0.11-0.23%
Magnesium	0.34%
Phosphorus	0.21-0.66%
Sodium	0.28%

Potassium	1.31%
Sulfur	0.23%
Carbonate	0.09%

**According to analyses made in India and Cuba.

Indian analyses of the mango kernel reveal the amino acids–alanine, arginine, aspartic acid, cystine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tyrosine, valine, at levels lower than in wheat and gluten. Tannin content may be 0.12-0.18% or much higher in certain cultivars.

*Kernel Flour**	
Protein	5.56%
Fat	16.17%
Carbohydrates	69.2%
Ash (minerals)	0.35%

*It is said to be equal to rice in food value, if tannin-free.

Kernel Fat	
Fully saturated glycerides	14.2%
Mono-oleoglycerides	24.2%
Di-oleoglycerides	60.8%
Tri-unsaturated glycerides	0.8%
Fatty Acids:	
Mysristic	0.69%
Palmitic	4.4-8.83%
Stearic	33.96-47.8%
Arachidic	2.7-6.74%
Oleic	38.2-49.78%
Linoleic	4.4-5.4%
Linolenic	0.5%

Leaves (immature)	
Moisture	78.2%
Protein	3.0%
Fat	0.4%
Carbohydrates	16.5%
Fiber	1.6%

Ash	1.9%
Calcium	29 mg/100 g
Phosphorus	72 mg
Iron	6.2 mg
Vitamin A (carotene) ß	1,490 I.U.
Thiamine	0.04 mg
Riboflavin	0.06 mg
Niacin	2.2 mg
Ascorbic Acid**	53 mg/100g

**According to various analyses made in India.

Toxicity

The sap which exudes from the stalk close to the base of the fruit is somewhat milky at first, also yellowish-resinous. It becomes pale-yellow and translucent when dried. It contains mangiferen, resinous acid, mangiferic acid, and the resinol, mangiferol. It, like the sap of the trunk and branches and the skin of the unripe fruit, is a potent skin irritant, and capable of blistering the skin of the normal individual. As with poison ivy, there is typically a delayed reaction. Hypersensitive persons may react with considerable swelling of the eyelids, the face, and other parts of the body. They may not be able to handle, peel, or eat mangos or any food containing mango flesh or juice. A good precaution is to use one knife to peel the mango, and a clean knife to slice the flesh to avoid contaminating the flesh with any of the resin in the peel.

The leaves contain the glucoside, mangiferine. In India, cows were formerly fed mango leaves to obtain from their urine euxanthic acid which is rich yellow and has been used as a dye. Since continuous intake of the leaves may be fatal, the practice has been outlawed.

When mango trees are in bloom, it is not uncommon for people to suffer itching around the eyes, facial swelling and respiratory difficulty, even though there is no airborne pollen. The few pollen grains are large and they tend to adhere to each other even in dry weather. The stigma is small and not designed to catch windborne pollen. The irritant is probably the vaporized essential oil of the flowers which contains the sesquiterpene alcohol, mangiferol, and the ketone, mangiferone.

Mango wood should never be used in fireplaces or for cooking fuel, as its smoke is highly irritant.

Other Uses

Seed kernels: After soaking and drying to 10% moisture content, the kernels are fed to poultry and cattle. Without the removal of tannins, the feeding value is low. Cuban scientists declare that the mineral levels are so low mineral supplementation is needed if the kernel is used for poultry feed, for which purpose it is recommended mainly because it has little crude fiber.

Seed fat: Having high stearic acid content, the fat is desirable for soap-making. The seed residue after fat extraction is usable for cattle feed and soil enrichment.

A mango stone decorticator has been designed and successfully operated by the Agricultural Engineering Department of Pantnagar University, India.

Wood: The wood is kiln-dried or seasoned in saltwater. It is gray or greenish-brown, coarse-textured, medium-strong, hard, durable in water but not in the ground; easy to work and finishes well. In India, after preservative treatment, it is used for rafters and joists, window frames, agricultural implements, boats, plywood, shoe heels and boxes, including crates for shipping tins of cashew kernels. It makes excellent charcoal.

Bark: The bark possesses 16% to 20% tannin and has been employed for tanning hides. It yields a yellow dye, or, with turmeric and lime, a bright rose-pink.

Gum: A somewhat resinous, red-brown gum from the trunk is used for mending crockery in tropical Africa. In India, it is sold as a substitute for gum arabic.

Medicinal Uses: Dried mango flowers, containing 15% tannin, serve as astringents in cases of diarrhea, chronic dysentery, catarrh of the bladder and chronic urethritis resulting from gonorrhea. The bark contains mangiferine and is astringent and employed against rheumatism and diphtheria in India. The resinous gum from the trunk is applied on cracks in the skin of the feet and on scabies, and is believed helpful in cases of syphilis.

Mango kernel decoction and powder (not tannin-free) are used as vermifuges and as astringents in diarrhea, hemorrhages and bleeding hemorrhoids. The fat is administered in cases of stomatitis. Extracts of unripe fruits and of bark, stems and leaves have shown antibiotic activity. In some of the islands of the Caribbean, the leaf decoction is taken as a remedy for diarrhea, fever, chest complaints, diabetes, hypertension and other ills. A combined decoction of mango and other leaves is taken after childbirth.

Related Species

Of approximately 40 other species of *Mangifera,* a few are cultivated for their fruits and several have been employed as rootstocks for the mango in Malaya.

M. sylvatica Roxb., is a large tree to 150 ft (45 m) growing wild in the eastern Himalayas, Nepal and the Andaman Islands, from 980 to 4,200 ft (300-1,300 m). The elliptic fruit, 3 1/4 to 4 in (8-10 cm) long, has yellow skin and fiberless, though rather thin, flesh. It is mostly utilized while still unripe for pickles and other preserves. The tree is valued mainly for its timber which is largely sapwood, light in weight and easily worked but medium-hard and strong.

M. foetida Lour., the horse mango, is a handsome, well-formed tree, 60 to 80 ft (18-24 m) tall with very stiff leaves and showy particles of pink-red, odorless flowers. The fruit is oblong, 3 to 5 1/2 in (7.5-16 cm) long, plump, with yellowish- or grayish-green skin when ripe. The flesh is variable, in some types orange, acid, strongly turpentine-scented; in others, pale-yellow, sweet in flavor and mildly aromatic. All types are fibrous and the stone has much fiber. Sweet types are eaten raw when ripe; others are used for pickles, chutneys and in curries. The sap of the tree and the immature fruit is highly irritating.

M. caesia Jack, ranging from 65 to 150 ft (20-45 m) at low altitudes in Malaysia and the Philippines, is frequently cultivated in Indonesia. The flowers are blue or lavender. Strongly and, to some people, unpleasantly aromatic, the fruit is oval to pear-shaped, 4 1/4 to 6 in (11-15 cm) long, with thin, pale-green or light-brown, scurfy skin which clings to the white or pale-yellow, juicy, fibrous flesh. Quality is highly variable; some types being subacid to sweet and agreeable and these are commonly eaten in Malaya. The seed is large and pink, enclosed in matted fibers; edible; monoembryonic. Young leaves are eaten raw. The sap of the tree and immature fruits is exceedingly irritant.

M. odorata Griff. is a medium to large tree, 60 to 80 ft (15-24 m) high, better suited than the mango to humid regions and much cultivated from Malaya to the Philippines where it is more familiar than the mango in eastern Mindanao. The flowers are whitish to yellowish and very fragrant. The fruit is round-oblique, somewhat oblate; to 5 in (12.5 cm) long, plump, with green or yellow-green, thick, tough skin. When ripe the flesh is pale-orange or yellowish, fibrous and resinous but juicy and sweet, though most types are distinctly turpentine -flavored. Nevertheless, all types are popular for curries and pickles. The stone is large with many coarse fibers. The sap of this tree is said to be fairly mild, but the milky sap of the immature fruit extremely acrid.

In addition to the above, Malayan villagers occasionally cultivate some lesser-known species: *M. longipetiolata* King, *M. maingayi* Hook f., *M. kemanga* Blume, and *M. pentandra* Hook f.

The gandaria, Plate XXIX, *Bouea gandaria* Blume (syn. *B. macrophylla* Griff.), is also called *kundangan, kundang, setar, star* and *rumia* in Malaya; *gandareed* in Java; *ma-prang* in Thailand. The tree, usually to 30 ft (9 m), sometimes to 60 ft (18 m), is short-trunked with resinous sap, drooping branches and evergreen, opposite, resinous, leathery, downward-pointing leaves 4 to 12 in (10-30 cm) long, 2 to 4 1/2 in (5-11.25 cm) wide. They are purple-red and silky when they first appear. Small, greenish flowers are borne in pendent panicles to 5 in (12.5 cm) in length. The fruit, like a miniature mango, is oval, round or oblong-ovoid, 1 1/2 to 2 1/2 in (4-6.25 cm) long, with thin, smooth, brittle, edible skin, yellow or apricot-colored when ripe. The yellow or orange pulp is juicy, varies from acid to sweet, and adheres to the leathery, whiskered stone. There is great variation in the fruits of seedling trees, especially in the degree of "turpentine" odor. The tree is native to Malaya and Sumatra; is frequently cultivated, either from seed or air-layers, in its natural range and also rather widely through Malaysia and the fruits are sold in markets. They are made into jam and chutney. When still immature, they are pickled in brine and used in curries. In Indonesia, the young leaves are marketed and eaten raw with rice. Budwood of a cultivar named 'Wan', meaning "sweet", was obtained by William F. Whitman from an orchard near Bangkok in 1967. His resulting grafted tree, in a protected location in South Florida, fruited in 1974. Earlier introductions (1935, 1936 and 1938) by the Agricultural Research and Education Center in Homestead failed to survive.

A lesser species, *B. oppositifolia* Adelb. (syn. *B. micro*phylla Griff.), is called plum mango, *rembunia, gemis,* or *rumia* in Malaya; *ma-pring* in Thailand. The tree is similar but deciduous, smaller in all its parts, and the fruit is orange or yellow and only 1 in (2.5 cm) long, acid and usually cooked when half-ripe. This species is abundant wild in lowland forests of Malaya and much cultivated as a shade tree. The wood is hard and very heavy, sinks in water, and is used for houseposts.

Food Value

Fruits from a 20-year-old gandaria tree *(Bouea gandaria* Blume) in the Lancetilla Experimental Garden, Tela, Honduras, were analyzed in 1950 and the following values were reported:

Food Value Per 100 g of Edible Portion

Moisture	85.2 g
Protein	0.112 g
Fat	0.04g
Fiber	0.6 g
Ash	0.23 g
Calcium	6.0 mg
Phosphorus	10.8 mg
Iron	0.31 mg
Carotene	0.043 mg
Thiamine	0.031 mg
Riboflavin	0.025 mg
Niacin	0.286 mg
Ascorbic Acid	75.0 mg

Morton, J. 1987. Cashew Apple. p. 239–240. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Cashew Apple

Anacardium occidentale L.

This pseudofruit (or "false fruit") is a by-product of the cashew nut industry. The cashew tree, *Anacardium occidentale* L., is called *marañon* in most Spanish-speaking countries, but *merey* in Venezuela; and *caju* or *cajueiro* in Portuguese. It is generally bushy, low-branched and spreading; may reach 35 ft (10.6 m) in height and width. Its leaves, mainly in terminal clusters, are oblong-oval or obovate, 4 to 8 in (10-20 cm) long and 2 to 4 in (5-10 cm) wide, and leathery. Yellowish-pink, 5-petalled flowers are borne in 6 to 10-in (15-25 cm) terminal panicles of mixed male, female and bisexual. The true fruit of the tree is the cashew nut resembling a miniature boxing-glove; consisting of a double shell containing a caustic phenolic resin in honeycomb-like cells, enclosing the edible kidney-shaped kernel. An interesting feature of the cashew is that the nut develops first and when it is full-grown but not yet ripe, its peduncle or, more technically, receptacle, fills out, becomes plump, fleshy, pear-shaped or rhomboid-to-ovate, 2 to 4 1/2 in (5-11.25 cm) in length, with waxy, yellow, red, or red-and-yellow skin and spongy, fibrous, very juicy, astringent, acid to subacid, yellow pulp. Thus is formed the conspicuous, so-called cashew apple.

Plate XXX: CASHEW APPLE, *Anacardium occidentale*

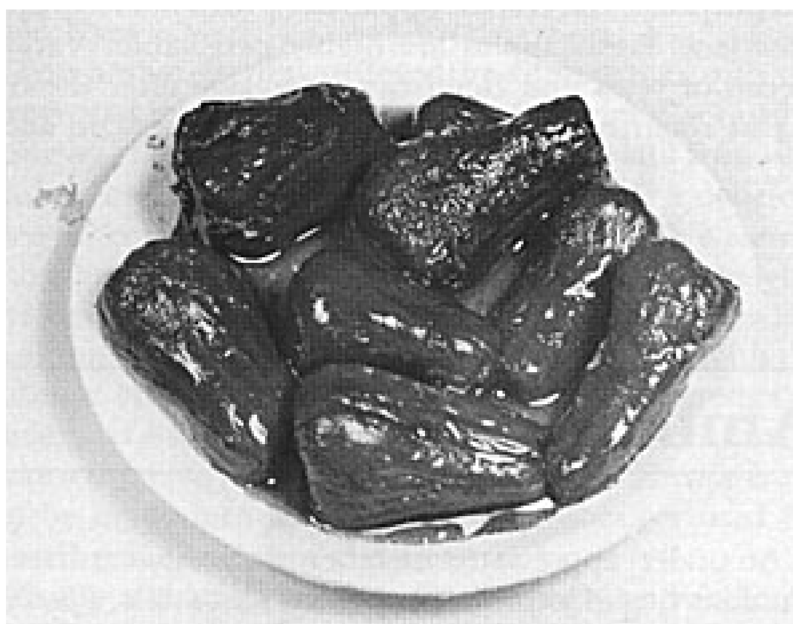


Fig. 66: The so-called "cashew apple", a pseudofruit–actually the swollen stalk of the true fruit of *Anacardium occidentale,* the cashew nut–is fibrous but juicy and locally popular preserved in sirup.

The cashew is native to and northeast Brazil and, in the 16th Century, Portuguese traders introduced it to Mozambique and coastal India, but only as a soil retainer to stop erosion on the coasts. It flourished and ran wild and formed extensive forests in these locations and on nearby islands, and eventually it also became dispersed in East Africa and throughout the tropical lowlands of northern South America, Central America and the West Indies. It has been more or less casually planted in all warm regions and a few fruiting specimens are found in experimental stations and private gardens in southern Florida.

Fig. 67: Food technologists in Mysore, India, developed a candied cashew apple product, more appealing than the canned. A similar confection is made and sold in the Dominican Republic.

The production and processing of cashew nuts are complex and difficult problems. Because of the great handicap of the toxic shell oil, Latin Americans and West Indians over the years have been most enthusiastic about the succulent cashew apple and have generally thrown the nut away or processed it crudely on a limited scale, except in Brazil, where there is a highly developed cashew nut processing industry, especially in Ceara. In Mozambique, also, the apple reigned supreme for decades. Attention then focused on the nut, but, in 1972, the industrial potential of the juice and sirup from the estimated 2 million tons of surplus cashew apples was being investigated. In India, on the other hand, vast tonnages of cashew apples have largely gone to waste while that country pioneered in the utilization and promotion of the nut.

The apple and nut fall together when both are ripe and, in commercial nut plantations, it is most practical to twist off the nut and leave the apple on the ground for later grazing by cattle or pigs. But, where labor costs are very low, the apples may be gathered up and taken to markets or processing plants. In Goa, India, the apples are still trampled by foot to extract the juice for the locally famous distilled liquor, *feni*. In Brazil, great heaps are displayed by fruit vendors, and the juice is used as a fresh beverage and for wine.

In the field, the fruits are picked up and chewed for refreshment, the juice swallowed, and the fibrous residue discarded. In the home and, in a limited way for commercial purposes, the cashew apples are preserved in sirup in glass jars. Fresh apples are highly perishable. Various species of yeast and fungi cause spoilage after the first day at room temperature. Food technologists in India have found that good condition can be maintained for 5 weeks at 32º to 35º F (0º-1.67º C) and relative humidity of 85% to 90%. Inasmuch as the juice is astringent and somewhat acrid due to 35% tannin content (in the red: less in the yellow) and 3% of an oily substance, the fruit is pressure-steamed for 5 to 15 minutes before candying or making into jam or chutney or extracting the juice for carbonated beverages, sirup or wine. Efforts are made to retain as much as possible of the ascorbic acid. Food technologists in Costa Rica recently worked out an improved process for producing the locally popular candied, sun-dried cashew apples. Failure to remove the tannin from the juice may account for the nutritional deficiency in heavy imbibers of cashew apple wine in

Mozambique, for tannin prevents the body's full assimilation of protein.

Food Value Per 100 g of Fresh Cashew Apple*

Moisture	84.4-88.7 g
Protein	0.101-0.162 g
Fat	0.05-0.50 g
Carbohydrates	9.08-9.75 g
Fiber	0.4-1.0 g
Ash	0.19-0.34 g
Calcium	0.9-5.4 mg
Phosphorus	6.1-21.4 mg
Iron	0.19-0.71 mg
Carotene	0.03-0.742 mg
Thiamine	0.023-0.03 mg
Riboflavin	0.13-0.4 mg
Niacin	0.13-0.539 mg
Ascorbic Acid	146.6-372.0 mg

*Analyses made in Central America and Cuba.

Medicinal Uses: Cashew apple juice, without removal of tannin, is prescribed as a remedy for sore throat and chronic dysentery in Cuba and Brazil. Fresh or distilled, it is a potent diuretic and is said to possess sudorific properties. The brandy is applied as a liniment to relieve the pain of rheumatism and neuralgia.

Morton, J. 1987. Ambarella. p. 240–242. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Ambarella

Spondias dulcis Forst.

Spondias cytherea Sonn.

An under-appreciated member of the Anacardiaceae, but deserving of improvement, is the ambarella, *Spondias dulcis* Forst. (syn. *S. cytherea* Sonn.). Among various colloquial names are Otaheite apple, Tahitian quince, Polynesian plum, Jew plum and golden apple. In Malaya it is called great hog plum or *kedondong;* in Indonesia, *kedongdong;* in Thailand, *ma-kok-farang;* in Cambodia, *mokak;* in Vietnam, *coc*, *pomme cythere* or *Pommier de cythere.* In Costa Rica, it is known as *juplón;* in Colombia, *hobo de racimos;* in Venezuela, *jobo de la India, jobo de Indio,* or *mango jobo;* in Ecuador, *manzana de oro;* in Brazil, *caja-manga*.

Description

The tree is rapid-growing, attaining a height of 60 ft (18 m) in its homeland; generally not more than 30 or 40 ft (9-12 m) in other areas. Upright and rather rigid and symmetrical, it is a stately ornamental with deciduous, handsome, pinnate leaves, 8 to 24 in (20-60 cm) in length, composed of 9 to 25 glossy, elliptic or obovate-oblong leaflets 2 1/2 to 4 in (6.25-10 cm) long, finely toothed toward the apex. At the beginning of the dry, cool season, the leaves turn bright-yellow and fall, but the tree with its nearly smooth, light gray-brown bark and graceful, rounded branches is not


Plate XXXI: AMBARELLA, *Spondias dulcis*

unattractive during the few weeks that it remains bare. Small, inconspicuous, whitish flowers are borne in large terminal panicles. They are assorted, male, female and perfect in each cluster. Long-stalked fruits dangle in bunches of a dozen or more; oval or somewhat irregular or knobby, and 2 1/2 to 3 1/2 in (6.25-9 cm) long, with thin but tough skin, often russetted. While still green and hard, the fruits fall to the ground, a few at a time, over a period of several weeks. As they ripen, the skin and flesh turn golden-yellow. While the fruit is still firm, the flesh is crisp, juicy and subacid, and has a somewhat pineapple-like fragrance and flavor. If allowed to soften, the aroma and flavor become musky and the flesh difficult to slice because of conspicuous and tough fibers extending from the rough ridges of the 5-celled, woody core containing 1 to 5 flat seeds. Some fruits in the South Sea Islands weigh over 1 lb (0.45 kg) each.

Origin and Distribution

The ambarella is native from Melanesia through Polynesia and has been introduced into tropical areas of both the Old and New World. It is common in Malayan gardens and fairly frequent in India and Ceylon. The fruits are sold in markets in Vietnam and elsewhere in former Indochina. It first fruited in the Philippines in 1915. It is cultivated in Queensland, Australia, and grown on a small scale in Gabon and Zanzibar.

It was introduced into Jamaica in 1782 and again 10 years later by Captain Bligh, probably from Hawaii where it has been grown for many years. It is cultivated in Cuba, Haiti, the Dominican Republic, and from Puerto Rico to Trinidad; also in Central America, Venezuela, and Surinam; is rare in Brazil and other parts of tropical America. Popenoe said there were only a few trees in the Province of Guayas, Ecuador, in 1924.

The United States Department of Agriculture received seeds from Liberia in 1909, though Wester reported at that time that the tree had already been fruiting for 4 years in Miami, Florida. In 1911, additional seeds reached Washington from Queensland, Australia. A number of specimens are scattered around the tip of Florida, from Palm Beach southward, but the tree has never become common here. Some that were planted in the past have disappeared.

Climate

The tree flourishes in humid tropical and subtropical areas, being only a trifle tenderer than its close relative, the mango. It succeeds up to an altitude of 2,300 ft (700 m). In Israel, the tree does not thrive, remaining small and bearing only a few, inferior fruits.

Soil

The ambarella grows on all types of soil, including oolitic limestone in Florida, as long as they are well-drained.

Propagation

The tree is easily propagated by seeds, which germinate in about 4 weeks, or by large hardwood cuttings, or air-layers. It can be grafted on its own rootstock, but Firminger says that in India it is usually grafted on the native *S. pinnata* Kurz (see below). Wester advised: "Use non-petioled, slender, mature, but green and smooth budwood; cut large buds with ample wood-shield, 1 1/2 to 1 3/4 in (4-4.5 cm) long; insert the buds in the stock at a point of approximately the same age and appearance as the scion."

Culture

Seedlings may fruit when only 4 years old. Ochse recommends that the young trees be given light shade. Mature trees are somewhat brittle and apt to be damaged by strong winds; therefore, sheltered locations are preferred.

Season

In Hawaii, the fruit ripens from November to April; in Tahiti, from May to July. In Florida, a single tree provides a steady supply for a family from fall to midwinter, at a time when mangos and many other popular fruits are out of season.

Pests and Diseases

Ochse says that in Indonesia the leaves are severely attacked by the larvae of the kedongdong spring-beetle, *Podontia affinis*. In Costa Rica, the bark is eaten by a wasp ("Congo"), causing necrosis which leads to death. No particular insects or diseases have been reported in Florida. In Jamaica, the tree is subject to gummosis and is consequently short-lived.

Food Uses

The ambarella has suffered by comparison with the mango and by repetition in literature of its inferior quality. However, taken at the proper stage, while still firm, it is relished by many out-of-hand, and it yields a delicious juice for cold beverages. If the crisp sliced flesh is stewed with a little water and sugar and then strained through a wire sieve, it makes a most acceptable product, much like traditional applesauce but with a richer flavor. With the addition of cinnamon or any other spices desired, this sauce can be slowly cooked down to a thick consistency to make a preserve very similar to apple butter. Unripe fruits can be made into jelly, pickles or relishes, or used for flavoring sauces, soups and stews.

Young ambarella leaves are appealingly acid and consumed raw in southeast Asia. In Indonesia, they are steamed and eaten as a vegetable with salted fish and rice, and also used as seasoning for various dishes. They are sometimes cooked with meat to tenderize it.

Food Value Per 100 g of Edible Portion*	
Calories	157.30

Total Solids	14.53-40-35%
Moisture	59.65-85.47%
Protein	0.50-0.80%
Fat	0.28-1.79%
Sugar (sucrose)	8.05-10-54%
Acid	0.47%
Crude Fiber	0.85-3-60%
Ash	0.44-0.65%

*According to analyses made in the Philippines and Hawaii. I

Miller, Louis and Yanazawa in Hawaii reported an ascorbic acid content of 42 mg per 100 g of raw pulp. It is a good source of iron. Unripe fruits contain 9.76% of pectin.

Other Uses

Wood: The wood is light-brown and buoyant and in the Society Islands has been used for canoes.

Medicinal Uses: In Cambodia, the astringent bark is used with various species of *Terminalia* as a remedy for diarrhea.

Related Species

The amra, *S. pinnata* Kurz (syns. *Mangifera pinnata* L. f.; *Pourpartia pinnata* Blanco), which some botanists consider merely a wild form of *S. dulcis*, is wild and cultivated from the Himalayas of northern India to the Andaman Islands and is commonly cultivated throughout southeast Asia and Malaysia. The twigs are smooth and the leaves are not toothed; the fruit is smaller than the ambarella and inferior in quality but has the same uses. The aromatic, acidulous leaves and flowers are employed as flavoring and consumed raw or cooked, especially in curries. The wood is used for making boats, floats, matches, etc. There are several medicinal applications of the bark, root, and the gum that exudes from the trunk.

Morton, J. 1987. Purple Mombin. p. 242–245. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Purple Mombin

Spondias purpurea L.

One of the most popular small fruits of the American tropics, the purple mombin, *Spondias Purpurea* L., has acquired many other colloquial names: in English, red mombin, Spanish plum, hog plum, scarlet plum; purple plum in the Virgin Islands; Jamaica plum in Trinidad; Chile plum in Barbados; wild plum in Costa Rica and Panama; red plum, as well as *noba* and *makka pruim* in the Netherlands Antilles. Spanish names include: *ajuela ciruela; chiabal; cirguelo; ciruela; ciruela agria; ciruela calentana; ciruela campechana; ciruela colorada; ciruela de coyote; ciruela de hueso; ciruela del país; ciruela de Mexico; ciruela morada; ciruela roja; ciruela sanjuanera; hobo; hobo colorado; ismoyo; jobillo; jobito; jobo; jobo colorado; jobo francés; jocote; jocote agrio; jocote amarillo* (yellow form); *jocote común; jocote de corona; jocote de iguana; jocote iguanero; jocote tronador; jocotillo; pitarillo; sineguelas* (Philippines); *sismoyo.* In Portuguese, it is called *ambu; ambuzeiro; ameixa da Espanha; cajá vermelha* (yellow form); *ciriguela; ciroela; imbu; imbuzeiro; umbu,* or *umbuzeiro.* In French, it is *cirouelle, mombin rouge, prune du Chili, prune d'Espagne, prune jaune* (yellow form) or *prune rouge.*

Description

The purple mombin may be a shrub or low-branched small tree in lowlands, or a spreading,

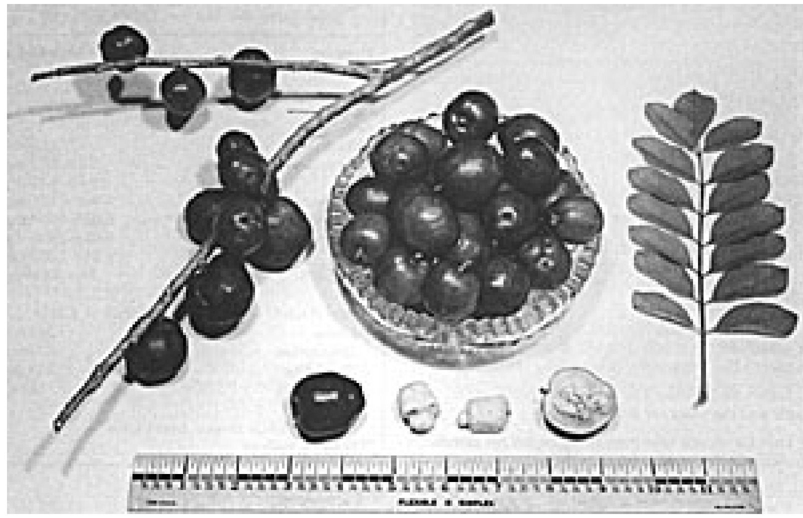


Fig. 68: The purple, or red, mombin *(Spondias Purpurea)*, despite its large seed, is popular for casual nibbling. In: K. & J. Morton, *Fifty Tropical Fruits of Nassau*, 1946.

thick-trunked tree reaching 25 or even 50 ft (7.5-15 m) in highlands. The branches are thickish and brittle. The deciduous, alternate, compound leaves bright-red or purple when young; 4 3/4 to 10 in (12-25 cm) long when mature; have 5 to 19 nearly sessile, obovate to lanceolate or oblong-elliptic leaflets 3/4 to 1 1/2 in (2-4 cm) long; oblique toward the base and faintly toothed toward the apex. The tiny, 4- to 5-petalled flowers, male, female and bisexual, are red or purple and borne in short, hairy panicles along the branches before the leaves appear. Somewhat plumlike, the fruits, borne singly or in groups of 2 or 3, may be purple, dark- or bright-red, orange, yellow, or red-and-yellow. They vary from 1 to 2 in (2.5-5 cm) in length and may be oblong, oval, obovoid or pear-shaped, with small indentations and often a knob at the apex. The skin is glossy and firm; the flesh aromatic, yellow, fibrous, very juicy, with a rich, plum-like, subacid to acid flavor, sometimes a trifle turpentiney; and it adheres to the rough, fibrous, hard, oblong, knobby, thick, pale stone, which is 1/2 to 3/4 in (1.25-2 cm) long and contains up to 5 small seeds.

Origin and Distribution

The purple mombin is native and common both wild and cultivated from southern Mexico through northern Peru and Brazil, particularly in and zones. There are some recent commercial plantings in Mexico and Venezuela. It is commonly planted in most of the islands of the West Indies and the Bahamas. Everywhere the fruits are sold along the roads and streets as well as in the native markets. Spanish explorers carried this species to the Philippines, where it has been widely adopted. The tree is naturalized throughout much of Nigeria and occasionally cultivated for its fruit. It has been infrequently planted in southern Florida, mainly as a curiosity.

Varieties

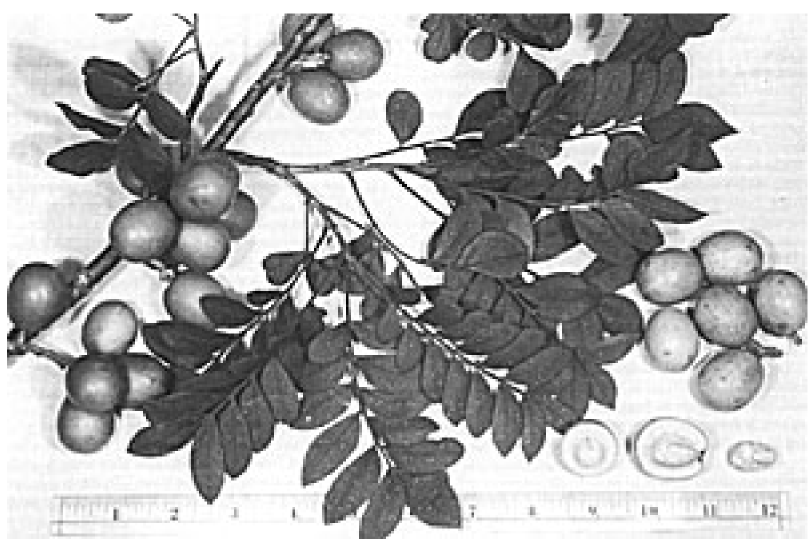


Fig. 69: The yellow form of the purple mombin, which has been called *S. purpurea* var. *lutea, is* smaller, less irregular in form.

The fruit is highly variable. The yellow form (uncommon) has been identified by some botanists as *S. purpurea* forma *lutea* F. & R., or even as a separate species, *S. cirouella* Tassac. It has been confused with the true yellow mombin, *S. mombin* L. (syn. S. *lutea* L.), q.v.

In Guatemala, the variety called *jocote de corona*, which is flattened and somewhat shouldered at the apex, is said to be of superior quality, and *jocote tronador is* nearly its equal.

Climate

The tree is tropical, ranging from sea-level to 5,500 or 6,000 ft (1,700-1,800 m) in Mexico and Central America; to 2,500 ft (760 m) in Jamaica, in either dry or humid regions. It flowers but does not fruit in Israel; is cold-sensitive in Florida.

Soil

The tree is found growing naturally on a great diversity of soils throughout Latin America-sand, gravel, heavy clay loam, or limestone.

Propagation and Culture

The purple mombin, including its yellow form, is grown very easily and quickly by setting large cuttings upright in the ground. It is one of the trees most used to create "living fences". It grows very slowly from seed.

Season

There are flowers and fruits of the red form nearly all year in Jamaica, but mainly in July and August, while the yellow variant fruits only from September to November. In the Bahamas, the fruiting season of the red type is brief, just May and June; the yellow ripens from August to early October.

Pests and Diseases

Fruit flies commonly infest the ripe fruits. In Florida, the foliage is subject to spot anthracnose caused by *Sphaceloma spondiadis.*

Food Uses

The ripe fruits are commonly eaten out-of-hand. While not of high quality, they are popular with people who have enjoyed them from childhood, and they serve a useful purpose in the absence of "snackbars". In the home, they are stewed whole, with sugar, and consumed as dessert. They can be preserved for future use merely by boiling and drying, which keeps them in good condition for several months. The strained juice of cooked fruits yields an excellent jelly and is also used for making wine and vinegar. It is a pleasant addition to other fruit beverages.

In Mexico, unripe fruits are made into a tart, green sauce, or are pickled in vinegar and eaten with salt and chili peppers.

The new shoots and leaves are acid and eaten raw or cooked as greens in northern Central America.

Food Value Per 100 g of Edible Portion*

Moisture	65.9-86.6 g
Protein	0.096-0.261 g
Fat	0.03-0.17 g
Fiber	0.2-0.6 g

Ash	0.47-1.13 g
Calcium	6.1-23.9 mg
Phosphorus	31.5-55.7 mg
Iron	0.09-1.22 mg
Carotene	0.004-0.089 mg
Thiamine	0.033-0.103 mg
Riboflavin	0.014-0.049 mg
Niacin	0.540-1.770 mg
Ascorbic Acid	26.4-73.0 mg
*Amino Acids***	(mg per g nitrogen [N = 6.25])
Lysine	316 mg
Methionine	178 mg
Threonine	219 mg
Tryptophan	57 mg

*Analyses made in Central America and Ecuador.

**Brazilian analyses.

Toxicity

In the Philippines, it is said that eating a large quantity of the fruits on an empty stomach may cause stomachache.

Other Uses

Gum: The tree exudes a gum that has served in Central America as a glue.

Wood: The wood is light and soft; has been found to be suitable for paper pulp in Brazil. It is sometimes burned to ashes which are employed in making soap.

Leaves and fruits: The leaves are readily grazed by cattle and the fruits are fed to hogs.

Lac: Lac insects have been raised on the red mombin in Mexico.

Medicinal Uses: in Mexico, the fruits are regarded as diuretic and antispasmodic. The fruit decoction is used to bathe wounds and heal sores in the mouth. A sirup prepared from the fruit is taken to overcome chronic diarrhea. The astringent bark decoction is a remedy for mange, ulcers, dysentery and for bloating caused by intestinal gas in infants. In the Philippines, the sap of the bark is used to treat stomatitis in infants.

The juice of the fresh leaves is a remedy for thrush. A decoction of the leaves and bark is employed as a febrifuge. In southwestern Nigeria, an infusion of shredded leaves is valued for washing cuts, sores and burns. Researchers at the University of Ife have found that an aqueous extract of the leaves has antibacterial action, and an alcoholic extract is even more effective. The gum-resin of the tree is blended with pineapple or soursop juice for treating jaundice. Most of the other uses indicate that the fruits, leaves and bark are fairly rich in tannin.

Morton, J. 1987. Yellow Mombin. p. 245–248. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Yellow Mombin

Spondias mombin L.

Spondias lutea L.

The true yellow mombin, *S. mombin* L. (syn. *S. lutea* L.) is most often called hog plum in the Caribbean Islands. In Jamaica, it is also known as Spanish plum, or gully plum. In Malaya, it is distinguished as thorny hog plum; in Ghana, it is hog plum or Ashanti plum. Among its Spanish names are *caimito, chupandilla, ciruela agria, ciruela amarilla, ciruela de jobo, ciruela del pais, ciruela de monte, ciruela loca, cirueld mango, ciruela obo, cuajo, guama zapotero, hobo de monte, hubu, jobillo, jobito, jobo, jobo arisco, joboban, jobo blanco, jobo de Castilla, Jobo de perro, jobo de puerco, jobo espino, jobo espinoso, jobo gusanero, jobo hembra, jobo jocote, jobo negro, jobo roñoso, jobo vano, jocote, jocote amarillo, jocote de chanche, jocote dejobo, jocote jobo, jocote montanero, jocote montero, jovo, marapa, obo de zopilote, palo de mulato, noma, tobo de montana, obo* and *uvo*. In Portuguese, it is called *acaiba, acaimiri, acaja, acajaiba, caja, caja mirim, caja pequeno, cajazeiro,* and *caja miudo.* In French, it is *mombin franc, mombin fruits jaunes, mombinier, myrobalane, prune mombin, prune myrobalan,* or *prunier mombin.* Local names in Surinam are *hoeboe, mompe, monbe, mopé* and *moppé.* Amazonian Indians call it *taperiba* or *tapiriba* (fruit of the tapir).

Description

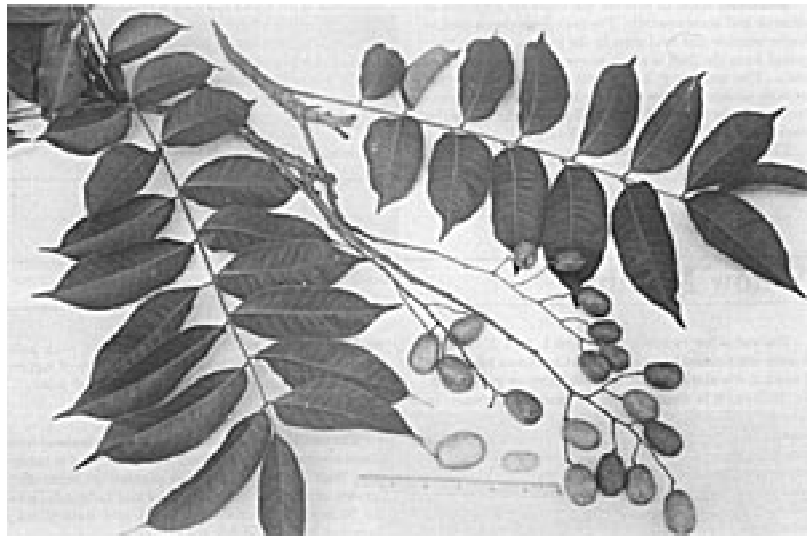


Fig. 70: The true yellow mombin *(Spondias mombin)* is borne in dangling clusters. It is eaten mostly by children and livestock.

The yellow mombin tree, unlike that of the purple mombin, is erect, stately, to 65 ft (20 m) tall, with trunk to 2 or 2 1/2 ft (60-75 cm) in diameter, somewhat buttressed, and thick, fissured bark, often, in young trees, bearing many blunt-pointed spines or knobs up to 3/4 in (2 cm) long. Generally, its lower branches are whorled. Its deciduous, alternate, pinnate leaves, 8 to 18 in (20-45 cm) long, have hairy, often pinkish, petioles and 9 to 19 sub-opposite, ovate or lanceolate, pointed leaflets, 2 to 6 in (5-15 cm) long, inequilateral and oblique at the base. Small, fragrant, whitish, male, female and bisexual flowers are borne, after the new leaves, in panicles 6 to 12 in (15-30 cm) long. The fruit, hanging in numerous, branched, terminal clusters of a dozen or more, is aromatic, ovoid or oblong, 1 1/4 to 1 1/2 in (3.2-4 cm) long and up to 1 in (2.5 cm) wide; golden-yellow; with thin, tough skin, and scant, medium-yellow, translucent, fibrous, very juicy pulp, somewhat musky, very acid, often with a hint of turpentine, clinging to the white, fibrous or "corky" stone.

Origin and Distribution

The tree is native and common in moist lowland forests from southern Mexico to Peru and Brazil, and in many of the West Indies. It has been planted in Bermuda; is grown to a limited extent in India and Indonesia; is rare in Malaya, but widely cultivated and naturalized in tropical Africa.

The United States Department of Agriculture received seeds from Colombia in 1914 (S.P.I. #39563); more seeds arrived in 1917 (S.P.I. #45086); and Dr. David Fairchild collected seeds in Panama in 1921 (S.P.I. #54632). Still, only a few specimens exist in special collections in southern Florida.

Climate

This is a strictly tropical tree, not growing above an elevation of 3,200 ft (1,000 m) in South America. It is well-adapted to arid as well as humid zones.

Propagation

The tree may be propagated by seeds but it is usually grown from large cuttings which root quickly.

Culture

The tree is fast-growing in full sun and in the American tropics and Africa is extensively planted as a living fence-post, as well as for shade and for its fruits.

Season

In Costa Rica, the tree blooms in November and December and again in March, and the fruits ripen in August, and in December/January. Blooming occurs in Jamaica in April, May and June and the crop matures in July and August. The fruits are in season in Mexico from July to October; in Florida from August to November, They fall to the ground when fully ripe, but children throw sticks up into the trees to bring them down sooner.

Pests

The fruits are commonly infested with fruit-fly larvae.

Food Uses

The yellow mombin is less desirable than the purple mombin and is appreciated mostly by children and way-farers as a means of alleviating thirst. Ripe fruits are eaten out-of-hand, or stewed with sugar. The extracted juice is used to prepare ice cream, cool beverages and jelly. Some people make those of fair quality into jam and various other preserves.

In Amazonas, the fruit is used mainly to produce wine sold as " *Vinho de Taperiba"*. In Guatemala, the fruit is made into a cider-like drink.

Mexicans pickle the green fruits in vinegar and eat them like olives with salt and chili, as they do with the unripe purple mombin.

Young leaves are cooked as greens.

Food Value Per 100 g of Edible Portion*	
Calories	21.8-48.1
Moisture	72.8-88.53 g
Protein	1.28-1.38 g
Fat	0.1-0.56 g
Fiber	1.16-1.18 g
Carbohydrates	8.70-10.0 g
Ash	0.65-0.66 g
Calcium	31.4 mg
Iron	2.8 mg
Carotene (Vitamin A)	71 I.U.
Thiamine	95 mcg
Riboflavin	50 mcg
Ascorbic Acid	46.4 mg

*Analyses made in Guatemala, Africa and the Philippines.

Toxicity

According to Altschul, E.L. Little recorded on an herbarium specimen collected in Colombia: ". . . fruit edible, but said to be bad for the throat." In tropical Africa, excessive indulgence in the fruits is said to cause dysentery.

Other Uses

Fruits: The fruits are widely valued as feed for cattle and pigs.

Gum: The tree exudes a gum that is used as a glue.

Wood: The wood is yellow or yellowish-brown with darker markings; light in weight, buoyant, flexible, strong; prone to attack by termites and other pests. It is much used in carpentry, also for matchsticks, match-boxes, physician's spatulas, sticks for sweetmeats, pencils, pen-holders, packing cases, interior sheathing of houses and boats and as a substitute for cork. It is not suited for turnery and does not polish well. In Brazil, the woody tubercles on the trunk are cut off and used for bottle stoppers and to make seals for stamping sealing wax. In tropical Africa, saplings serve as poles for huts; branches for garden poles and for axe and hoe handles. In Costa Rica and Puerto Rico the wood is employed only as fuel. Ashes from the burned wood are utilized in indigo-dyeing in Africa.

Bark: The bark, because of its tannin content, is used in tanning and dyeing. It is so thick that it is popular for carving amulets, statuettes, cigarette holders, and various ornamental objects.

Roots: Potable water can be derived from the roots in emergency.

Nectar: The flowers are worked intensively by honeybees early in the morning.

Medicinal Uses: The fruit juice is drunk as a diuretic and febrifuge. The decoction of the astringent bark serves as an emetic, a remedy for diarrhea, dysentery, hemorrhoids and a treatment for gonorrhea and leucorrhea; and, in Mexico, it is believed to expel calcifications from the bladder. The powdered bark is applied on wounds. A tea of the flowers and leaves is taken to relieve stomachache, biliousness, urethritis, cystitis and eye and throat inflammation. In Belize, a decoction of the young leaves is a remedy for diarrhea and dysentery. The juice of crushed leaves and the powder of dried leaves are used as poultices on wounds and inflammations. The gum is employed as an expectorant and to expel tapeworms.

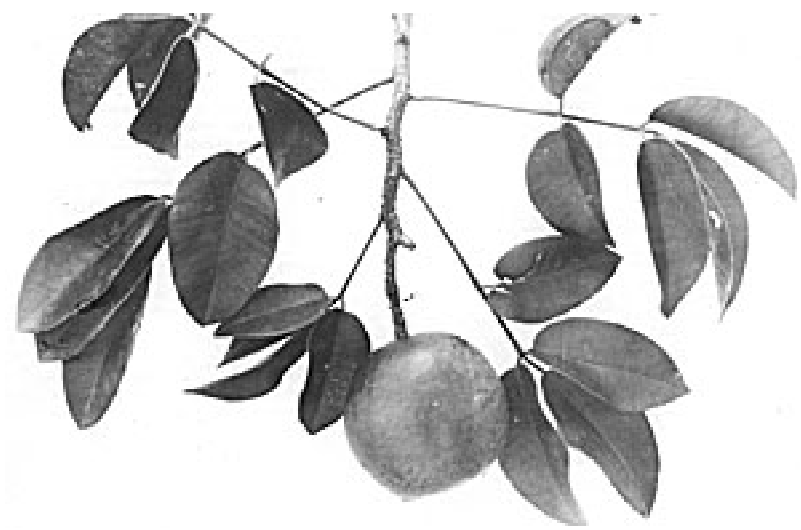


Fig. 71: The imbu. *(Spondias tuberosa)* of northeastern Brazil is an appreciated wild source of juice in that semi-arid land. Photo'd by the plant explorer, P.H. Dorsett in 1914, for the U.S. Dept. of Agriculture.

Related Species

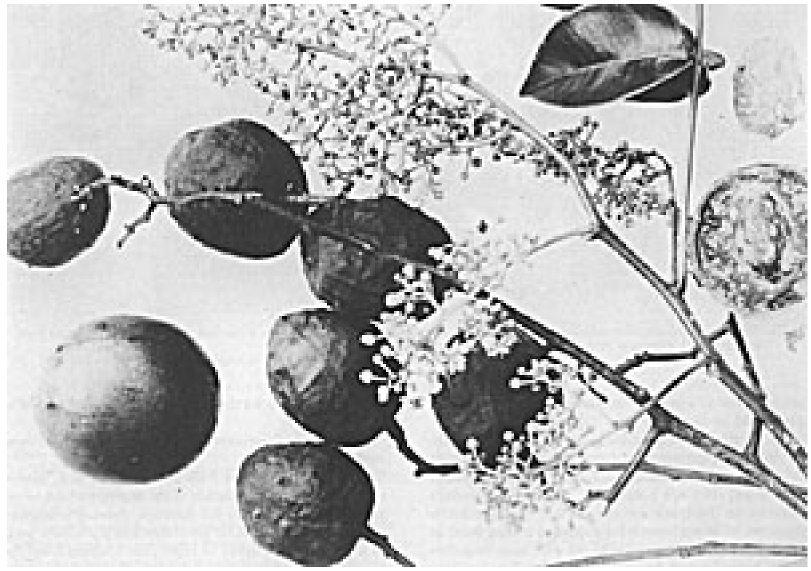


Fig. 72: The imbu *(Spondias tuberosa)* from The Navel Orange of Bahia, with notes on some little-known Brazilian fruits, by P.H. Dorsett, A.D. Shamel and W. Popenoe. Bull. 445, Bureau of Plant Industry, U.S. Department of Agriculture, Washington, D.C. 1917.

The imbu, or umbu, *S. tuberosa* Arruda, is a low-branching tree to 13 or 16 ft (4-5 m) high, spreading to a width of 30 ft (9 m). It has a shallow system of soft, tuberous roots called *cunca*, which store much water. The pinnate leaves have 5 to 9 oblong-ovate leaflets, 1 to 1 3/4 in (2.5-4.5 cm) long, sometimes faintly toothed. Flowers, small, white and 4- to 5-petalled, are produced in panicles 4 to 6 in (10-15 cm) in length. The fruit, borne in great abundance, exhibits minor seedling variations; is usually more or less oval, 1 1/2 in (4 cm) long, with greenish-yellow, fairly thick, tough skin and tender, melting pulp, acid unripe, sweet when ripe, and adherent to the single stone, 3/4 in (2 cm) long.

The tree thrives in very dry soil, gravelly loam, sandy or partly clay, throughout much of subtropical, semi-arid northeastern Brazil. It is rarely cultivated. It is a much-appreciated, bountiful, wild food resource of rural people. The fruits are gathered from the ground and sold in village markets. They are eaten out-of-hand, or the juice is blended with boiled milk and sugar, or made into ice cream or jelly. The roots have been consumed in emergency and they readily yield potable water.

Introductions into Florida and Malaya have been unsuccessful.

Morton, J. 1987. Lychee. p. 249–259. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Lychee

Litchi chinensis Sonn.

Nephelium litchi Cambess

The lychee is the most renowned of a group of edible fruits of the soapberry family, Sapindaceae. It is botanically designated *Litchi chinensis* Sonn. *(Nephelium litchi* Cambess) and widely known as litchi and regionally as *lichi*, *lichee*, *laichi*, *leechee* or lychee. Professor G. Weidman Groff, an influential authority of the recent past, urged the adoption of the latter as approximating the pronunciation of the local name in Canton, China, the leading center of lychee production. I am giving it preference here because the spelling best indicates the desired pronunciation and helps to standardize English usage. Spanish and Portuguese-speaking people call the fruit *lechia;* the French, *litchi*, or, in French-speaking Haiti, *quenepe chinois*, distinguishing it from the *quenepe*, *genip* or mamoncillo of the West Indies, *Melicoccus bijugatus*, q.v. The German word is *litschi.*


Plate XXXII: LYCHEE, *Litchi chinensis*

Description The lychee tree is handsome, dense, round-topped, slow-growing, 30 to 100 ft (9-30 m) high and equally broad. Its evergreen leaves, 5 to 8 in (12.5-20 cm) long, are pinnate, having 4 to 8 alternate, elliptic-oblong to lanceolate, abruptly pointed, leaflets, somewhat leathery, smooth, glossy, dark-green on the upper surface and grayish-green beneath, and 2 to 3 in (5-7.5 cm) long. The tiny petalless, greenish-white to yellowish flowers are borne in terminal clusters to 30 in (75 cm) long. Showy fruits, in loose, pendent clusters of 2 to 30 are usually strawberry-red, sometimes rose, pinkish or amber, and some types tinged with green. Most are aromatic, oval, heart-shaped or nearly round, about 1 in (2.5 cm) wide and 1 1/2 in (4 cm) long; have a thin, leathery, rough or minutely warty skin, flexible and easily peeled when fresh. Immediately beneath the skin of some varieties is a small amount of clear, delicious juice. The glossy, succulent, thick, translucent-white to grayish or pinkish fleshy aril which usually separates readily from the seed, suggests a large, luscious grape. The flavor of the flesh is subacid and distinctive. There is much variation in the size and form of the seed. Normally, it is oblong, up to 3/4 in (20 mm) long, hard, with a shiny, dark-brown coat and is white internally. Through faulty pollination, many fruits have shrunken, only partially developed seeds (called "chicken tongue") and such fruits are prized because of the greater proportion of flesh. In a few days, the fruit naturally dehydrates, the skin turns brown and brittle and the flesh becomes dry, shriveled, dark-brown and raisin-like, richer and somewhat musky in flavor. Because of the firmness of the shell of the dried fruits, they came to be nicknamed "lychee, or litchi, nuts" by the uninitiated and this erroneous name has led to much misunderstanding of the nature of this highly desirable fruit. It is definitely not a "nut", and the seed is inedible.

Origin and Distribution

The lychee is native to low elevations of the provinces of Kwangtung and Fukien in southern China, where it flourishes especially along rivers and near the seacoast. It has a long and illustrious history having been praised and pictured in Chinese literature from the earliest known record in 1059 A.D. Cultivation spread over the years through neighboring areas of southeastern Asia and offshore islands. Late in the 17th Century, it was carried to Burma and, 100 years later, to India. It arrived in the West Indies in 1775, was being planted in greenhouses in England and France early in the 19th Century, and Europeans took it to the East Indies. It reached Hawaii in 1873, and Florida in 1883, and was conveyed from Florida to California in 1897. It first fruited at Santa Barbara in 1914. In the 1920's, China's annual crop was 30 million lbs (13.6 million kg). In 1937 (before WW II) the crop of Fukien Province alone was over 35 million lbs (16 million kg). In time, India became second to China in lychee production, total plantings covering about 30,000 acres (12,500 ha). There are also extensive plantings in Pakistan, Bangladesh, Burma, former Indochina, Taiwan, Japan, the Philippines, Queensland, Madagascar, Brazil and South Africa. Lychees are grown mostly in dooryards from northern Queensland to New South Wales, but commercial orchards have been established in the past 20 years, some consisting of 5,000 trees.

Madagascar began experimental refrigerated shipments of lychees to France in 1960. It is recorded that there were 2 trees about 6 years old in Natal, South Africa, in 1875. Others were introduced from Mauritius in 1876. Layers from these latter trees were distributed by the Durban Botanical Gardens and lychee-growing expanded steadily until in 1947 there were 5,000 bearing trees on one estate and 5,000 newly planted on another property, a total of 40,000 in all.

In Hawaii, there are many dooryard trees but commercial plantings are small. The fruit appears on local markets and small quantities are exported to the mainland but the lychee is too undependable to be classed as a crop of serious economic potential there. Rather, it is regarded as a combination ornamental and fruit tree.

There are only a few scattered trees in the West Indies and Central America apart from some groves in Cuba, Honduras and Guatemala. In California, the lychee will grow and fruit only in protected locations and the climate is generally too dry for it. There are a few very old trees and one small commercial grove. In the early 1960's, interest in this crop was renewed and some new plantings were being made on irrigated land.

At first it was believed that the lychee was not well suited to Florida because of the lack of winter dormancy, exposing successive flushes of tender new growth to the occasional periods of low temperature from December to March. The earliest plantings at Sanford and Oviedo were killed by severe freezes. A step forward came with the importation of young lychee trees from Fukien, China, by the Rev. W.M. Brewster between 1903 and 1906. This cultivar, the centuries-old 'Chen-Tze' or 'Royal Chen Purple', renamed 'Brewster' in Florida, from the northern limit of the lychee-growing area in China, withstands light frost and proved to be very successful in the Lake Placid area–the "Ridge" section of Central Florida.

Layered trees were available from Reasoner's Royal Palm Nurseries in the early 1920's, and the Reasoner's and the U.S. Department of Agriculture made many new introductions for trial. But there were no large plantings until an improved method of propagation was developed by Col. William R. Grove who became acquainted with the lychee during military service in the Orient, retired from the Army, made his home at Laurel (14 miles south of Sarasota, Florida) and was encouraged by knowledgeable Prof. G. Weidman Groff, who had spent 20 years at Canton Christian College. Col. Grove made arrangements to air-layer hundreds of branches on some of the old, flourishing 'Brewster' trees in Sebring and Babson Park and thus acquired the stock to establish his lychee grove. He planted the first tree in 1938, and by 1940 was selling lychee plants and promoting the lychee as a commercial crop. Many small orchards were planted from Merritt's Island to Homestead and the Florida Lychee Growers' Association was founded in 1952, especially to organize cooperative marketing. The spelling "lychee" was officially adopted by the association upon the strong recommendation of Professor Groff.

In 1960, over 6,000 lbs (2,720 kg) were shipped to New York, 4,000 lbs (1,814 kg) to California, nearly 6,000 lbs (2,720 kg) to Canada, and 3,900 lbs (1, 769 kg) were consumed in Florida, though this was far from a record year. The commercial lychee crop in Florida has fluctuated with weather conditions, being affected not only by freezes but also by drought and strong winds. Production was greatly reduced in 1959, to a lesser extent in 1963, fell drastically in 1965, reached a high of 50,770 lbs (22,727 kg) in 1970, and a low of 7,200 lbs (3,273 kg) in 1974. Some growers lost up to 70% of their crop because of severe cold in the winter of 1979-80. Of course, there are many bearing trees in home gardens that are not represented in production figures. The fruit from these trees may be merely for household consumption or may be purchased at the site by Chinese grocers or restaurant operators, or sold at roadside stands.

Though the Florida lychee industry is small, mainly because of weather hazards, irregular bearing and labor of hand-harvesting, it has attracted much attention to the crop and has contributed to the dissemination of planting material to other areas of the Western Hemisphere. Escalating land values will probably limit the expansion of lychee plantings in this rapidly developing state. Another limiting factor is that much land suitable for lychee culture is already devoted to citrus groves.

Varieties

Professor Groff, in his book, *The lychee and the lungan,* tells us that the production of superior types of lychee is a matter of great family pride and local rivalry in China, where the fruit is esteemed as no other. In 1492, a list of 40 lychee varieties, mostly named for families, was published in the *Annals of Fukien.* In the Kwang provinces there were 22 types, 30 were listed in the Annals of Kwangtung, and 70 were tallied as varieties of Ling Nam. The Chinese claim that the lychee is highly variable under different cultural and soil conditions. Professor Groff concluded that one could catalog 40 or 50 varieties as recognized in Kwangtung, but there were only 15 distinct, widely-known and commercial varieties grown in that province, half of them marketed in season in the City of Canton. Some of these are classed as "mountain" types; the majority are "water types" (grown in low, well-irrigated land). There is a special distinction between the kinds of lychee that leak juice when the skin is broken and those that retain the juice within the flesh. The latter are called "dry- and -clean" and are highly prized. There is much variation in form (round, egg-shaped or heart-shaped), skin color and texture, the fragrance and flavor and even the color, of the flesh; and the amount of "rag" in the seed cavity; and, of prime importance, the size and form of the seed.

The following are the 15 cultivars recognized by Professor Groff:

'No Mai Tsze', or 'No mi ts 'z' (glutinous rice) is the leading variety in China; large, red, "dry-and-clean"; seeds often small and shriveled. It is one of the best for drying, and is late in season. It does best when grafted onto the 'Mountain' lychee.

'Kwa Iuk' or 'Kua lu' (hanging green) is a famous lychee; large, red with a green tip and a typical green line; "dry-and-clean"; of outstanding flavor and fragrance. It was, in olden times, a special fruit for presentation to high officials and other persons in positions of honor. Professor Groff was given a single fruit in a little red box!

'Kwai mi' or 'Kuei Wei', (cinnamon flavor) which came to be called 'Mauritius' is smaller, heart-shaped, with rough red skin tinged with green on the shoulders and usually having a thin line running around the fruit. The seed is small and the flesh very sweet and fragrant. The branches of the tree curve upward at the tips and the leaflets curl inward from the midrib.

'Hsiang li', or 'Heung lai' (fragrant lychee) is home by a tree with distinctive erect habit having upward-pointing leaves. The fruit is small, very rough and prickly, deep-red, with the smallest seeds of all, and the flesh is of superior flavor and fragrance. It is late in season. Those grown in Sin Hsing are better than those grown in other locations.

'Hsi Chio tsu', or 'Sai kok tsz' (rhinoceros horn) is borne by a large-growing tree. The fruit is large, rough, broad at the base and narrow at the apex; has somewhat tough and fibrous, but fragrant, sweet, flesh. It ripens early.

'Hak ip', or 'Hei yeh', (black leaf) is borne by a densely-branched tree with large, pointed, slightly curled, dark-green leaflets. The fruit is medium-red, sometimes with green tinges, broad-shouldered, with thin, soft skin and the flesh, occasionally pinkish, is crisp and sweet. This is rated as "one of the best 'water' lychees."

'Fei tsu hsiao', or 'Fi tsz siu' (imperial concubine's laugh, or smile) is large, amber-colored, thin-skinned, with very sweet, very fragrant flesh. Seeds vary from large to very small. It ripens early.

'T' ang po', or 'T' ong pok' (pond embankment) is from a small-leaved tree. The fruit is small, red, rough, with thin, juicy acid flesh and very little rag. It is a very early variety.

'Sheung shu wai' or'Shang hou huai', (President of a Board's embrace) is borne on a small-leaved tree. The fruit is large, rounded, red, with many dark spots. It has sweet flesh with little scent and the seed size is variable. It is rather late in season.

'Ch'u ma lsu', or 'Chu ma lsz' (China grass fiber) has distinctive, lush foliage. The leaves are large, overlapping, with long petioles. The fruits are large with prominent shoulders and rough skin, deep red inside. While very fragrant, the flesh is of inferior flavor and clings to the seed which varies from large to small.

'Ta tsao', or 'Tai tso' (large crop) is widely grown around Canton; somewhat egg-shaped; skin rough, bright-red with many small, dense dots; flesh firm, crisp, sweet, faintly streaked with yellow near the large seed. The juice leaks when the skin is broken. The fruit ripens early.

'Huai chih', or 'Wai chi' (the Wai River lychee) has medium-sized, blunt leaves. The fruit is round with medium-smooth skin, a rich red outside, pink inside; and leaking juice. This is not a high class variety but the most commonly grown, high yielding, and late in season.

'San yueh hung', or 'Sam ut hung' (third month red), also called 'Ma yuen', 'Ma un', 'Tsao kuo', 'Tso kwo', 'Tsao li', or 'Tsoli' (early lychee) is grown along dykes. The branches are brittle and break readily; the leaves are long, pointed, and thick. The fruit is very large, with red, thick, tough skin and thick, medium-sweet flesh with much rag. The seeds are long but aborted. This variety is popular mainly because it comes into season very early.

'Pai la li chih', or 'Pak lap lai chi' (white wax lychee), also called 'Po le tzu', or 'Pak lik tsz (white fragrant plant), is large, pink, rough, with pinkish, fibrous, not very sweet flesh and large seeds. It ripens very late, after 'Huai chih'.

'Shan chi', or 'Shan chih' (mountain lychee), also called 'Suan chih', or 'Sun chi' (sour lychee) grows wild in the hills and is often planted as a rootstock for better varieties. The tree is of erect habit with erect twigs and large, pointed, short-petioled leaves. The fruit is bright-red, elongated, very rough, with thin flesh, acid flavor and large seed.

'T'im ngam', or 'T'ien yeh' (sweet cliff) is a common variety of lychee which Professor Groff reported to be quite widely grown in Kwantung, but not really on a commercial basis.

In his book, *The Litchi,* Dr. Lal Behari Singh wrote that Bihar is the center of lychee culture in India, producing 33 selected varieties classified into 15 groups. His extremely detailed descriptions of the 10 cultivars recommended for large-scale cultivation I have abbreviated (with a few bracketed additions from other sources):

'Early Seedless', or 'Early Bedana'. Fruit 1 1/3 in (3.4 cm) long, heart-shaped to oval; rough, red, with green interspaces; skin firm and leathery; flesh [ivory] to white, soft, sweet; seed shrunken, like a dog's tooth. Of good quality. The tree bears a moderate crop, early in season.

'Rose-scented'. Fruit 1 1/4 in (3.2 cm) long; rounded-heart-shaped; slightly rough, purplish-rose, slightly firm skin; flesh gray-white, soft, very sweet. Seed round-ovate, fully developed. Of good quality. [Tree bears a moderate crop] in midseason.

'Early Large Red'. Fruit slightly more than 1 1/3 in (3.4 cm) long, usually obliquely heart-shaped; crimson [to carmine], with green interspaces; very rough; skin very firm and leathery, adhering slightly to the flesh. Flesh grayish-white, firm, sweet and flavorful. Of very good quality. [Tree is a moderate bearer], early in season.

'Dehra Dun', [or 'Dehra Dhun']. Fruit less than 1 1/2 in (4 cm) long; obliquely heart-shaped to conical; a blend of red and orange-red; skin rough, leathery; flesh gray-white, soft, of good, sweet flavor. Seed often shrunken, occasionally very small. Of good quality; midseason. [This is grown extensively in Uttar Pradesh and is the most satisfactory lychee in Pakistan.]

'Late Long Red', or 'Muzaffarpur'. Fruit less than 1 1/2 in (4 cm) long; usually oblong-conical; dark-red with greenish interspaces; skin rough, firm and leathery, slightly adhering to the flesh; flesh grayish-white, soft, of good, sweet flavor. Seed cylindrical, fully developed. Of good quality. [Tree is a heavy bearer], late in season.

'Pyazi'. Fruit 1 1/3 in (3.4 cm) long; oblong-conical to heart-shaped; a blend of orange and orange-red, with yellowish-red, not very prominent, tubercles. Skin leathery, adhering; flesh gray-white, firm, slightly sweet, with flavor reminiscent of "boiled onion". Seed cylindrical, fully developed. Of poor quality. Early in season.

'Extra Early Green'. Fruit 1 1/4 in (3.2 cm) long; mostly heart-shaped, rarely rounded or oblong; yellowish-red with green interspaces; skin slightly rough, leathery, slightly adhering; flesh creamy-white, [firm, of good, slightly acid flavor]; seed oblong, cylindrical or flat. Of indifferent quality. Very early in season.

'Kalkattia', ['Calcuttia', or 'Calcutta']. Fruit 1 1/2 in (4 cm) long; oblong or lopsided; rose-red with darker tubercles; skin very rough, leathery, slightly adhering; flesh grayish ivory, firm, of very sweet, good flavor. Seed oblong or concave. Of very good quality. [A heavy bearer; withstands hot winds]. Very late in season.

'Gulabi'. Fruit 1 1/3 in (3.4 cm) long; heart-shaped, oval or oblong; pink-red to carmine with orange-red tubercles; skin very rough, leathery, non-adherent; flesh gray-white, firm, of good subacid flavor; seed oblong-cylindrical, fully developed. Of very good quality. Late in season.

'Late Seedless', or 'Late Bedana'. Fruit less than 1 3/8 in (3.65 cm) long; mainly conical, rarely ovate; orange-red to carmine with blackish-brown tubercles; skin rough, firm, non-adherent; flesh creamy-white, soft; very sweet, of very good flavor except for slight bitterness near the seed. Seed slightly spindle-shaped, or like a dog's tooth; underdeveloped. Of very good quality. [Tree bears heavily. Withstands hot winds.] Late in season.

There are numerous lychee orchards in the submontane region of the Punjab. The leading variety is:

'Panjore common'. Fruit is large, heart-shaped, deep-orange to pink; skin is rough, very thin, apt to split. Tree bears heavily and has the longest fruiting season-for an entire month beginning near the end of May. Six other varieties commonly grown there are: 'Rose-scented', 'Bhadwari', 'Seedless No. 1', 'Seedless No. 2', 'Dehra Dun', and 'Kalkattia'.

In South Africa, only one variety is produced commercially. It is the 'Kwai Mi' but it is locally called 'Mauritius' because nearly all of the trees are descendants of those brought in from that island. In South Africa, the fruit is of medium size, nearly round but slightly oval, reddish-brown. Flesh is firm, of good quality and usually contains a medium-sized seed, but certain fruits with broad, flat shoulders and shortened form tend to have "chicken-tongue" seeds.

There have been many other introductions into South Africa from China and India but most failed to survive. In 1928, 16 varieties from India were planted at Lowe's Orchards, Southport, Natal, but the records were lost and they remained unnamed. A Litchi Variety Orchard of 26 cultivars from India, China, Taiwan and elsewhere was established at the Subtropical Horticulture Research Station in Nelspruit. Tentative classifications grouped these into 3 distinct types–'Kwai Mi' ['Mauritius'], 'Hak Ip' (of high quality and small seed but a shy bearer in the Low-veld), and the 'Madras', a heavy bearer of choice fruits, bright-red, very rough, and with large seeds, but very sweet, luscious flesh.

The first lychee introduced into Hawaii was the 'Kwai Mi', as was the second introduction several years later. The high quality of this variety (sometimes locally called 'Charlie Long') caused the lychee to become extremely popular and widely planted. The Hawaiian Agricultural Experiment Station imported 3 'Brewster' trees in 1907, and various efforts were made to bring other types from China but not all survived. A total of 16 varieties became well established in Hawaii, including 'Hak Ip' which has become second to 'Kwai Mi' in importance.

In 1942, the Agricultural Experiment Station set out a collection of 500 seedlings of 'Kwai Mi', 'Hak Ip' and 'Brewster' with a view to selecting the trees showing the best performance. One tree of outstanding character (a seedling of 'Hak Ip') was first designated H.A.E.S. Selection 1-18-3 and was given the name 'Groff' in 1953. It is a consistent bearer, late in season. The fruit is of medium size, dark rose-red with green or yellowish tinges on the apex of each tubercle. The flesh is white and firm; there is no leaking juice; the flavor is excellent, sweet and subacid; most of the fruits have abortive, "chicken-tongue" seeds and, accordingly have 20% more flesh than if the seeds were fully developed.

'No Mai Tsze' has been growing in Hawaii for over 40 years but has produced very few fruits. 'Pat Po Heung' (eight precious fragrances), erroneously called 'Pat Po Hung' (eight precious red), somewhat resembles 'No Mai Tsze' but is smaller; the skin is purplish-red, thin and pliable; the juice leaks when the skin is broken; the flesh is soft, juicy, sweet even when slightly unripe; the seed varies from medium to large. The tree is slow-growing and of weak, spreading habit; it bears well in Hawaii. Nevertheless, it is not commonly planted.

'Kaimana', or 'Poamoho', an open-pollinated seedling of 'Hak Ip', developed by Dr. R.A. Hamilton at the Poamoho Experiment Station of the University of Hawaii, was released in 1982. The fruit resembled 'Kwai Mi' but is twice as large, deep-red, of high quality, and the tree is a regular bearer.

'Brewster' is large, conical or wedge-shaped, red, with soft flesh, more acid than that of 'Kwai mi', and the seeds are very often fully formed and large. The leaflets are flat with slightly recurved margins and taper to a sharp point.

There were many other introductions of seeds, seedlings, cuttings or air-layers into the United States, from 1902 to 1924, mostly from China; also from India and Hawaii, and a few from Java, Cuba, and Trinidad; and these were distributed to experimenters in Florida and California, and some to botanical gardens in other states, and to Cuba, Puerto Rico, Panama, Honduras, Costa Rica and Brazil. Many were killed by cold weather in California and Florida.

In 1908, the United States Department of Agriculture brought in 27 plants of 'Kwai mi'. At the same time, 20 plants of 'Hak Ip' were imported and these were sent to George B. Cellon in Miami in 1918. A tree of the 'Bedana' was introduced from India in 1913. In 1920, Professor Groff obtained seedlings of 'Shan Chi' (mountain lychee) from Kwantung Province, together with air-layers of 'Sheung shu wai', 'No mai ts 'z', and 'T' im ngam' (sweet cliff). The latter was found to bear more regularly than 'Brewster' but exhibited nutritional deficiencies in limestone soil.

Most of the various plants and rooted cuttings from them were distributed for trial; the rest were kept in U.S. Department of Agriculture greenhouses in Maryland.

'Bengal'–In 1929, the U.S. Department of Agriculture received a small lychee plant, supposedly a seedling of 'Rose-scented', from Calcutta. It was planted at the Plant Introduction Station in Miami and began bearing in 1940. The fruits resembled 'Brewster' but were more elongated, were home in large clusters, and the flesh was firm, not leaking juice when peeled. All the fruits had fully developed seeds but smaller in proportion to flesh than those of 'Brewster'. The habit of the tree is more spreading than that of 'Brewster'; it has larger, more leathery, darker green leave's, and the bark is smoother and paler. The original tree and its air-layered progeny have shown no chlorosis on limestone in contrast to 'Brewster' trees growing nearby.

'Peerless', believed to be a seedling of 'Brewster', originated at the Royal Palm Nursery at Oneco; was transplanted to the T.R. Palmer Estate in Belleair where C.E. Ware noticed from 1936 to 1938 that it bore fruit of larger size, brighter color and higher percentage of abortive seed than 'Brewster'. In 1938, Ware air-layered and removed 200 branches, purchased the tree and moved it to his property in Clearwater. It resumed fruiting in 1940 and annual crops recorded to 1956 showed good productivity-averaging 383.4 lbs (174 kg) per year, and the rate of abortive seeds ranged from 62% to 85%. The 200 air-layers were planted out by Ware in 1942 and began bearing in 1946. Most of the fruits had fully developed seeds but the rate of abortive seeds increased year by year and in 1950 was 61% to 70%. The cultivar was named with the approval of the Florida Lychee Growers Association. Two seedling selections by Col. Grove, 'Yellow Red' and 'Late Globe', Prof. Groff believed to be natural hybrids of 'Brewster' ´ 'Mountain'.

In northern Queensland, 'Kwai Mi' is the earliest cultivar grown, and about 10% of the fruits have "chicken tongue" seeds. 'Brewster' bears in mid-season and is important though the seed is nearly always fully formed and large. 'Hak Ip' is also midseason and large-seeded there. 'Bedana' is grown only in home gardens and the fruits have large seeds unlike the usual "chicken tongue" seeds of the fruits of this cultivar borne in India i

'Wai Chi' is late in season (December), has small, round fruits, basically yellow overlaid with red; the seed is small and oval. The tree is very compact with upright branches, and prefers a cooler climate than that of coastal north Queensland where it does not fruit heavily. The leaflets are concave like those of 'Kwai Mi'.

A very similar, perhaps identical, cultivar called 'Hong Kong' is grown in South Queensland. 'No Mai' bears poorly in Queensland and seems better adapted to cooler areas.

Blooming and Pollination

There are 3 types of flowers appearing in irregular sequence or, at times, simultaneously, in the lychee inflorescence: a) male; b) hermaphrodite, fruiting as female (about 30% of the total); c) hermaphrodite fruiting as male. The latter tend to possess the most viable pollen. Many of the flowers have defective pollen and this fact probably is the main cause of the abortive seeds and also the common problem of shedding of young fruits. The flowers require transfer of pollen by insects.

In India, L.B. Singh recorded 11 species of bees, flies, wasps and other insects as visiting lychee flowers for nectar. But honeybees, mostly *Apis cerana indica*, *A. dorsata* and *A. florea*, constitute 78% of the lychee-pollinating insects and they work the flowers for pollen and nectar from sunrise to sundown. *A. cerana* is the only hive bee and is essential in commercial orchards for maximum fruit production.

A 6-week survey in Florida revealed 27 species of lychee-flower visitors, representing 6 different insect Orders. Most abundant, morning and afternoon, was the secondary screw-worm fly *(Callitroga macellaria)*, an undesirable pest. Next was the imported honeybee *(Apis mellifera)* seeking nectar daily but only during the morning and apparently not interested in the pollen. No wild bees were seen on the lychee flowers, though wild bees were found in large numbers collecting pollen in an adjacent fruit-tree planting a few weeks later. Third in order, but not abundant, was the soldier beetle *(Chauliognathus marginatus)*. The rest of the insect visitors were present only in insignificant number. Maintenance of bee hives in Florida lychee groves is necessary to enhance fruit set and development. The fruits mature 2 months after flowering.

In India and Hawaii, there has been some interest in possible cross-breeding of the lychee and pollen storage tests have been conducted. Lychee pollen has remained viable at room temperature for 10 to 30 days in petri dishes; for 3 to 5 months in desiccators; 15 months at 32° F (0° C) and 25% relative humidity in desiccators; and 31 months under deep-freeze, -9.4° F (-23° C). There is considerable variation in the germination rates of pollen from different cultivars. In India, 'Rose Scented' has shown mean viability of 61.99% compared with 42.52% in 'Khattl'.

Climate

Groff provided a clear view of the climatic requirements of the lychee. He said that it thrives best in regions "not subject to heavy frost but cool and dry enough in the winter months to provide a period of rest." In China and India, it is grown between 15° and 30° N. "The Canton delta ... is crossed by the Tropic of Cancer and is a subtropical area of considerable range in climate. Great fluctuations of temperature are common throughout the fall and winter months. In the winter sudden rises of temperature will at times cause the lychee ... to flush forth ... new growth. This new growth is seldom subject to a freeze about Canton. On the higher elevations of the mountain regions which are subject to frost the lychee is seldom grown . . . The more hardy mountainous types of the lychee are very sour and those grown near salt water are said to be likewise. The lychee thrives best on the lower plains where the summer months are hot and wet and the winter months are dry and cool."

Heavy frosts will kill young trees but mature trees can withstand light frosts. Cold tolerance of the lychee is intermediate between that of the sweet orange on one hand and mango and avocado on the other. Location, land slope, and proximity to bodies of water can make a great difference in degree of damage by freezing weather. In the severe low temperature crisis during the winter of 1957-58, the effects ranged from minimal to total throughout central and southern Florida. A grove of 12-to 14-year-old trees south of Sanford was killed back nearly to the ground; on Merritt Island trees of the same age were virtually undamaged, while a commercial mango planting was totally destroyed. L.B. Singh resists the common belief that the lychee needs winter cold spells that provide periods of temperature between 30° and 40° F (-1.11° and 4.44° C) because it does well in Mauritius where the temperature is never below 40° F (-1.11° C). However, lychee trees in Panama, Jamaica, and other tropical areas set fruit only occasionally or not at all.

Heavy rain or fog during the flowering period is detrimental, as are hot, dry, strong winds which cause shedding of flowers, also splitting of the fruit skin. Splitting occurs, too, during spells of alternating rain and hot, dry periods, especially on the sunny side of the tree. Spraying with Ethephon at 10 ppm reduced splitting in 'Early Large Red' in experiments in Nepal.

Soil

The lychee grows well on a wide range of soils. In China it is cultivated in sandy or clayey loam, "river mud", moist sandy clay, and even heavy clay. The pH should be between 6 and 7. If the soil is deficient in lime, this must be added. However, in an early experiment in a greenhouse in Washington, D.C., seedlings planted in acid soil showed superior growth and the roots had many nodules filled with mycorrhizal fungi. This caused some to speculate that inoculation might be desirable. Later, in Florida, profuse nodulation was observed on roots of lychee seedlings that had not been inoculated but merely grown in pots of sphagnum moss and given a well-balanced nutrient solution.

The lychee attains maximum growth and productivity on deep alluvial loam but flourishes in extreme southern Florida on oolitic limestone providing it is put in an adequate hole and irrigated in dry seasons.

The Chinese often plant the lychee on the banks of ponds and streams. In low, wet land, they dig ditches 10 to 15 ft (3-4.5 m) wide and 30 to 40 ft (9-12 m) apart, using the excavated soil to form raised beds on which they plant lychee trees, so that they have perfect drainage but the soil is always moist. Though the lychee has a high water requirement, it cannot stand water-logging. The water table should be at least 4 to 6 ft (1.2-1.8 m) below the surface and the underground water should be moving inasmuch as stagnant water induces root rot. The lychee can stand occasionally brief flooding better than citrus. It will not thrive under saline conditions.

Propagation

Lychees do not reproduce faithfully from seed, and the choicest have abortive, not viable, seed. Furthermore, lychee seeds remain viable only 4 to 5 days, and seedling trees will not bear until they are 5 to 12, or even 25, years old. For these reasons, seeds are planted mostly for selection and breeding purposes or for rootstock.

Attempts to grow the lychee from cuttings have been generally discouraging, though 80% success has been claimed with spring cuttings in full sun, under constant mist and given weekly liquid nutrients. Ground-layering has been practiced to some extent. In China, air-layering (marcotting, or gootee) is the most popular means of propagation and has been practiced for ages. By their method, a branch of a chosen tree is girdled, allowed to callus for 1 to 2 days and then is enclosed in a ball of sticky mud mixed with chopped straw or dry leaves and wrapped with burlap. With frequent watering, roots develop in the mud and, in about 100 days, the branch is cut off, the ball of earth is increased to about 12 in (30 cm) in width, and the air-layer is kept in a sheltered nursery for a little over a year, then gradually exposed to full sun before it is set out in the orchard. Some air-layers are planted in large clay pots and grown as ornamentals.

The Chinese method of air-layering has many variations. In fact, 92 modifications have been recorded and experimented with in Hawaii. Inarching is also an ancient custom, selected cultivars being joined to 'Mountain' lychee rootstock.

In order to make air-layering less labor-intensive, to eliminate the watering, and also to produce portable, shippable layers, Colonel Grove, after much experimentation, developed the technique of packing the girdle with wet sphagnum moss and soil, wrapping it in moisture-proof clear plastic that permits exchange of air and gasses, and tightly securing it above and below. In about 6 weeks, sufficient roots are formed to permit detaching of the layer, removal of the plastic wrap, and planting in soil in nursery containers. It is possible to air-layer branches up to 4 in (10 cm) thick, and to take 200 to 300 layers from a large tree.

Studies in Mexico have led to the conclusion that, for maximum root formation, branches to be air-layered should not be less than 5/8 in (15 mm) in diameter, and, to avoid undue defoliation of the parent tree, should not exceed 3/4 in (20 mm). The branches, of any age, around the periphery of the canopy and exposed to the sun, make better air-layers with greater root development than branches taken from shaded positions on the tree. The application of growth regulators, at various rates, has shown no significant effect on root development in the Mexican experiments. In India, certain of the various auxins tried stimulated root formation, forced early maturity of the layers, but contributed to high mortality. South African horticulturists believe that tying the branch up so that it is nearly vertical induces vigorous rooting.

The new trees, with about half of the top trimmed off and supported by stakes, are kept in a shadehouse for 6 weeks before setting out. Improvements in Colonel Grove's system later included the use of constant mist in the shadehouse. Also, it was found that birds pecked at the young roots showing through the transparent wrapping, made holes in the plastic and caused dehydration. It became necessary to shield the air-layers with a cylinder of newspaper or aluminum foil. As time went on, some people switched to foil in place of plastic for wrapping the air-layers.

The air-layered trees will fruit in 2 to 5 years after planting, Professor Groff said that a lychee tree is not in its prime until it is 20 to 40 years old; will continue bearing a good crop for 100 years or longer. One disadvantage of air-layering is that the resultant trees have weak root systems. In China, a crude method of cleft-grafting has long been employed for special purposes, but, generally speaking, the lychee has been considered very difficult to graft. Bark, tongue, cleft, and side-veneer grafting, also chip-and shield-budding, have been tried by various experimenters in Florida, Hawaii, South Africa and elsewhere with varing degrees of success. The lychee is peculiar in that the entire cambium is active only during the earliest phases of secondary growth. The use of very young rootstocks, only 1/4 in (6 mm) in diameter and wrapping the union with strips of vinyl plastic film, have given good results. A 70% success rate has been achieved in splice-grafting in South Africa. Hardened-off, not terminal, wood of young branches 1/4 in (6 mm) thick is first ringed and the bark-ring removed. After a delay of 21 days, the branch is cut off at the ring, defoliated but leaving the base of each petiole, then a slanting cut is made in the rootstock 1 ft (30 cm) above the soil, at the point where it matches the thickness of the graftwood (scion), and retaining as many leaves as possible. The cut is trimmed to a perfectly smooth surface 1 in (2.5 cm) long; the scion is then trimmed to 4 in (10 cm) long, making a slanting cut to match that on the rootstock. The scion should have 2 slightly swollen buds. After joining the scion and the rootstock, the union is wrapped with plastic grafting tape and the scion is completely covered with grafting strips to prevent dehydration. In 6 weeks the buds begin to swell, and the plastic is slit just above the bud to permit sprouting. When the new growth has hardened off, all the grafting tape is removed. The grafting is performed in a moist, warm atmosphere. The grafted plants are maintained in containers for 2 years or more before planting out, and they develop strong taproots.

In India, a more recent development is propagation by stooling, which has been found "simpler, quicker and more economical" there than air-layering. First, air-layers from superior trees are planted 4 ft (1.2 m) apart in "stool beds" where enriched holes have been prepared and left open for 2 weeks. Fertilizer is applied when planting (at the beginning of September) and the air-layers are well established by mid-October and putting out new flushes of growth in November. Fertilizer is applied again in February-March and June-July. Shallow cultivation is performed to keep the plot weed-free. At the end of 2 1/2 years, in mid-February, the plants are cut back to 10 in (25 cm) from the ground. New shoots from the trunk are allowed to grow for 4 months. In mid-June, a ring of bark is removed from all shoots except one on each plant and lanolin paste containing IBA (2,500 ppm) is applied to the upper portion of the ringed area. Ten days later, earth is heaped up to cover 4 to 6 in (10-15 cm) of the stem above the ring. This causes the shoots to root profusely in 2 months. The rooted shoots are separated from the plant and are immediately planted in nursery beds or pots. Those which do not wilt in 3 weeks are judged suitable for setting out in the field. The earth around the parent plants is leveled and the process of fertilization, cultivation, ringing and earthing-up and harvesting of stools is repeated over and over for years until the parent plants have lost their vitality. It is reported that the transplanted shoots have a survival rate of 81-82% as compared with 40% to 50% in air-layers.

Culture

Spacing: For a permanent orchard, the trees are best spaced 40 ft (12 m) apart each way. In India, a 30 ft spacing is considered adequate, probably because the drier climate limits the overall growth. Portions of the tree shaded by other trees will not bear fruit. For maximum productivity, there must be full exposure to light on all sides.

In the Cook Islands, the trees are planted on a 40 x 20 ft (12 x 6 m) spacing–56 trees per acre (134 per ha)–but in the 15th year, the plantation is thinned to 40 x 40 ft (12 x l2 m).

Wind protection: Young trees benefit greatly by wind protection. This can be provided by placing stakes around each small tree and stretching cloth around them as a windscreen. In very windy locations, the entire plantation may be protected by trees planted as windbreaks but these should not be so close as to shade the lychees. The lychee tree is structurally highly wind-resistant, having withstood typhoons, but shelter may be needed to safeguard the crop. During dry, hot months, lychee trees of any age will benefit from overhead sprinkling; they are seriously retarded by water stress.

Fertilization: Newly planted trees must be watered but not fertilized beyond the enrichment of the hole well in advance of planting. In China, lychee trees are fertilized only twice a year and only organic material is used, principally night soil, sometimes with the addition of soybean or peanut residue after oil extraction, or mud from canals and fish ponds. There is no great emphasis on fertilization in India. It has been established that a harvest of 1,000 lbs (454.5 kg) removes approximately 3 lbs (1,361 g) K_2O, 1 lb (454 g) P2O5, 1 lb (454 g) N, 3/4 lb (340 g) CaO, and 1/2 lb (228 g) MgO from the soil. It is judged, therefore, that applications of potash, phosphate, lime and magnesium should be made to restore these elements.

Fertilizer experiments on fine sand in central Florida have shown that medium rates of N (either sulfate of ammonia or ammonium nitrate), P2O5, K2O, and MgO, together with one application of dolomite limestone at 2 tons/acre (4.8 tons/ha) are beneficial in counteracting chlorosis and promoting growth, flowering and fruit-set and reducing early fruit shedding. Excessive use of nitrogen suppresses growth and interferes with the uptake of other nutrients. If vegetative dormancy is to be encouraged in bearing trees, fertilizer should be withheld in fall and early winter.

In limestone soil, it may be necessary to spread chelated iron 2 or 3 times a year to avoid chlorosis. Zinc deficiency is evidenced by bronzing of the leaves. It is corrected by a foliar spray of 8 lbs (3.5 kg) zinc sulphate and 4 lbs (1.8 kg) hydrated lime in 48 qts (45 liters) of water. Because of the very shallow root system of the lychee, a surface mulch is very beneficial in hot weather.

Pruning: Ordinarily, the tree is not pruned after the judicious shaping of the young plant, because the clipping off of a branch tip with each cluster of fruits is sufficient to promote new growth for the next crop. Severe pruning of old trees may be done to increase fruit size and yield for at least a few years.

Girdling: The Indian farmer may girdle the branches or trunk of his lychee trees in September to enhance flowering and fruiting. Tests on 'Brewster' in Hawaii confirmed the much higher yield obtained from branches girdled in September. Girdling of trees that begin to flush in October and November is ineffective. Similar trials in Florida showed increased yield of trees that had poor crops the previous year, but there was no significant increase in trees that had been heavy bearers. Furthermore, many branches were weakened or killed by girdling. Repeated girdling as a regular practice would probably seriously interfere with overall growth and productivity.

Indian horticulturists warn that girdling in alternate years, or girdling just half of the tree, may be preferable to annual girdling and that, in any case, heavy fertilization and irrigation should precede girdling. Fall spraying of growth inhibitors has not been found to increase yields.

Harvesting

For home use or for local markets, lychees are harvested when fully colored; for shipment, when only partly colored. The final swelling of the fruit causes the protuberances on the skin to be less crowded and to slightly flatten out, thus an experienced picker will recognize the stage of full maturity. The fruits are rarely picked singly except for immediate eating out-of-hand, because the stem does not normally detach without breaking the skin and that causes the fruit to spoil quickly. The clusters are usually clipped with a portion of stem and a few leaves attached to prolong freshness. Individual fruits are later clipped from the cluster leaving a stub of stem attached. Harvesting may need to be done every 3 to 4 days over a period of 3-4 weeks. It is never done right after rain, as the wet fruit is very perishable. The lychee tree is not very suitable for the use of ladders. High clusters are usually harvested by metal or bamboo pruning poles. A worker can harvest 55 lbs (25 kg) of fruits per hour.

Yield

The yield varies with the cultivar, age, weather, presence of pollinators, and cultural practices. In India, a 5-year-old tree may produce 500 fruits, a 20-year-old tree 4,000 to 5,000 fruits–160 to 330 lbs (72.5-149.6 kg). Exceptional trees have borne 1,000 lbs (455 kg) of fruit per year. One tree in Florida has borne 1,200 lbs (544 kg). In China, there are reports of 1,500 lb crops (680 kg). In South Africa, trees 25 years old have averaged 600 lbs (272 kg) each in good years; and an average yield per acre is approximately 10,000 lbs annually (roughly equivalent to 10,000 kg per hectare).

Keeping Quality, Storage and Shipping

Freshly picked lychees keep their color and quality only 3 to 5 days at room temperature. If pre-treated with 0.5% copper sulphate solution and kept in perforated polyethylene bags, they will remain fresh somewhat longer.

Fresh fruits, picked individually by snapping the stems and later de-stemmed during grading, and packed in shallow, ventilated cartons with shredded-paper cushioning, have been successfully shipped by air from Florida to markets throughout the United States and also to Canada. In South Africa, freshly picked lychees have been placed on trays in ventilated sheds, dusted with sulphur and left overnight, and then allowed to "wilt" in lugs for 24 to 48 hours to permit any infested or injured fruits to become conspicuous before grading and packing. It is said that fruits so treated retain their fresh color and are unaffected by fungi or pests for several weeks.

In China and India, lychees are packed in baskets or crates lined with leaves or other cushioning.

The clusters or loose fruits are best packed in trays with protective sheets between the layers and no more than 5 single layers or 3 double layers are joined together. The pack should not be too tight. Containers for stacked trays or fruits not so arranged, must be fairly shallow to avoid too much weight and crushing. Spoilage may be retarded by moistening the fruits with a salt solution.

In the Cook Islands, the fruits are removed from the clusters, dipped in Benlate to control fungal growth, dried on racks, then packed in cartons for shipment to New Zealand. South African shippers immerse the fruits for 10 minutes in a suspension of 0.375 dicloran 50% wp plus 0.625 g benomyl 50% wp per liter of water warmed to 125.6º F (52º C). Tests at CSIRO, Div. of Food Research, New South Wales, Australia, in 1982, showed good color retention, retardation of weight loss and fungal spoilage in lychees dipped in hot benomyl 0.05% at 125.6º F (52º C) for two minutes and packed in trays with PVC "skrink" film covering. The chemical treatment had not yet been approved by health authorities.

Lychee clusters shipped to France by air from Madagascar have arrived in fresh condition when packed 13 lbs (6 kg) to the carton and cushioned with leaves of the traveler's tree *(Ravenala madagascariensis* Sonn.).

Boat shipment requires hydrocooling at the plantation at 32º-35.6º F (0º-2º C), packing in sealed polyethylene bags, storing and conveying to the port at -4º to -13º F (-20º--25º C) and shipping at 32º to 35.6º F (0º-2º C).

In Florida, fresh lychees in sealed, heavy-gauge polyethylene bags keep their color for 7 days in storage or transit at 35º to 50º F (1.67º-10º C). Each bag should contain no more than 15 lbs (6.8 kg) of fruit.

Lychees placed in polyethylene bags with moss, leaves, paper shavings or cotton packing have retained fresh color and quality for 2 weeks in storage at 45º F (7.22º C); for a month at 40º F (4.44º C). At 32º to 35º F(0º-1.67º C) and 85% to 90% relative humidity, untreated lychees, can be stored for 10 weeks; the skin will turn brown but the flesh will be virtually in fresh condition but sweeter.

Frozen, peeled or unpeeled, lychees in moisture-vapor-proof containers keep for 2 years.

Drying of Lychees

Lychees dehydrate naturally. The skin loses its original color, becomes cinnamon-brown, and turns brittle. The flesh turns dark-brown to nearly black as it shrivels and becomes very much like a raisin. The skin of 'Kwai Mi' becomes very tough when dried; that of 'Madras' less so. The fruits will dry perfectly if clusters are merely hung in a closed, air-conditioned room.

In China, lychees are preferably dried in the sun on hanging wire trays and brought inside at night and during showers. Some are dried by means of brick stoves during humid weather.

When exports of dried fruits from China to the United States were suspended, India welcomed the opportunity to supply the market. Experimental drying involved preliminary disinfection by immersing the fruits in 0.5% copper sulphate solution for 2 minutes. Sun-drying on coir-mesh trays took 15 days and the results were good except that thin-skinned fruits tended to crack. It was found that shade-drying for 2 days before full exposure to the sun prevented cracking.

Plate XXXIII: LYCHEE, *Litchi chinensis*: dried

Electric-oven drying of single layers arranged in tiers, at 122º to 140º F (50º-65º C), requires only 4 days. Hot-air-blast at 160º F(70º C) dries seedless fruits in 48 hours. Fire-oven and vacuum-oven drying were found unsatisfactory. Florida researchers have demonstrated the feasibility of drying untreated lychees at 120º F (48.8º C) with free-stream air flow rates above 35 CMF/f^2. Drying at higher temperatures gave the fruits a bitter flavor.

The best quality and light color of flesh instead of dark-brown is achieved by first blanching in boiling water for 5 minutes, immersing in a solution of 2% potassium metabisulphite for 48 hours, and dipping in citric acid prior to drying.

Dried fruits can be stored in tins at room temperature for about a year with no change in texture or flavor.

Pests

In most areas where lychees are grown, the most serious foliage pest is the erinose, or leaf-curl, mite, *Aceria litchii,* which attacks the new growth causing hairy, blister-like galls on the upperside of the leaves, thickening, wrinkling and distorting them, and brown, felt-like wool on the underside. The mite apparently came to Florida on plants from Hawaii in 1953 but has been effectively eradicated. A leaf-webber, *Dudua aprobola*, attacks the new growth of all lychee trees in the Punjab.

The most destructive enemy of the lychee in China is a stinkbug *(Tessaratoma papillosa)* with bright-red markings. It sucks the sap from young twigs and they often die; at least there is a high rate of fruit-shedding. This pest is combatted by shaking the trees in winter, collecting the bugs and dropping them into kerosene. Without such efforts, it works havoc. A stinkbug *(Banasa lenticularis)* has been found on lychee foliage in Florida. The leaf-eating false-unicorn caterpillar *(Schizura ipomeae)*, which is parasitized by a tachinid fly *(Thorocera floridensis)* feeds on the leaves. The foliage is sometimes infested with red spider mites *(Paratetranychus hawaiiensis).*

The citrus aphid *(Toxoptera aurantii)* preys on flush foliage. Two leaf rollers, *Argyroploce leucaspis,* and *A. aprobola,* are active on lychee trees in India. Thrips *(Dolicothrips idicus)* attack the foliage and *Megalurothrips (Taeniothrips) distalis* and *Lymantria mathura* damage the flowers.

A twig-pruner, *Hypermallus villosus,* has damaged lychee trees in Florida and a twig borer, *Proteoteras implicata*, has killed twigs of new growth on Florida lychees. The larvae of a native leaf beetle, *Exema nodulosa*, has been found puncturing and girdling lychee branchlets 1/8 to 1/4 in (3-6 mm) thick. Ambrosia beetles bore into the stems of young trees and fungi enter through their holes. A shoot-borer, *Chlumetia transversa, is* found on lychee trees all over India. Two bark-boring caterpillars, *Indarbela quadrinotata* and *I. tetraonis,* bore rings around the trunk underneath the bark of older trees. The larvae of a small moth, *Acrocerops cramerella,* eat developing seeds and the pith of young twigs. A small parasitic wasp helps to control this predator, as does the sanitary practice of burning the fallen lychee leaves.

The aphid *(Aphis spiraecola)* occurs on young plants in shaded nurseries, as does the armored scale, or lychee bark scale, *Pseudaulacaspis major,* and white peach scale, *P. pentagona.* The Florida red scale, *Chrysomphalus aonidum,* has been seen on lychee trees, also the banana-shaped scale, *Coccus acutissimus,* and green-shield scale, *Pulvinaria psidii.* The latter is the second most serious pest in Florida. Others are the six-spotted mite, *Eotetranychus sexmaculatus,* the leaf-footed bug, *Leptoglossus phyllopus*, and less troublesome creatures such as the several species of Scarabaeidae (related to June bugs) which attack leaves and flower buds.

In South Africa, the parasitic nematode *Hemicriconemoides mangiferae* and *Xiphinema brevicolle* cause die-back, decline and ultimately death of lychee trees, sometimes devastating orchards. The root-knot nematode, *Meloidogyne javanica,* also attacks the lychee in South Africa but is less prevalent.

In Florida, the southern green stinkbug, *Nezara viridula*, and the larvae of the cotton square borer, *Strymon metinus*, attack the fruit. Seed-feeding Lepidoptera, especially *Cryptophlebia ombrodelta* and *Lobesia* sp. cause much fruit damage and falling in northern Queensland. Carbaryl sprays considerably reduce the losses. In South Africa, a moth, *Argyroploce peltastica*, lays eggs on the surface of the fruit and the larvae may penetrate weak areas of the skin and infest the flesh. The fruit flies, *Ceratites capitata* and *Pterandrus rosa* make minute holes and cracks in the skin and cause internal decay. These pests are so detrimental that growers have adopted the practice of enclosing bunches of clusters (with most of the leaves removed) in bags made of "wet-strength" paper or unbleached calico 6 to 8 weeks before harvest-time. The Caribbean fruit fly, *Anastrepha suspensa*, has attacked lychee fruits in Florida.

Birds, bats and bees damage ripe fruits on the trees in China and sometimes a stilt house is built beside a choice lychee tree for a watchman to keep guard and ward off these predators, or a large net may be thrown over the tree. In Florida, birds, squirrels, raccoons and rats are prime enemies. Birds have been repelled by hanging on the branches thin metallic ribbons which move, gleam and rattle in the wind. Grasshoppers, crickets, and katydids may, at times, feed heavily on the foliage.

Diseases

Few diseases have been reported from any lychee-growing locality. The glossy leaves are very resistant to fungi. In Florida, lychee trees are occasionally subject to green scurf, or algal leaf spot *(Cephaleuros virescens)*, leaf blight (*Gleosporium* sp.), die-back, caused by *Phomopsis* sp., and mushroom root rot *(Clitocybe tabescens)* which is most likely to attack lychee trees planted where oak trees formerly stood. Old oak roots and stumps have been found thoroughly infected with the fungus.

In India, leaf spot caused by *Pestalotia pauciseta* may be prevalent in December and can be controlled by lime-sulphur sprays. Leaf spots caused by *Botryodiplodia theobromae* and *Colletotrichum gloeosporioides*, which begin at the tip of the leaflet, were first noticed in India in 1962.

Lichens and algae commonly grow on the trunks and branches of lychee trees.

The main post-harvest problem is spoilage by the yeast-like organism, which is quick to attack warm, moist fruits. It is important to keep the fruits dry and cool, with good circulation of air. When conditions favor rotting, dusting with fungicide will be necessary.

Food Uses

Lychees are most relished fresh, out-of-hand. Peeled and pitted, they are commonly added to fruit cups and fruit salads. Lychees stuffed with cottage cheese are served as salad topped with dressing and pecans. Or the fruit may be stuffed with a blend of cream cheese and mayonnaise, or stuffed with pecan meats, and garnished with whipped cream. Sliced lychees, congealed in lime gelatin, are served on lettuce with whipped cream or mayonnaise. The fruits may be layered with pistachio ice cream and whipped cream in parfait glasses, as dessert. Halved lychees have been placed on top of ham during the last hour of baking, or grilled on top of steak. Pureed lychees are added to ice cream mix. Sherbet is made by extracting the juice from fresh, seeded lychees and adding it to a mixture of prepared plain gelatin, hot milk, light cream, sugar and a little lemon juice, and freezing.

Fig. 73: Peeled, seeded, lychees *(Litchi chinensis)* are canned in sirup in the Orient and exported to the United States and other countries.

Peeled, seeded lychees are canned in sugar sirup in India and China and have been exported from China for many years. Browning, or pink discoloration, of the flesh is prevented by the addition of 4% tartaric acid solution, or by using 30º Brix sirup containing 0.1% to 0.15% citric acid to achieve a pH of about 4.5, processing for a maximum of 10 minutes in boiling water, and chilling immediately.

Food Value Per 100 g of Edible Portion*

	Fresh	*Dried*
Calories	63-64	277
Moisture	81.9-84.83%	17.90-22.3%
Protein	0.68-1.0 g	2.90-3.8 g
Fat	0.3-0.58 g	0.20-1.2 g
Carbohydrates	13.31-16.4 g	70.7-77.5 g
Fiber	0.23-0.4 g	1.4 g
Ash	0.37-0.5 g	1.5-2.0 g
Calcium	8-10 mg	33 mg
Phosphorus	30-42 mg	
Iron	0.4 mg	1.7 mg
Sodium	3 mg	3 mg
Potassium	170 mg	1,100 mg
Thiamine	28 mcg	
Nicotinic Acid	0.4 mg	
Riboflavin	0.05 mg	0.05 mg
Ascorbic Acid	24-60 mg	42 mg

*According to analyses made in China, India and the Philippines.

The lychee is low in phenols and non-astringent in all stages of maturity.

To a small extent, lychees are also spiced or pickled, or made into sauce, preserves or wine. Lychee jelly has been made from blanched, minced lychees and their accompanying juice, with 1% pectin, and combined phosphoric and citric acid added to enhance the flavor.

The flesh of dried lychees is eaten like raisins. Chinese people enjoy using the dried flesh in their tea as a sweetener in place of sugar.

Whole frozen lychees are thawed in tepid water. They must be consumed very soon, as they discolor and spoil quickly.

Other Uses

In China, great quantities of honey are harvested from hives near lychee trees. Honey from bee colonies in lychee groves in Florida is light amber, of the highest quality, with a rich, delicious flavor like that of the juice which leaks when the fruit is peeled, and the honey does not granulate.

Medicinal Uses: Ingested in moderate amounts, the lychee is said to relieve coughing and to have a beneficial effect on gastralgia, tumors and enlargements of the glands. One stomach-ulcer patient in Florida, has reported that, after eating several fresh lychees he was able to enjoy a large meal that, ordinarily, would have caused great discomfort. Chinese people believe that excessive consumption of raw lychees causes fever and nosebleed. According to legends, ancient devotees have consumed from 300 to 1,000 per day.

In China, the seeds are credited with an analgesic action and they are given in neuralgia and orchitis. A tea of the fruit peel is taken to overcome smallpox eruptions and diarrhea. In India, the seeds are powdered and, because of their astringency, administered in intestinal troubles, and they have the reputation there, as in China, of relieving neuralgic pains. Decoctions of the root, bark and flowers are gargled to alleviate ailments of the throat. Lychee roots have shown activity against one type of tumor in experimental animals in the United States Department of Agriculture/National Cancer Institute Cancer Chemotherapy Screening Program.

Morton, J. 1987. Longan. p. 259–262. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Longan

Dimocarpus longan Lour.

Euphoria longan Steud.

Euphoria longana Lam.

Nephelium longana Cambess.

Closely allied to the glamorous lychee, in the family Sapindaceae, the longan, or lungan, also known as dragon's eye or eyeball, and as *mamoncillo chino* in Cuba, has been referred to as the "little brother of the lychee", or *li-chihnu*, "slave of the lychee". Botanically, it is placed in a separate genus, and is currently designated *Dimocarpus longan* Lour. (syns. *Euphoria longan* Steud.; *E. longana* Lam.; *Nephelium longana* Cambess.). According to the esteemed scholar, Prof. G. Weidman Groff, the longan is less important to the Chinese as an edible fruit, more widely used than the lychee in Oriental medicine.

Description

The longan tree is handsome, erect, to 30 or 40 ft (9-12 m) in height and to 45 ft (14 m) in width, with rough-barked trunk to 2 1/2 ft (76.2 cm) thick and long, spreading, slightly drooping, heavily

Fig. 74: The brown-skinned longan *(Euphoria longan),* less luscious than the lychee, is hardier, bears heavily and later in the year,

foliaged branches. The evergreen, alternate, paripinnate leaves have 4 to 10 opposite leaflets, elliptic, ovate-oblong or lanceolate, blunt-tipped; 4 to 8 in (10-20 cm) long and 1 3/8 to 2 in (3.5-5 cm) wide; leathery, wavy, glossy-green on the upper surface, minutely hairy and grayish-green beneath. New growth is wine-colored and showy. The pale-yellow, 5- to 6-petalled, hairy-stalked flowers, larger than those of the lychee, are borne in upright terminal panicles, male and female mingled. The fruits, in drooping clusters, are globose, 1/2 to 1 in (1.25-2.5 cm) in diameter, with thin, brittle, yellow-brown to light reddish-brown rind, more or less rough (pebbled), the protuberances much less prominent than those of the lychee. The flesh (aril) is mucilaginous, whitish, translucent, somewhat musky, sweet, but not as sweet as that of the lychee and with less "bouquet". The seed is round, jet-black, shining, with a circular white spot at the base, giving it the aspect of an eye.

Origin and Distribution

The longan is native to southern China, in the provinces of Kwangtung, Kwangsi, Schezwan and Fukien, between elevations of 500 and 1,500 ft (150-450 m). Groff wrote: "The lungan, not so highly prized as the lychee, is nevertheless usually found contiguous to it .... It thrives much better on higher ground than the lychee and endures more frost. It is rarely found growing along the dykes of streams as is the lychee but does especially well on high ground near ponds .... The lungan is more seldom grown under orchard conditions than is the lychee. There is not so large a demand for the fruit and the trees therefore more scattered although one often finds attractive groups of lungan." Groff says that the longan was introduced into India in 1798 but, in Indian literature, it is averred that the longan is native not only to China but also to southwestern India and the forests of upper Assam and the Garo hills, and is cultivated in Bengal and elsewhere as an ornamental and shade tree. It is commonly grown in former Indochina (Thailand, Cambodia, Laos and Vietnam and in Taiwan). The tree grows but does not fruit in Malaya and the Philippines. There are many of the trees in Reúnion and Mauritius.

The longan was introduced into Florida from southern China by the United States Department of Agriculture in 1903 and has flourished in a few locations but never became popular. There was a young tree growing at the Agricultural Station in Bermuda in 1913. A tree planted at the Federal Experiment Station in Mayaguez, Puerto Rico, was 10 ft (3 m) high in 1926, 23 ft (7 m) in 1929. A longan tree flourished in the Atkins Garden in Cuba and seedlings were distributed but found to fruit irregularly and came to be valued mostly for their shade and ornamental quality. In Hawaii, the longan was found to grow faster and more vigorously than the lychee but the fruit is regarded there as less flavorful than the lychee.

Varieties

It seems that the type of longan originally brought to the New World was not one of the best, having aroused so little interest in the fruit. Groff stated that the leading variety of Fukien was the round-fruited 'Shih hsía', the "Stone Gorge Lungan" from P'ing Chou. There were 2 types, one, 'Hei ho shih hsia', black-seeded, and 'Chin ch' i ho shih hsia', brown-seeded. This variety did not excel in size but the flesh was crisp, sweeter than in other varieties, the seed small and the dried flesh, after soaking in water, was restored almost to fresh condition.

None of the other 4 varieties described by Groff has any great merit.

'Wu Yuan' ("black ball") has small, sour fruit used for canning. The tree is vigorous and seedlings are valued as rootstocks. 'Kao Yuan' is believed to be a slightly better type of this variety and is widely canned.

'Tsao ho' ('Early Rice') is the earliest variety and a form called 'Ch'i chin tsao ho' precedes it by 2 weeks. In quality, both are inferior to 'Wu Yuan'.

'She p' i' ('Snake skin') has the largest fruit, as big as a small lychee and slightly elongated. The skin is rough, the seed large, some of the juice is between the rind and the flesh, and the quality is low. Its only advantage is that it is very late in season.

'Hua Kioh' ('Flower Skin'), slightly elongated, has thin, nearly tasteless flesh, some of the juice is between the rind and the flesh, and the overall quality is poor. It is seldom propagated vegetatively.

There are no "chicken- tongue" (aborted seed) varieties in China.

There are 2 improved cultivars grown extensively in Taiwan**–'Fukien Lungan'** ('Fukugan') was introduced from Fukien Province in mainland China. The other, very similar and possibly a mutant of 'Fukien', is **'Lungan Late',** which matures a month later than 'Fukien'.

In 1954, William Whitman of Miami introduced a superior variety of longan, the **'Kohala',** from Hawaii. It began to bear in 1958. The fruit is large for the species, the seed is small, and the flesh is aromatic, sweet and spicy. The tree produces fairly good crops in midsummer. One hundred or more air-layers have been brought by air from Hawaii and planted at various locations in southern Florida and in the Bahamas. A seedling planting and selection program was started in 1962 at the USDA Subtropical Horticulture Research Unit, Miami. The plants were all open-pollinated seedlings of the canning variety, 'Wu Yuan', brought in from Canton in 1930 as P.I. #89409. Some set fruit in 1966 and 1967 but more of them in 1968. Evaluation of these and other acquisitions continues. Included in the study are M-17886, 'Chom Poo Nuch', and M-17887, 'E-Haw'.

Climate

Professor Groff wrote that "the lungan . . . is found growing at higher latitudes and higher altitudes than the lychee." Also: "On the higher elevations of the mountainous regions which are subject to frost the lychee is seldom grown. The longan appears in these regions more often but it, too, cannot stand heavy frosts." The longan's range in Florida extends north to Tampa on the west coast and to Merritt Island on the east coast. Still, small trees suffer leaf-and twig-damage if the temperature falls to 31º or 30º F (-0.56º--l.11º C) and are killed at just a few degrees lower. Larger trees show leaf injury at 27º to 28º F (-2.78º--2.22º C), small branch injury at 25º to 26º F

(-3-89º--3.33º C), large branch and trunk symptoms at 24º F (-4.44º C) and sometimes fail to recover.

On the other hand, after a long period of cool weather over the 3 winter months, with no frost, longan trees bloom well. Blooming is poor after a warm winter.

Soil

The longan thrives best on a rich sandy loam and nearly as well on moderately acid, somewhat organic, sand. It also grows to a large size and bears heavily in oolitic limestone. In organic muck soils, blooming and fruiting are deficient.

Propagation

Most longan trees have been grown from seed. The seeds lose viability quickly. After drying in the shade for 4 day, they should be planted without delay, but no more than 3/4 in (2 cm) deep, otherwise they may send up more than one sprout. Germination takes place within a week or 10 days. The seedlings are transplanted to shaded nursery rows the following spring and set in the field 2-3 years later during winter dormancy.

In Kwangtung Province, when vegetative propagation is undertaken, it is mostly by means of inarching, nearly always onto 'Wu Yuan' trees 3-5 years old and 5 to 6 ft (1.5-1.8 m) high. The union is made no less than 4 ft (1.2 m) from the ground because it is most convenient. Nevertheless, the point of attachment remains weak and needs to be braced with bamboo to avoid breaking in high winds.

Grafting is uncommon and when it is done, it is a sandwich graft on longan rootstock, 3 or 4 grafts being made successively, one onto the beheaded top of the preceding one, in the belief that it makes the graft wind-resistant and that it induces better size and quality in the fruit.

Conventional modes of grafting have not been successful in Florida, but whip-grafting has given 80% success in Taiwan. Air-layering is frequently done in Fukien Province and was found a feasible means of distributing the 'Kohala' from Hawaii. Air-layers bear in 2 to 3 years after planting. A tree can be converted to a preferred cultivar by cutting it drastically back and veneer-grafting the new shoots.

Culture

In China, if the longan is raised on the lowlands it is always put on the edges of raised beds. On high ground, the trees are placed in pre-enriched holes on the surface. The trees are fertilized after the fruit harvest and during the blooming season, at which time the proportion of nitrogen is reduced. Fresh, rich soil is added around the base of the trees year after year. The longan needs an adequate supply of water and can even stand brief flooding, but not prolonged drought. Irrigation is necessary in dry periods.

An important operation is the pruning of many flower-bearing twigs–3/4 of the flower spikes in the cluster being removed. Later, the fruit clusters are also thinned, in order to increase the size and quality of the fruits.

Generally, the trees are planted too close together, seriously inhibiting productivity when they become overcrowded. In China, full-grown trees given sufficient room–at least 40 ft (12 m) apart–may yield 400 to 500 lbs (180-225 kg) in good years. Crops in Florida from trees 20 ft (6 m) tall and broad, have varied from light–50-100 lbs (22.5-45 kg)–to medium–150-250 lbs (68-113 kg), and heavy–300-500 lbs (135-225 kg). Rarely such trees may produce 600-700 lbs (272-317 kg). Larger trees have larger crops but if the trees become too tall harvesting is too difficult, and they should be topped. Harvesters, working manually from ladders, or using pruning poles cut the entire cluster of fruit with leaves attached.

A serious problem with the longan is its irregular bearing–often one good year followed by 1 or 2 poor years. Another handicap is the ripening season–early to mid-August in China, which is the time of typhoons; August and September in Florida which is during the hurricane season. Rain is a major nuisance in harvesting and in conveying the fruit to market or to drying sheds or processing plants.

Keeping Quality

At room temperature, longans remain in good condition for several days. Because of the firmer rind, the fruit is less perishable than the lychee.

Preliminary tests in Florida indicate that the fruit can be frozen and will not break down as quickly as the lychee when thawed.

Pests and Diseases

The longan is relatively free of pests and diseases. At times, there may be signs of mineral deficiency which can be readily corrected by supplying minor elements in the fertilization program.

Food Uses

Longans are much eaten fresh, out-of-hand, but some have maintained that the fruit is improved by cooking. In China, the majority are canned in sirup or dried. The canned fruits were regularly shipped from Shanghai to the United States in the past. Today, they are exported from Hong Kong and Taiwan.

For drying, the fruits are first heated to shrink the flesh and facilitate peeling of the rind. Then the seeds are removed and the flesh dried over a slow fire. The dried product is black, leathery and smoky in flavor and is mainly used to prepare an infusion drunk for refreshment.

A liqueur is made by macerating the longan flesh in alcohol.

Food Value Per 100 g of Edible Portion		
	Fresh	*Dried*
Calories	61	286
Moisture	82.4 g	17.6 g
Protein	1.0 g	4.9 g
Fat	0.1 g	0.4 g
Carbohydrates	15.8 g	74.0 g

Fiber	0.4 g	2.0 g
Ash	0.7 g	3.1 g
Calcium	10 mg	45 mg
Phosphorus	42 mg	196 mg
Iron	1.2 mg	5.4 mg
Thiamine		0.04 mg
Ascorbic Acid	6 mg (possibly)	28 mg

Other Uses

Seeds and rind: The seeds, because of their saponin content, are used like soapberries *(Sapindus saponaria* L.) for shampooing the hair. The seeds and the rind are burned for fuel and are part of the payment of the Chinese women who attend to the drying operation.

Wood: While the tree is not often cut for timber, the wood is used for posts, agricultural implements, furniture and construction. The heartwood is red, hard, and takes a fine polish. It is not highly valued for fuel.

Medicinal Uses: The flesh of the fruit is administered as a stomachic, febrifuge and vermifuge, and is regarded as an antidote for poison. A decoction of the dried flesh is taken as a tonic and treatment for insomnia and neurasthenic neurosis. In both North and South Vietnam, the "eye" of the longan seed is pressed against a snakebite in the belief that it will absorb the venom.

Leaves and flowers are sold in Chinese herb markets but are not a part of ancient traditional medicine. The leaves contain quercetin and quercitrin. Burkill says that the dried flowers are exported to Malaysia for medicinal purposes. The seeds are administered to counteract heavy sweating and the pulverized kernel, which contains saponin, tannin and fat, serves as a styptic.

Morton, J. 1987. Rambutan. p. 262–265. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Rambutan

Nephelium lappaceum L.

Euphoria nephelium DC.

Dimocarpus crinita Lour.

Though a close relative of the lychee and an equally desirable fruit, this member of the Sapindaceae is not nearly as well-known. Botanically, it is *Nephelium lappaceum* L. (syns. *Euphoria nephelium* DC.; *Dimocarpus crinita* Lour.). In the vernacular, it is generally called rambutan (in French, *ramboutan* or *ramboutanier;* in Dutch, *ramboetan);* occasionally in India, *ramboostan.* To the Chinese it is *shao tzu*, to Vietnamese, *chom chom* or *vai thieu;* to Kampucheans, *ser mon*, or *chle sao mao.* There are other local names in the various dialects of southeast Asia and the East Indies.

Description

The rambutan tree reaches 50 to 80 ft (15-25 m) in height, has a straight trunk to 2 ft (60 cm) wide, and a dense, usually spreading crown. The evergreen leaves are alternate, pinnately compound, 2 3/4 to 12 in (7-30 cm) long, with reddish rachis, hairy when young, and 1 to 4 pairs of leaflets, subopposite or alternate, elliptic to oblong-elliptic, or rather obovate, sometimes oblique at the base; slightly leathery; yellowish-green to dark-green and somewhat dull on the upper surface, yellowish or bluish-green beneath; 2 to 8 in (5-20 cm) long, 1 to 4 1/3 in (2.5-11 cm) wide, the 6 to 15 pairs of principal veins prominent on the underside. The small, petalless flowers, of three kinds: males, hermaphrodite functioning as males, and hermaphrodite functioning as females, are borne in axillary or pseudo-terminal, much branched, hairy panicles. The fruit is ovoid, or ellipsoid, pinkish-red, bright-or deep-red, orange-red, maroon or dark-purple, yellowish-red, or all yellow or orange-yellow; 1 1/3 to 3 1/8 in (3.4-8 cm) long. Its thin, leathery rind is covered with tubercles from each of which extends a soft, fleshy, red, pinkish, or yellow spine 1/5 to 3/4 in (0.5-2 cm) long, the tips deciduous in some types. The somewhat hairlike covering is responsible for the common name of the fruit, which is based on the Malay word *"rambut"*, meaning "hair". Within is the white or rose-tinted, translucent, juicy, acid, subacid or sweet flesh, 1/6 to 1/3 in (0.4-0.8 cm) thick, adhering more or less to the ovoid or oblong, somewhat flattened seed, which is 1 to 1 1/3 in (2.5-3.4 cm) long and 2/5 to 3/5 in (1-1.5 cm) wide. There may be 1 or 2 small undeveloped fruits nestled close to the stem of a mature fruit.

Plate XXXIV: RAMBUTAN, *Nephelium lappaceum* Painted by Dr. M.J. Dijkman

Origin and Distribution

The rambutan is native to Malaysia and commonly cultivated throughout the archipelago and southeast Asia. Many years ago, Arab traders introduced it into Zanzibar and Pemba. There are limited plantings in India, a few trees in Surinam, and in the coastal lowlands of Colombia, Ecuador, Honduras, Costa Rica, Trinidad and Cuba. Some fruits are being marketed in Costa Rica. The rambutan was taken to the Philippines from Indonesia in 1912. Further introductions were made in 1920 (from Indonesia) and 1930 (from Malaya), but until the 1950's its distribution was rather limited. Then popular demand brought about systematic efforts to improve the crop and resulted in the establishment of many commercial plantations in the provinces of Batangas, Cavite, Davan, Iloilo, Laguna, Oriental Mindoro and Zamboanga. Seeds were imported into the United

States from Java in 1906 (SPI #17515) but the species is not grown in this country.

Varieties

Popular varieties in Malaya include 'Chooi Ang', 'Peng Thing Bee', 'Ya Tow', 'Azimat', and 'Ayer Mas'. Dr. J.J. Ochse described 6 named varieties in Indonesia:

'Lebakbooloos'–a broad-topped tree with dark-red fruits having uncrowded spines 3/5 in (1.5 cm) long, and grayish-white, tough, subacid flesh 1/5 in (0.5 cm) thick, frequently difficult to separate from the seed and often takes pieces of the testa with it. Ships well over long distances. (Cultivated also in India).

'Seematjan'–Tree has an open crown and long, flexible branches. Fruits are dark-red with spines to 3/4 in (2 cm) long. In Java the tree is especially prone to attack by various insects. It is cultivated also in India and in the Philippines where it has averaged 16 lbs/acre (16 kg/ha). There are 2 forms: 1) 'Seematjan besar' with small fruit, thin rind, spines fairly far apart; very sweet, somewhat coarse, fairly juicy flesh to which the coarse, fibrous testa tightly adheres; 2) 'Seematjan ketjil' (or 'Koombang')–the fruit has soft, tough, and less sweet flesh to which the seed coat does not tightly adhere.

'Seenjonja'–Tree low-growing; has a drooping crown. Fruit nearly ovoid, about 1 1/2 in (4 cm) long and 1 1/5 in (3 cm) wide; dark wine-red with slender, flexible spines about 2/5 in (1 cm) long. Flesh clings firmly to the seed. In the Philippines has yielded on the average 41 lbs/acre (41 kg/ha).

'Sectangkooweh'–Tree broad-topped. Fruit flattened ellipsoid, about 2 in (5 cm) long, 1 1/2 in (4 cm) wide with slim spines 2/5 in (1 cm) long. Rind is thin, pliable, tough. Flesh yellowish-white, sweet, clings tightly to the thick testa which separates from the seed. Fruits stand long-distance shipment.

'Seelengkeng'–Tree low-growing with drooping crown. Fruit ovoid, 1 1/5 in (3 cm) long, 3/4 in (2 cm) wide, with very fine, soft spines. Flesh slightly glossy, tough, moderately sweet, and separates from the seed with a few particles of testa clinging to it. Air-layers are unsatisfactory, so it is rare in cultivation and expensive on the market. Much favored by Chinese because of its resemblance to the lychee. (Cultivated also in India.)

'Seekonto'–Tree has broad crown; is fast-growing. Fruits ellipsoid, faintly flattened, about 2 in (5 cm) long, 1 1/2 in (4 cm) wide. Spines are thick and short. Flesh is dull, grayish-white, somewhat coarse and dry; clings to the testa which separates readily from the seed.

'Maharlika' (no description available) has yielded 21 lbs/ acre (21 kg/ha) in the Philippines.

Yellow-fruited rambutans are called 'Atjeh koonig' in Batavia. In Malaya, 'Rambutan gading' indicates a yellow type.

Among the many "races" of rambutan in Malaya, the best "freestone" types are found in Penang. One race with a partly free stone is known as 'rambutan lejang'. Burkill says that some rambutans are so sour that monkeys are reluctant to eat them.

In 1950, Philippine agriculturists undertook a program of selection and the creation of a Testing Plot at the Provincial Nursery, Victoria, Oriental Mindoro. There they assembled 360 trees of which 140 were found to be bearing in 1960 and 196 (mostly males) were non-bearing. Observations of the bearing trees there and at the Arago Farm not far away, resulted in the selection of 21 clones which they classified into 4 groups according to fruit size: 1) very large, 14 or less per lb (31 or less/kg); 2) large, 15 to 16 per lb (32-36/kg); 3) medium, 17 to 19 per lb (37-41/kg); 4) small, 20 or more per lb (42 or more/kg).

The main characteristics of the 21 named selections are here summarized:

'Queen Zaida'–Dark-red, oblong, medium-size; flesh thick (38.76% of fruit), sweet, juicy; freestone; 60% of fruits kept well for 2 weeks in cold storage. Yield: 275 lbs (125 kg) per tree at 20 years of age.
'Baby Eulie'–Light-red, very large, flesh thick (39.92% of fruit), soft, freestone. Kept well only 1 week at 60º F (15.56º C). Yield: 352 lbs (160 kg) per tree at 8 years of age.
'Princess Caroline'–Dark-red, small, rind pliable; flesh thick (44.14% of fruit); seeds small. Kept well for 2 weeks at 60º F (15.56º C). Yield; 440 lbs (200 kg) per tree at 8 years of age.
'Quezon'–Yellowish- red, small to medium; rind pliable; flesh thick (38.24% of fruit); sweet, slightly acid, juicy. Yield: 343 lbs (156 kg) per tree at 8 years of age.
'Roxas'–Dark-red; medium-sized; flesh thick (42.97% of fruit); juicy, sweet, adheres to seed. Yield: 429 lbs (195 kg) per tree at 8 years of age.
'Zamora'–Yellowish rind with pale-pink spines; oblong; small; rind hard; flesh thick (38.29% of fruit), juicy and sweet. Yield: 330 lbs (150 kg) per tree at 7 years of age. Ripens mid-to late October. After 2 weeks of refrigeration at 60º F (15.56º C) 80% of the fruits were still in good condition.
'Quirino'–Yellowish with pinkish-red spines; small; flesh thick (32.78 % of fruit), juicy and sweet. Borne in large clusters of up to 85 fruits each.
'Magsaysay'–Dark-red to near-black with dark-red spines; oblong, large; rind pliable; flesh thick (42.68% of fruit); juicy, sweet; freestone. Yield: 176 lbs (80 kg) per tree at 6 years of age.
'Santo Tomas'–Yellowish-pink with reddish-pink, soft spines. Nearly round; rind hard; flesh thick (43.25% of fruit); seed small. Yield: 352 lbs (160 kg) per tree at 8 years of age.
'Victoria'–Yellowish with red spines; rind thick; flesh thick, juicy, sweet, freestone. Yield: 132 lbs (60 kg) per tree at 6 years of age. Early in season (mid-July).
'Baby Christie'–Yellowish-red with soft, silvery-pink spines; large. Flesh thick (36.41% of fruit).
'Governor Infantada'–Oblong, very large; rind pliable; flesh thick (39.28% of fruit), juicy, sweet and slightly acid; adheres tightly to seed. Yield: 330 lbs (150 kg) per tree at 6 years of age. Fruits keep only 1 week at 60º F (15.56º C).
'Laurel, Sr.'–Pinkish-red, small; flesh thick (39.76% of fruit). Tree very low-growing, spreading.
'Fortich'–Yellowish-red; medium-sized; flesh thick (40.95% of fruit); juicy, sweet; freestone. Early in season.
'Osmeña, Sr.'–Purple-red; medium-sized; flesh thick (38.90% of fruit); juicy, sweet; freestone. Ripens late in season.
'Ponderosa Ferreras' (from Arago, Farm)–Crimson red with very prominent spines; very large; flesh thick (35.73% of fruit); juicy, sweet, freestone. Early in season. Yield: 303 lbs (138 kg) per tree at 6 years of age.
'Rodrigas' (from Arago Farm)–Medium-sized; flesh thick (38.46% of fruit).
'Manahan' (from Arago Farm)–Medium-sized; flesh thick (37.37% of fruit).
'Santan' (from Arago Farm)–Flesh thick (34.26% of fruit).
'Arago' (from Arago Farm)–flesh very thick (41.42% of fruit).
'Cruz' or 'Cruzas' (from Arago Farm)–flesh medium-thick (26.15% of fruit).

About 1960, 10 outstanding rambutans were selected in an evaluation of 100 seedling trees of the unsurpassed Indonesian 'Seematjan', also 'Seenjonja', 'Maharlika', 'Divata', 'Marikit', 'Dalisay', 'Marilag', 'Bituin', 'Alindog', and 'Paraluman'.

Climate

The rambutan flourishes from sea-level to 1,600 or even 1,800 ft (500-600 m), in tropical, humid regions having well-distributed rainfall. In the ideal environment of Oriental Mindora Philippines, the average temperature year-round is about 81º F (27.3º C), relative humidity is 82%, rainfall 71 in (180 cm)-about 165 rainy days. The dry season should not last much over 3 months.

Soil

The tree does best on deep, clay-loam or rich sandy loam rich in organic matter, or in deep peat. It needs good drainage.

Propagation

Rambutan seeds, after removal from the fruit and thorough washing, should be planted horizontally with the flattened side downward in order that the seedling will grow straight and have a normal, strong root system. Seeds will germinate in 9 to 25 days, the earlier, the more vigor in the seedling. The rate of germination of 2-day-old seeds is 87% to 95%. A week after seed removal from the fruit, there may be only 50% to 65% germination. Sun-drying for 8 hours and oven-drying at 86º F (30º C) kills seeds within a week. Washed seeds will remain viable in moist sawdust, sphagnum moss or charcoal for 3-4 weeks, and some will even sprout in storage. The juice of the flesh inhibits germination. Accordingly, unwashed seeds or seeds treated with the juice can be held for a month in moist sawdust without sprouting.

Rambutan seedlings bear in 5-6 years, but the ratio of female to male trees is 4 or 5 to 7. One Philippine seedling orchard was found to have 67% male trees. Then, too, hardly 5% of female trees give a profitable yield. Vegetative propagation is essential.

Cuttings have been rooted experimentally under mist and with the use of growth-promoting hormones, but this technique is not being practiced. Air-layering may at first appear successful, but many air-layers die after being transplanted into 5-gal containers, or, later, in the field, long after separation from the mother tree.

Marching is very effective onto 5- to 9-month-old seedlings of rambutan or of pulasan *(N. mutabile* L.) or *N. intermedium* Radlk., but is a rather cumbersome procedure. After 2 or 3 months, the scion is notched 3 times over a period of 2 weeks and then severed from the parent tree. Cleft-, splice-, and side-grafting are not too satisfactory. Patch-budding is preferred as having a much greater rate of success. Seedlings for use as rootstocks are taken from the seedbed after 45 days and transplanted into 1-quart cans with a mixture of 50% cured manure and later transferred to 5 gal containers. In Oriental Mindoro Province, if the budding is done in the month of May, they can achieve 83.6% success; if done in June and July, 82%. Budded trees flower 2 1/2 to 3 years after planting in the field.

Culture

In the Philippines, it is recommended that the trees be planted at least 33 ft (10 m) apart each way, though 40 ft (12 m) is not too much in rich soil. If the trees are set too close to each other, they will become overcrowded in a few years and production will be seriously affected.

Philippine agronomists apply 2.2 lbs (1 kg) ammonium sulfate together with 2.2 lbs (1 kg) complete fertilizer (12-24-12) per tree immediately after harvest and give the same amount of ammonium sulfate to each tree near the end of the rainy season. Studies in Malaya show that a harvest of 6,000 lbs/acre (6,720 kg/ha) of rambutan fruits removes from the soil 15 lbs/acre (approximately 15 kg/ha) nitrogen, 2 lbs/acre (2 kg/ha) phosphorus, 11.5 lbs/acre (11.5 kg/ha) potassium, 5.9 lbs/acre (5.9 kg/ha) calcium, and 2.67 lbs/acre (2.67 kg/ha) magnesium.

Irrigation is given as needed in dry seasons. Light pruning is done only to improve the form of the tree and strengthen it. Rambutan trees should be sheltered from strong winds which do much damage during the flowering and fruiting periods.

Harvesting

In Malaya, the rambutan generally fruits twice a year, the first, main crop in June and a lesser one in December. In the Philippines, flowering occurs from late March to early May and the fruits mature from July to October or occasionally to November.

The entire fruit cluster is cut from the branch by harvesters. If single fruits are picked, they should be snapped off with a piece of the stem attached, so as not to rupture the rind. The fruits must be handled carefully to avoid bruising and crushing, and kept dry, cool, and well-ventilated to delay spoilage.

Yield

Generally, shoots that bear fruit one year will put out new growth and will bloom and fruit the next year, so that biennial bearing is rare in the rambutan. However, yield may vary from year to year. Individual trees 8 years old or older have borne as much as 440 lbs (200 kg) one season and only 132 lbs (60 kg) the next. In the Philippines, the average production per tree of 21 selections was 264 lbs (120 kg) over a 4-year period, while the general average is only 106 lbs (48 kg).

From 1965 to 1967, agronomists at the College of Agriculture, University of the Philippines, studied the growth, flowering habits and yield of the Indonesian cultivars, 'Seematjan', 'Seenjonja', and 'Maharlika'. They found that all the 'Seematjan' flowers were hermaphrodite functioning as female (h.f.f.) and that it is necessary to plant male trees with this cultivar. 'Seenjonja' and 'Maharlika' flowers were mostly h.f.f. with a very few hermaphrodite functioning as males (h.f.m.) in the same panicles, and concluded that, though self-pollination is possible, planting of male trees with these cultivars should improve production.

Keeping Quality

Ordinarily, the fruits must be gotten to local markets within 3 days of picking before shriveling and decay begin. Fungicidal applications and packing in perforated polyethylene bags have extended fresh life somewhat. Weight loss has been reduced by packing in sawdust, or coating with a wax emulsion. Storing in sealed polyethylene bags at 40º F (10º C) and 95% relative humidity has preserved the fruits in fresh condition for 12 days. Some cultivars, as noted, keep better than others.

Pests and Diseases

Few pests or diseases have been reported by rambutan growers. Leaf-eating insects, the mealybug, *Pseudococcus lilacinus*, and the giant bug, *Tessaratoma longicorne*, may require control measures. The mango twig-borer, *Niphonoclea albata*, occasionally appears on rambutan trees. The Oriental fruit fly attacks very ripe fruits. Birds and flying foxes (fruit-eating bats) consume many of the fruits, probably considerably reducing yield figures.

There are several pathogens that attack the fruits and cause rotting under warm, moist conditions. Powdery mildew, caused by *Oidium* sp., may affect the foliage or other parts of the tree. A serious disease, stem canker, caused by *Fomes lignosus* in the Philippines and *Ophioceras* sp. in Malaya, can be fatal to rambutan trees if not controlled at the outset.

Food Uses

Rambutans are most commonly eaten out-of-hand after merely tearing the rind open, or cutting it around the middle and pulling it off. It does not cling to the flesh. The peeled fruits are occasionally stewed as dessert. They are canned in sirup on a limited scale. In Malaya a preserve is made by first boiling the peeled fruit to separate the flesh from the seeds. After cooling, the testa is discarded and the seeds are boiled alone until soft. They are combined with the flesh and plenty of sugar for about 20 minutes, and 3 cloves may be added before sealing in jars. The seeds are sometimes roasted and eaten in the Philippines, although they are reputedly poisonous when raw.

Food Value Per 100 g of Edible Portion*

Moisture	82.3 g
Protein	0.46 g
Total Carbohydrates	16.02 g
Reducing Sugars	2.9 g
Sucrose	5.8 g
Fiber	0.24g
Calcium	10.6 mg
Phosphorus	12.9 mg
Ascorbic Acid	30 mg

*Analyses made in Ceylon.

Toxicity
There are traces of an alkaloid in the seed, and the testa contains saponin and tannin. The seeds are said to be bitter and narcotic. The fruit rind also is said to contain a toxic saponin and tannin.

Other Uses
Seed fat: the seed kernel yields 37-43% of a solid, white fat or tallow resembling cacao butter. When heated, it becomes a yellow oil having an agreeable scent. Its fatty acids are: palmitic, 2.0%; stearic, 13.8%; arachidic, 34.7%; oleic, 45.3%; and ericosenoic, 4.2%. Fully saturated glycerides amount to 1.4%. The oil could be used in making soap and candles if it were available in greater quantity.
Wood: The tree is seldom felled. However, the wood–red, reddish-white, or brownish–is suitable for construction though apt to split unless carefully dried.
Medicinal Uses: The fruit (perhaps unripe) is astringent, stomachic; acts as a vermifuge, febrifuge, and is taken to relieve diarrhea and dysentery. The leaves are poulticed on the temples to alleviate headache. In Malaya the dried fruit rind is sold in drugstores and employed in local medicine. The astringent bark decoction is a remedy for thrush. A decoction of the roots is taken as a febrifuge.

Morton, J. 1987. Pulasan. p. 265–266. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Pulasan

Nephelium mutabile Blume

The pulasan, or poolasan, *Nephelium mutabile* Blume (family, Sapindaceae), is closely allied to the rambutan and sometimes confused with it. One of its local names in Malaya is *rambutan-kafri* (negro's rambutan); another is *rambutan paroh.* In Malacca it is sometimes called *pening-pening-ramboetan.* The Dutch name in Java is *kapoelasan.* In the Philippines it is mostly known as *bulala.* There are numerous tribal names for this species throughout Malaysia.

Description

The pulasan tree is a handsome ornamental; attains 33 to 50 ft (10-15 m); has a short trunk to 12 to 16 in (30-40 cm) thick; and the branchlets are brown-hairy when young. The alternate leaves, pinnate or odd-pinnate, and 6 3/4 to 18 in (17-45 cm) long, have 2 to 5 pairs of opposite or nearly opposite leaflets, oblong-or elliptic-lanceolate, 2 1/2 to 7 in (6.25-17.5 cm) long and up to 2 in (5 cm) wide; slightly wavy, dark-green and barely glossy on the upper surface; pale, somewhat bluish, with a few short, silky hairs on the underside. Very small, greenish, petalless flowers with 4-5 hairy sepals, are borne singly or in clusters on the branches of the erect, axillary or terminal, panicles clothed with fine yellowish or brownish hairs. The fruit is ovoid, 2 or 3 in (5-7.5 cm) long, dark- or light-red, or yellow, its thick, leathery rind closely set with conical, blunt-tipped tubercles or thick, fleshy, straight spines, to 3/8 in (1 cm) long. There may be 1 or 2 small, undeveloped fruits nestled close to the stem. Within is the glistening, white or yellowish-white flesh (aril) to 3/8 in (1 cm) thick, more or less clinging to the thin, grayish-brown seedcoat (testa) which separates from the seed. The flavor is generally much sweeter than that of the rambutan. The seed is ovoid, oblong or ellipsoid, light-brown, somewhat flattened on one side, 3/4 to 1 1/3 in (2-3.5 cm) long.

Origin and Distribution

The pulasan is native to Western Malaysia. Wild trees are infrequent in lowland forests around Perak, Malaya but abundant in the Philippines at low elevations from Luzon to Mindanao. The tree has long been cultivated in Malaya and Thailand; is rarely domesticated in the Philippines. Ochse reported that there were extensive plantings in Java only around Bogor and the villages along the railway between Boger and Djakarta.

The tree was planted at the Trujillo Plant Propagation Station in Puerto Rico in 1926 and young trees from Java were sent to the Lancetilla Experimental Garden, Tela, Honduras, in 1927. The latter were said in 1945 to be doing well at Tela and fruiting moderately. The pulasan is little-known elsewhere in the New World except in Costa Rica where it is occasionally grown and the fruits sometimes appear on the market.

Varieties

Ochse refers to 2 forms of pulasan in Java: in one group, distinguished as ''Seebabat' or 'Kapoolasan seebabat', the fruit is mostly dark-red, the tubercles are crowded together, the flesh is very sweet and juicy and separates easily from the seed. In the other group, the fruit is light-red and smaller, the tubercles are not so closely set, and the flesh adheres firmly to the seed.

Wester mentions a fine variety growing in Jolo. The plants introduced into Honduras were 2 superior varieties called 'Asmerah Tjoplok' and 'Kapoelasan mera tjoplok'. There are some trees in Malaya and in Thailand that bear seedless fruits and these are being vegetatively propagated.

Climate

The pulasan is ultra-tropical and thrives only in very humid regions between 360 and 1,150 ft (110-350 in) of altitude. In Malaya, it is said that the tree bears best after a long, dry season.

Soil

There is little information on the soil requirements of the pulasan but Ochse says it must be constantly moist. He was of the opinion that the richer soil around Bogor contributed to the superior quality of the fruits grown in that area.

Propagation

Planting of seeds is not favored because the seedlings may be male or female. As with the rambutan, air-layers are very short-lived. Budding is successful if it is done in the rainy season on rootstocks already set out in the field so that they will not be subject to transplanting which causes many fatalities, particularly during dry weather.

Culture

The trees require less space than rambutan trees and can be 26 to 33 ft (8 to 10 m) apart each way.

As a rule, they receive little or no fertilizer or other cultural attention.

Food Uses

The flesh of ripe fruits is eaten raw or made into jam. Boiled or roasted seeds are used to prepare a cocoa-like beverage.

Food Value Per 100 g of Edible Portion*

Moisture	84.54-90.87 g
Protein	0.82 g
Carbohydrates	12.86 g
Fiber	0.14 g
Fat	0.55 g
Ash	0.43-0.45 g
Calcium	0.01-0.05 mg
Iron	0.002 mg

*Analyses made in the Philippines.

Toxicity

Hydrocyanic acid has been detected in the bark and leaves.

Other Uses

Oil: The dried seed kernels yield 74.9% of a solid, white fat, melting at 104º to 107.6º F (40º-42º C), to a faintly perfumed oil. Presumably, this could be utilized in soap-making.

Wood: The wood is light-red, harder and heavier than that of the rambutan and of excellent quality but rarely available.

Medicinal Uses: The leaves and roots are employed in poultices. The root decoction is administered as a febrifuge and vermifuge. Burkill says that the roots are boiled with *Gleichenia linearis* Clarke, and the decoction is used for bathing fever patients.

Morton, J. 1987. Mamoncillo. p. 267–269. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mamoncillo

Melicoccus bijugatus Jacq.

Melicocca bijuga L.

One of the minor fruits of the family Sapindaceae, the mamoncillo *(Melicoccus bijugatus* Jacq., syn. *Melicocca bijuga* L.) has, nevertheless acquired an assortment of regional names, such as: ackee (Barbados only; not to be confused with *Blighia sapida,* q.v.); genip, ginep, ginepe, guenepa, guinep (Barbados, Jamaica, Bahamas, Puerto Rico, Trinidad and Tobago); *grosella de miel* (Mexico); *guayo* (Mexico); honeyberry (Guyana); Jamaica bullace plum, kanappy (Puerto Rico); *kenet* (French Guiana); *knepa* (Surinam); *knepe* (French West Indies); *knippa* (Surinam); *limoncillo* (Dominican Republic); *macao* (Colombia, Venezuela); *maco* (Venezuela); *mamon* (Colombia, Venezuela, El Salvador, Nicaragua, Costa Rica, Panama, Argentina); *mamon de Cartagena* (Costa Rica); marmalade box (Guyana); *mauco* (Venezuela); *muco* (Colombia, Venezuela); *quenepa* (Dominican Republic, Puerto Rico, Colombia); *quenepe* (Haiti); *quenett* (French Guiana); *sensiboom* (Surinam); Spanish lime (Florida); *tapaljocote* (El Salvador).

Description

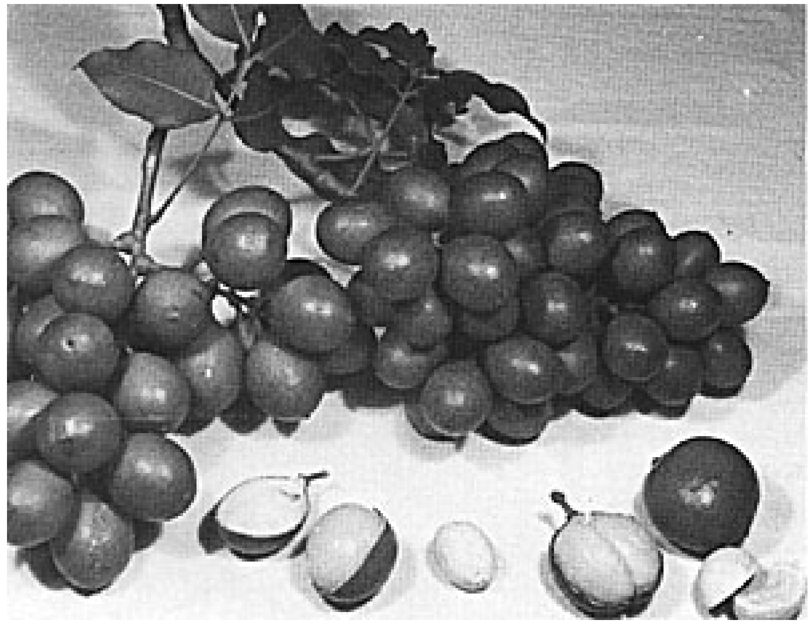


Fig. 75: The mamoncillo *(Melicoccus bijugatus)*, with its large seeds and thin layer of adhering flesh, provides little but juice.

The mamoncillo tree is slow-growing, erect, stately, attractive; to 85 ft (25 m) high, with trunk to 5 1/2 ft (1.7 m) thick; smooth, gray bark, and spreading branches. Young branchlets are reddish. The leaves are briefly deciduous, alternate, compound, having 4 opposite, elliptic, sharp-pointed leaflets 2 to 5 in (5-12.5 cm) long and 1 1/4 to 2 1/2 in (3.25-6.25 cm) wide, the rachis frequently conspicuously winged as is that of the related soapberry *(Sapindus saponaria* L.). The flowers, in slender racemes 2 1/3 to 4 in (6-10 cm) long, often clustered in terminal panicles, are fragrant, white, 1/5 to 1/3 in (5-8 mm) wide, with 4 petals and 8 stamens. Male and female are usually borne on separate trees but some trees are partly polygamous. The fruit clusters are branched, compact and heavy with nearly round, green fruits tipped with a small protrusion, and suggesting at first glance small unripe limes, but there the resemblance ends. The skin is smooth, thin but leathery and brittle. The glistening pulp (aril) is salmon-colored or yellowish, translucent, gelatinous, juicy but very scant and somewhat fibrous, usually clinging tenaciously to the seed. When fully ripe, the pulp is pleasantly acid-sweet but if unripe acidity predominates. In most fruits there is a single, large, yellowish-white, hard-shelled seed, while some have 2 hemispherical seeds. The kernel is white, crisp, starchy, and astringent.

Origin and Distribution

The mamoncillo is native to Colombia, Venezuela, and the island of Margarita, also French Guiana, Guyana and Surinam. It is commonly cultivated and spontaneous in those countries, also in coastal Ecuador, the lowlands of Central America, the West Indies and in the Bahamas. In Florida, it is occasionally grown as far north as Ft. Myers on the West Coast and Palm Beach on the east; is much more plentiful in Key West, especially as a street tree. There are some specimens in California and in botanical gardens in the Philippines, Zanzibar, Hawaii and elsewhere. According to Britton, there was a tree about 30 ft (9 m) tall in Bermuda in 1914 but it had never bloomed. There are a few trees in Israel but none has flowered before 10 years of age.

Varieties

Little horticultural attention has been given this fruit. In the 1950's, a large-fruited, sweet type was found in Key West. Air-layers and inarchings were made in order to permit trial of this type on the mainland. In the 1960's, horticulturist George Jackson evaluated the fruits of 54 trees in southern Puerto Rico. Fruits with less than 45% edible pulp and 20% total sugars were disregarded. He rated 9 trees as meriting further testing. Of these, 4 were selected as having the most desirable qualities. Their main characters were listed as follows:

'Puerto Rico #1'–round, of medium size, 28 to the lb (62/kg); flesh firm, semi-dry, separating easily from the seed; sweet, with 26.0% sugars.

'Puerto Rico #2'–round, of medium size, 27 to the pound (60/kg); rind medium-thick; flesh firm, semi-dry, separating easily from seed; sweet, 24.1% total sugars.

'Puerto Rico #3'–round -oblong, small, 49 to the pound (108/kg); rind thin, pliable; flesh firm, semi-dry, separating easily from the seed; very sweet, 24.1% total sugars.

'Puerto Rico #4'–round, medium-small, 40 to the lb (88/kg); rind medium-thin, flesh firm, semi-dry, separating easily from seed; agreeably acid and slightly sweet; 22.7% total sugar.

The percentage of edible matter by fruit-weight ranged from 46.6% to 48.6%.

In 1976, Dr. Carl Campbell of the University of Florida's Agricultural Research and Education Center in Homestead, Florida, reported on his comparison of 3 selections made by interested individuals and an ordinary seedling growing at the Center. The latter, labeled 'No. 1', was graded as: small, 49.1% pulp, but of only fair flavor, and poor annual yield.

'No. 2', or **'Queen'**, brought by W.F. Whitman from Key West; large, 55.6% pulp, only fair in flavor, and medium in yield.

'No. 3', brought by R.G. Newcomb from Key West; of good size, 48.2% pulp; of good flavor and borne heavily in most years.

'No. 4', or **'Montgomery'**, from the Montgomery (later, Jennings) Estate in Coral Gables; large, with sometimes 18% of crop having 2 seeds; 51.5% pulp; of good flavor, and borne heavily in most years.

Pollination

Generally, the presence of a male tree is necessary to pollinate the flowers of trees that are predominantly female (or hermaphrodite functioning as female). However, in Cuba, some trees have sufficient numbers of flowers of both sexes to yield regularly large crops without interplanting.

Climate

The mamoncillo is not strictly tropical, for it ascends up to 3,300 ft (1,000 m) above sea-level in South America. It can stand several degrees of frost in Florida. Nevertheless, it is too tender to fruit in California though it has been planted there on various occasions. It is well adapted to areas of low rainfall. That of Key West ranges from 30 to 50 in (75-125 cm) annually. The tree can tolerate long periods of drought.

Soil

In Cuba, the tree is said to flourish in nearly all types of terrain but particularly in deep, rich soil of calcareous origin. It seems perfectly at home in the oolitic-limestone of southern Florida and the Florida Keys. In Colombia, it has been observed to grow on such poor soils that it has been adopted for planting in soil reclamation efforts. It is spontaneous especially in dry, coastal districts.

Propagation

The mamoncillo is usually grown from seed but superior types should be vegetatively reproduced. Air-layering of fairly large branches, at least 2 in (5 cm) in diameter, is successful in the summer and there will be adequate root development in 5 to 6 weeks. Approach-grafting is feasible provided the rootstocks are raised in a lightweight medium, in plastic bags to facilitate attachment to the selected tree. Attempts to veneer-graft or chip-bud have generally failed.

Culture

Ordinarily, the mamoncillo, tree is given no care except for watering and fertilizing when first planted. Vegetatively propagated trees bear earlier than seedlings.

Season and Harvesting

In Florida, the fruits ripen from June to September. In the Bahamas, the season extends from July to October. Ladders and picking poles equipped with cutters are necessary in harvesting fruits from tall trees. The entire cluster is clipped from the branch when sampling indicates that the fruits are fully ripe. At this stage, the rind becomes brittle but does not change color. If picked prematurely, the rind turns blackish, a sign of deterioration.

Keeping Quality

Because of the leathery skin, the fruit remains fresh for a long time and ships and markets well. The tropical horticulturist, David Sturrock, related that horsemen in Cuba often hung branches of mamoncillos on the saddle horn to enjoy and relieve thirst during long rides.

Pests and Diseases

The tree is a host of the Citrus black fly, *Aleurocanthus woglumi*. There are several parasites (*Prospaltella* spp., *Eretmocerus serius*, and *Amitus hesperidium*) which provide effective control of this pest. In Florida, *Armillariella (Clitocybe) tabescens* causes mushroom root rot; *Fusarium* and *Phyllosticta* cause leaf spot; and *Cephaleuros virescens*, algal leaf spot and green scurf.

Food Uses

For eating out-of-hand, the rind is merely torn open at the stem end and the pulp-coated seed is squeezed into the mouth, the juice being sucked from the pulp until there is nothing left of it but the fiber. With fruits that have non-adherent pulp, the latter may be scraped from the seed and utilized to make pie-filling, jam, marmalade or jelly, but this entails much work for the small amount of edible material realized. More commonly, the peeled fruits are boiled and the resulting juice is prized for cold drinks. In Colombia, the juice is canned commercially.

The seeds are eaten after roasting. Indians of the Orinoco consume the cooked seeds as a substitute for cassava.

Food Value Per 100 g of Edible Portion*

Calories	58.11-73

Moisture	68.8-82.5 g
Protein	0.50-1.0 g
Fat	0.08-0.2 g
Carbohydrates	13.5-19.2 g
Fiber	0.07-2.60 g
Ash	0.34-0.74g
Calcium	3.4-15 mg
Phosphorus	9.8-23.9 mg
Iron	0.47-1.19 mg
Carotene	0.02-0.44 mg (70 I.U.)
Thiamine	0.03-0.21 mg
Riboflavin	0.01-0.20 mg
Niacin	0.15-0.90 mg
Ascorbic Acid	0.8-10 mg
Tannin	1.88 g
Amino Acids	
Tryptophan	14 mg
Methionine	0
Lysine	17 mg

*Analyses made in Cuba, Central America and Colombia.

Seed Hazard

It has been said that the pulp fibers coat the lining of the stomach, adversely affecting the health, but this has been denied by the Government Chemist of the Department of Science and Agriculture in Jamaica who declares that fatalities in children are the result of choking on the seed. When coated with pulp, it is very slippery, is accidentally swallowed and, because of its size, lodges in the throat, causing suffocation or strangulation.

Other Uses

Juice: A dye has been experimentally made from the juice of the raw fruit which makes an indelible stain.

Flowers: The flowers are rich in nectar and highly appealing to hummingbirds and honeybees. The honey is somewhat dark in color but of agreeable flavor. The tree is esteemed by Jamaican beekeepers though the flowering season (March/April) is short.

Leaves: In Panama, the leaves are scattered in houses where there are many fleas. It is claimed that the fleas are attracted to the leaves and are cast out with the swept-up foliage. Some believe that the leaves actually kill the fleas.

Wood: The heartwood is yellow with dark lines, compact, hard, heavy, fine-grained; inclined to decay out of doors, but valued for rafters, indoor framing, and cabinetwork.

Medicinal Uses: In Venezuela, the astringent roasted seed kernels are pulverized, mixed with honey and given to halt diarrhea. The astringent leaf decoction is given as an enema for intestinal complaints.

Morton, J. 1987. Akee. p. 269–271. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Akee

Blighia sapida K. Konig

Cupania sapida Voigt.

More widely known for its poisonous properties than as an edible fruit, the akee, *Blighia sapida* K. Konig (syn. *Cupania sapida* Voigt.), of the family Sapindaceae, is sometimes called ackee, akee apple, or vegetable brain *(seso vegetal* in Spanish). Other Spanish names are *arbol de seso, palo de seso* (Cuba); *huevo vegetal* and *fruto de huevo* (Guatemala and Panama); *arbor del huevo* and *pera roja* (Mexico); *merey del diablo* (Venezuela); *bien me sabe* or *pan y quesito* (Colombia); *akí* (Costa Rica). In Portuguese, it is *castanha* or *castanheiro de Africa.* In French, it is *arbre fricassé* or *arbre a fricasser* (Haiti); *yeux de crabe* or *ris de veau* (Martinique). In Surinam it is known as *akie*. On the Ivory Coast of West Africa, it is called *kaka or finzan;* in the Sudan, *finza*. Elsewhere in Africa it is generally known as *akye*, *akyen* or *ishin*, though it has many other dialectal names. In the timber trade, the wood is marketed as *achin.*
It should be noted that the name "akee" may refer to the mamoncillo, q.v., in Barbados. As a colloquial term for the mamoncillo it may be a corruption of the Mayan "acche" which was applied to several plants whose flowers attract honeybees.

Description

The tree, reaching 33 to 40 ft (10-12 m), is rather hand some, usually with a short trunk to 6 ft (1.8 m) in circumference, and a dense crown of spreading branches. Its bark is gray and nearly smooth.

The evergreen (rarely deciduous), alternate leaves are compound with 3 to 5 pairs of oblong, obovate-oblong, or elliptic leaflets, 6 to 12 in (15-30 cm) long, rounded at the base, short-pointed at the apex; bright-green and glossy on the upper surface, dull and paler and finely hairy on the veins on the under side. Bisexual and male flowers, borne together in simple racemes 3 to 7 in (7.5-17.5 cm) long, are fragrant, 5 petalled, white and hairy. The fruit is a leathery, pear shaped, more or less distinctly 3-lobed capsule 2 3/4 to 4 in (7-10 cm) long; basically yellow, more or less flushed with bright-scarlet. When it is fully mature, it splits open revealing 3 cream-colored, fleshy, glossy arils, crisp, somewhat nutty-flavored, attached to the large, black, nearly round, smooth, hard, shining seeds–nonnally 3; often 1 or 2 may be aborted. The base of each aril is attached to the inside of the stem-end of the "jacket" by pink or orange-red membranes.

Fig. 76: The akee *(Blighia sapida)* from Africa is a favorite in Jamaica but the fleshy arils are poisonous until fully exposed to light. The seeds are always poisonous.

Origin and Distribution

The akee is indigenous to the forests of the Ivory Coast and Gold Coast of West tropical Africa where it is little eaten but various parts have domestic uses. In Ghana, the fruiting tree is admired as an ornamental and is planted in villages and along streets for shade. The akee was brought to Jamaica in 1793 by the renowned Captain Bligh to furnish food for the slaves. It was readily adopted and became commonly grown in dooryards and along roadsides and, to some extent, naturalized. The arils still constitute a favorite food of the island and the fruit is featured in a calypso despite the health hazards associated with it. Canned arils are exported to the United Kingdom where they are welcomed byJamaican immigrants. Importation has been banned by the United States Food and Drug Administration.

The akee was planted also in Trinidad and Haiti and some other islands of the West Indies and the Bahamas and apparently was carried by Jamaican slaves to Panama and the Atlantic Coast of Guatemala and Costa Rica. In 1900 it was outlawed in Trinidad after it had caused some fatalities. There are scattered trees in Surinam, Venezuela, Colombia, Ecuador and Brazil, quite a number maintained as curiosities in southern Florida; and some planted around Calcutta, India. The tree has been tried in the warm, moist climate of Guyana and Malaya but has never survived. At Lamao in the Philippines it first bore fruit in 1919.

Climate

The akee tree is tropical to subtropical; flourishes from sea-level to an elevation of 3,000ft (900 m) in Jamaica. It does not bear fruit in Guatemala City; fruits heavily in southern Florida where young trees have been killed by winter cold but mature trees have escaped serious injury during brief periods of 26° F (-3.33° C).

Soil

The tree does very well on oolitic limestone and on sand in southern Florida and the Bahamas, though it grows faster in more fertile soils.

Propagation and Culture

Akee trees are grown from seeds or by shield-budding, and show very little variation. In European greenhouses, cuttings of ripe shoots are rooted in sand and raised in a mixture of peat and loam. In warm climates, the tree grows fast and requires little cultural attention.

Season

There is some flowering and fruiting all year in Jamaica. In Florida, flowers appear in spring and the fruits in mid summer and there may be a light blooming period in the fall. In the Bahamas, there are 2 distinct crops a year, one from February through April and the second from July to October.

Food Uses

The akee must be allowed to open fully or at least partly before it is detached from the tree. When it has "yawned", the seeds are discarded and the arils, while still fresh and firm, are best parboiled in salted water or milk and then lightly fried in butter. Then they are really delicious. In Jamaica, they are often cooked with codfish, onions and tomatoes. After parboiling, they are added to a stew of beef, salt-pork and scallions, thyme and other seasonings. Sometimes they are curried and eaten with rice. They are served, not only in the home, but also in hotel dining rooms and other restaurants. In Africa, they may be eaten raw or in soup, or after frying in oil.

Food Value Per 100 g of Raw Arils*

Moisture	57.60 g
Protein	8.75 g
Fat	18.78 g
Fiber	3.45 g
Carbohydrates	9.55 g
Ash	1.87 g
Calcium	83 mg
Phosphorus	98 mg
Iron	5.52 mg
Carotene	--
Thiamine	0.10 mg
Riboflavin	0.18 mg
Niacin	3.74 mg
Ascorbic Acid	65 mg

*Analyses made in Mexico.

Toxicity

The toxicity of the akee was long misunderstood and believed to reside in the membranes attaching the arils to the jacket, or only in the overripe and decomposing arils. There have been intensive clinical and chemical studies of the akee and its effects since 1940, and it is now known that the unripe arils contain hypoglycin, *a*-amino-*B*-(2-methylenecyclopropyl) propionic acid, formerly called hy poglycin A. This toxic property is largely dispelled by light as the jacket opens. When fully ripe, the arils still possess 1/12 of the amount in the unripe. The seeds are always poisonous. They contain hypoglycin and its y-glutamyl derivative, *y*-L-glutamyl *a*-amino-*B*-(2-methylene cyclopropyl) propionic acid, formerly called hypoglycin B. The latter is 1/2 as toxic as the former.

In feeding experiments at the University of Miami, Dr. Edward Larson found that the membrane of open fruits was harmless; rabbits were readily killed by the unripe arils; rats were resistant and had to be force fed to be fatally poisoned. I have found that squirrels will make holes in the unopened fruits on the tree to consume the unripe arils but they leave the seeds untouched.

Akee poisoning in humans is evidenced by acute vomiting, sometimes repeated, without diarrhea (called "vomiting sickness" in Jamaica), followed by drowsiness, convulsions, coma and, too often, death. Because of hypoglycaemic effects, administration of sugar solutions have been found helpful. Most cases occur in winter in Jamaica when 30% to 50% of the arils have small, underdeveloped seeds, often not apparent externally. Ingestion of such arils, raw or cooked, is hazardous. For more information on the toxicity of the akee, one may consult Kean, *Hypoglycin* (1975), and Morton, *Forensic Medicine*, Vol. III, Chap. 71 (1977).

Other Uses

Fruit: In West Africa, the green fruits, which produce lather in water, are used for laundering. Crushed fruits are employed as fish poison. The seeds, because of their oil content, and the jacket because of its potash content, are burned and the ashes used in making soap.

Flowers: In Cuba an extract of the flowers is appreciated as cologne.

Bark: On the Gold Coast, a mixture of the pulverized bark and ground hot peppers is rubbed on the body as a stimulant.

Wood: The sapwood is white or light greenish-brown. The heartwood is reddish-brown, hard, coarse-grained, durable, immune to termites. It is used locally for construction and pilings and has been recommended for railway sleepers. It is also fashioned into oars, paddles and casks.

Medicinal Uses: In Brazil, repeated small doses of an aqueous extract of the seed has been administered to expel parasites. The treatment is followed by a saline or oily purative. Cubans blend the ripe arils with sugar and cinnamon and give the mixture as a febrifuge and as a treatment for dysentery. On the Ivory Coast, the bark is mixed with pungent spices in an ointment applied to relieve pain. The crushed new foliage is applied on the forehead to relieve severe headache. The leaves, crushed with salt, are poulticed on ulcers. The leaf juice is employed as eye drops in ophthalmia and conjunctivitis. In Colombia, the leaves and bark are considered stomachic. Various preparations are made for treatment of epilepsy and yellow fever.

Morton, J. 1987. Indian Jujube. p. 272–275. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Indian Jujube

Ziziphus mauritiana Lam.

Ziziphus jujuba L.

While the better-known, smooth-leaved Chinese jujube *(Ziziphus jujuba* Mill.) of the family Rhamnaceae, is of ancient culture in northern China and is widely grown in mild-temperate, rather dry areas, of both hemispheres, the Indian jujube, *Z. mauritiana* Lam. (syn. *Z. jujuba* L.) is adapted to warm climates. It is often called merely jujube, or Chinese date, which leads to confusion with the hardier species. Other English names are Indian Plum, Indian cherry and Malay jujube. In Jamaica it may be called coolie plum or crabapple; in Barbados, dunk or mangustine; in Trinidad and Tropical Africa, dunks; in Queensland, Chinee apple. In Venezuela it is *ponsigne* or *yuyubo;* in Puerto Rico, *aprin* or *yuyubi;* in the Dominican Republic, *perita haitiana;* in the

French-speaking West Indies, *pomme malcadi, pomme surette, petit pomme, liane croc chien, gingeolier* or *dindoulier.* In the Philippines it is called *manzana* or *manzanita* ("apple" or "little apple"); in Malaya, *bedara;* in Indonesia and Surinam, *widara;* in Thailand, *phutsa* or *ma-tan;* in Cambodia, *putrea;* in Vietnam, *tao* or *tao nhuc.* In India it is most commonly known as *ber,* or*bor.*

Description

Plate XXXV: INDIAN JUJUBE, *Zizyphus mauritiana*

The plant is a vigorous grower and has a rapidly-developing taproot. It may be a bushy shrub 4 to 6 ft (1.2-1.8 m) high, or a tree 10 to 30 or even 40 ft (3-9 or 12 m) tall; erect or wide-spreading, with gracefully drooping branches and downy, zigzag branchlets, thornless or set with short, sharp straight or hooked spines. It may be evergreen, or leafless for several weeks in hot summers. The leaves are alternate, ovate- or oblong-elliptic, 1 to 2 1/2 in (2.5-6.25 cm) long, 3/4 to 1 1/2 in (2-4 cm) wide; distinguished from those of the Chinese jujube by the dense, silky, whitish or brownish hairs on the underside and the short, downy petioles. On the upper surface, they are very glossy, dark-green, with 3 conspicuous, depressed, longitudinal veins, and there are very fine teeth on the margins.

The 5-petalled flowers are yellow, tiny, in 2's or 3's in the leaf axils. The fruit of wild trees is 1/2 to 1 in (1.25-2.5 cm) long. With sophisticated cultivation, the fruit reaches 2 1/2 in (6.25 cm) in length and 1 3/4 in (4.5 cm) in width. The form may be oval, obovate, round or oblong; the skin smooth or rough, glossy, thin but tough, turns from light-green to yellow, later becomes partially or wholly burnt-orange or red-brown or all-red. When slightly underripe, the flesh is white, crisp, juicy, acid or subacid to sweet, somewhat astringent, much like that of a crabapple. Fully ripe fruits are less crisp and somewhat mealy; overripe fruits are wrinkled, the flesh buff-colored, soft, spongy and musky. At first the aroma is applelike and pleasant but it becomes peculiarly musky as the fruit ages. There is a single, hard, oval or oblate, rough central stone which contains 2 elliptic, brown seeds, 1/4 in (6 mm) long.

Origin and Distribution

The Indian jujube is native from the Province of Yunnan in southern China to Afghanistan, Malaysia and Queensland, Australia. It is cultivated to some extent throughout its natural range but mostly in India where it is grown commercially and has received much horticultural attention and refinement despite the fact that it frequently escapes and becomes a pest. It was introduced into Guam about 1850 but is not often planted there or in Hawaii except as an ornamental. Specimens are scattered about the drier parts of the West Indies, the Bahamas, Colombia and Venezuela, Guatemala, Belize, and southern Florida. In Barbados, Jamaica and Puerto Rico the tree is naturalized and forms thickets in uncultivated areas. In 1939, 6 trees from Malaysia were introduced into Israel and flourished there. They bore very light crops of fruit heavily infested with fruit flies and were therefore destroyed to protect other fruit trees.

Varieties

In India, there are 90 or more cultivars differing in the habit of the tree, leaf shape, fruit form, size, color, flavor, keeping quality, and fruiting season. Among the important cultivars, eleven are described in the encyclopaedic *Wealth of India:* **'Banarasi** (or Banarsi) **Pewandi', 'Dandan', 'Kaithli'** ('Patham'), **'Muria Mahrara', 'Narikelee', 'Nazuk', 'Sanauri 1', 'Sanauri 5', 'Thornless' and 'Umran'** ('Umri'). The skin of most is smooth and greenish-yellow to yellow.

At Haryana Agricultural University, a study was made of 70 cultivars collected from all jujube-growing areas of northern India and set out in an experimental orchard in 1967-68. In 1980, 16 midseason selections from these were evaluated. **'Banarasi Karaka'** (poor-flavored) gave the highest yield-286 lbs (130 kg) per tree-followed by 'Mudia Murhara' and 'Kaithli' (both of good flavor), and 'Sanauri 5' and **'Desi Alwar'** (both of medium flavor). It was decided that 'Mudia Murhara', 'Kaithli' and 'Sanauri 5' were worthy of commercial cultivation. For breeding purposes, 'Banarasi Karaka' and 'Desi Alwar' could contribute high pulp content; 'Mudia Murhara', total soluble solids; 'Kaithli', high ascorbic acid content and good flavor, in efforts to develop a superior midseason cultivar.

In 1982, 4 were singled-out as the most promising cultivars:

'Umran'–large, golden-yellow turning chocolate-brown when fully ripe; sweet; 19% TSS; 0.12% acidity; average fruit weight, 30-89 g; yield, 380-440 lbs (150-200 kg) per tree; late-ripening; of good keeping and shipping quality.

'Gola'–medium to large (average, 14-17 g); 17-19% TSS; 0.46-0.51% acidity; golden-yellow, juicy, of good flavor; yield, 175-220 lbs (80-100 kg) per tree. Earliest to ripen; sells at a high price.

'Kaithli'–of medium size (average 180.0 g); 18% TSS; 0.5% acidity; pulp soft and sweet. Average yield, 220-330 lbs (100-150 kg).

'Katha phal'–small to medium (average 10.0 g); greenish blushed on one cheek with reddish-yellow; 23% TSS; 0.77% acidity; yield, medium, 175-220 lbs (80- 100 kg) per tree. Late in season.

In addition to these, 5 cultivars have been described at the Indian Agricultural Research Institute, New Delhi. All are grown in Delhi, the southeastern Punjab and neighboring Uttar Pradesh. Their special features are, briefly, as follows:

'Dandan'–non-spiny; fruit medium to large; of fairly good quality; keeps well. Late in season.

'Gular Bashi'–fruit of medium size, juicy, sweet, nonacrid; of excellent quality when fresh, musky after storage. TSS 18.8% when yellow, 22.4% after turning brown. Stone medium to thin, funnel-shaped, easily separated from the flesh. Late in season. Keeps well.

'Kheera'–medium to large, oval with a beak; pulp soft, juicy, of good, sweet flavor. TSS 19.8%. Late; a heavy bearer; of fairly good keeping quality.

'Nazuk'–medium to small, elliptic-oblong; pulp slimy, fairly juicy; of good, sweet flavor, nearly without astringency. TSS 17.4%. Midseason. A moderate bearer. Of poor keeping quality.

'Seo ber' ('Seb')–medium to large; skin thick; pulp moderately juicy, astringent unless peeled or not eaten until light-brown, when it is very sweet and excellent. TSS 19%. Stone large, thick, pitted. Late in season. Keeps very well.

In Assam 5 wild or cultivated types, collected from various parts of the state, have been described by S. Dutta:

'Var. 1'–a very thorny wild shrub, with small, round, inferior fruits; grown as a fence to protect crops.

'Var. 2'–a wild, thorny tree to 30 ft (9 m) with red-brown, tough-skinned fruit having slimy, acid-sweet pulp. Much eaten by children and rural folk. Commonly used in cooking and preserving.

'Var. 3'–a very thorny, spreading tree. Fruit dark-red or brown, with sour pulp. Bears heavily. Planted for shade.

'Var. 4' ('Bali bogri')–a wild, thornless tree, with greenish-yellow fruits blushed with red; pulp slightly slimy, mealy, sweet-and-acid, of good flavor. Bears heavily.

'Var. 5' ('Tenga-mitha-bogri')–A wild, thorny tree, with oblong, brownish fruit; pulp slightly slimy, sweet-and-acid, with very pleasant flavor. Bears heavily. A choice jujube recommended for vegetative propagation and commercial cultivation.

Pollination

Pollen of the Indian jujube is thick and heavy. It is not airborne but is transferred from flower to flower by honeybees (*Apis* spp.), a yellow wasp *(Polister hebraeus)*, and the house fly *(Musca domestica)*.

The cultivars 'Banarasi Karaka', 'Banarasi Pewandi' and 'Thornless' are self-incompatible. 'Banarasi Karaka' and 'Thornless' are reciprocally cross-incompatible.

Climate

In China and India, wild trees are found up to an elevation of 5,400 ft (1,650 m) but commercial cultivation extends only up to 3,280 ft (1,000 m). In northern Florida, it is sensitive to frost. Young trees may be frozen to the ground but will recover. Mature trees have withstood occasional short periods of freezing temperatures without damage. In India, the minimum shade temperature for survival is 44.6º to 55.4º F (7º-13º C); the maximum, 98.6º to 118º F (37º-48º C). The tree requires a fairly dry climate with an annual rainfall of 6 to 88.5 in (15-225 cm), being unsuited to the lower, wetter parts of Malaysia. For high fruit production, the tree needs full sun.

Soil

In India, the tree does best on sandy loam, neutral or slightly alkaline. It also grows well on laterite, medium black soils with good drainage, or sandy, gravelly, alluvial soil of dry river-beds where it is vigorously spontaneous. Even moderately saline soils are tolerated. The tree is remarkable in its ability to tolerate water-logging as well as drought.

Propagation

The Indian jujube is widely grown from seeds, which may remain viable for 2 1/2 years but the rate of germination declines with age. Superior selections are grafted or budded onto seedlings of wild types. Vegetative propagation of highly prized varieties was practiced near Bombay about 1835 but kept secret until 1904, and then was quickly adopted by many people. Ring-budding has been popular in the past but has been largely superseded by shield-budding or T-budding. Grafted plants are less thorny than seedlings.

To select seeds for growing rootstocks, the stones must be taken from fruits that have fully ripened on the tree. They are put into a 17 to 18% salt solution and all that float are discarded. The stones that sink are dipped in 500 ppm thiourea for 4 hours, then cracked and the separated seeds will germinate in 7 days. Seeds in uncracked stones require 21 to 28 days. If seeds are sown in spring, the seedlings will be ready for budding in 4 months. Great care must be taken in transplanting nursery stock to the field because of the taproot. Therefore, the rootstocks may be raised directly in the field and budding done *in situ*. Inferior seedling trees, including wild trees, can be topworked to preferred cultivars in June and some fruit will be borne a year later. From 1935 to 1939, the Punjab Department of Agriculture top-worked 50,000 trees without cost to the growers. Air-layers will root if treated with IBA and NAA at 5,000 to 7,500 ppm and given 100 ppm boron. Cuttings of mature wood at least 2 years old can be rooted and result in better yields than those taken at a younger stage.

At Punjab University, horticulturists have experimented with stooling as a means of propagation. They transplanted one-year-old seedlings into stool beds, cut them back to 4 in (10 cm), found that the shoots would root only if ringed and treated with IBA, preferably at 12,000 ppm.

Culture

Untrimmed trees must be spaced at 36 to 40 ft (11-12 m), but carefully pruned trees can be set at 23 to 26 ft (7-8 m). Pruning should be done during the first year of growth to reduce the plant to one healthy shoot, and branches lower than 30 in (75 cm) should be removed. At the end of the year, the plant is topped. During the 2nd and 3rd years, the tree is carefully shaped. Thereafter, the tree should be pruned immediately after harvesting at the beginning of dormancy and 25 to 50% of the previous year's growth may be removed. Sometimes a second lighter pruning is performed just before flowering. There will be great improvement in size, quality and number of fruits the following season.

In India, it has been traditional to apply manure and ash as fertilizer, but, in recent years, each tree has been given annual treatments of 22 lbs (10 kg) manure with 1.1 lbs (0.5 kg) ammonium sulphate for every year of age up to the 5th year. More advanced farmers utilize only commercial fertilizer (NPK) in larger amounts, twice annually, the first at the rate of 110 lbs/acre (about 110 kg/ha) and the second at 172 lbs/acre (about 172 kg/ha). Growth regulators are now being utilized to bring about early and heavier blooming, enhance fruit setting, prevent fruit drop, and increase fruit size, and promote uniform ripening. These practices have demonstrated that an improved crop can bring in 2 to 3 times the revenue of that achieved by conventional practices.

During hot weather and also in the period of fruit development, irrigation is highly beneficial.

Water-stress will cause immature fruit drop. In India, water has been applied as many as 35 times during the winter months. Zinc and boron sprays are sometimes applied to enhance glossiness of the fruits.

Season and Harvesting

In India, some types ripen as early as October, others from mid-February to mid-March, others in March, or mid-March, to the end of April. In the Assiut Governorate, there are 2 crops a year, the main in early spring, the second in the fall. In India, 2 or 3 pickings are done by hand from ladders, a worker being capable of manually harvesting about 110 lbs (50 kg) per day. The fruits remaining on the tree are shaken down. After wrapping in white cloth, the fruits are put into paper-lined burlap bags holding 110 lbs (50 kg) for long trips to markets throughout the country.

Yield

Seedling trees bear 5,000 to 10,000 small fruits per year in India. Superior grafted trees may yield as many as 30,000 fruits. The best cultivar in India, with fruits normally averaging 30 to the lb (66 to the kg), yields 175 lbs (77 kg) annually. Special cultural treatment increases both fruit size and yield.

Keeping Quality

The Indian jujube stands handling, shipment and marketing very well. Storage experiments in India showed that slightly underripe fruits ripen and keep for 8 days under wheat straw, 7 days under leaves, and 4 days in carbide (50 to 60 g).

Pests and Diseases

The greatest enemies of the jujube in India are fruit flies, *Carpomyia vesuviana* and *C. incompleta.* Some cultivars are more susceptible than others, the flies preferring the largest, sweetest fruits, 100% of which may be attacked while on a neighboring tree, bearing a smaller, less-sweet type, only 2% of the crop may be damaged. The larvae pupate in the soil and it has been found that treatment of the ground beneath the tree helps reduce the problem. Control is possible with regular and effective spraying of insecticide.

A leaf-eating caterpillar, *Porthmologa paraclina,* and the green slug caterpillar, *Thosea* sp., attack the foliage. A mite, *Larvacarus transitans,* forms scale-like galls on twigs retarding growth and reducing the fruit crop.

Lesser pests include a small caterpillar, *Meridarches scyrodes,* that bores into the fruit; the gray-hairy caterpillar, *Thiacidas postica,* also *Tarucus theophrastus*, *Myllocerus transmarinus,* and *Xanthochelus superciliosus.*

The tree is subject to shrouding by a parasitic vine *(Cuscuta spp.).* Powdery mildew *(Oidium sp.)* causes defoliation and fruit-drop. Sooty mold *(Cladosporium zizyphi)* causes leaves to fall. Leafspot results from infestation by *Cercospora* spp. and *Isariopsis indica* var. *zizyphi.* In 1973, a witches'-broom disease caused by a mycoplasma-like organism was found in jujube plants near Poona University. It proved to be transmitted by grafting or budding diseased scions onto healthy *Z. mauritiana* seedlings. Leaf rust, caused by *Phakopsora zizyphivulgaris,* ranges from mild to severe on all commercial cultivars in the Punjab.

Fruits on the tree are attacked by *Alternaria chartarum, Aspergillus nanus, A. parasiticus, Helminthosporium atroolivaceum, Phoma hessarensis,* and *Stemphyliomma valparadisiacum.* Twigs and branches may be affected by *Entypella zizyphi, Hypoxylon hypomiltum,* and *Patellaria atrata.* In storage, the fruits may be spotted by the fungi, *Alternaria brassicicola, Phoma* spp., *Curvularia lunata, Cladosporium herbarum.* Fruit rots are caused by *Fusarium* spp., *Nigrospora oryzae, Epicoccum nigrum,* and *Glomerella cingulata.*

Food Uses

In India, the ripe fruits are mostly consumed raw, but are sometimes stewed. Slightly underripe fruits are candied by a process of pricking, immersing in a salt solution gradually raised from 2 to 8%, draining, immersing in another solution of 8% salt and 0.2% potassium metabisulphite, storing for 1 to 3 months, rinsing and cooking in sugar sirup with citric acid. Residents of Southeast Asia eat the unripe fruits with salt. Ripe fruits crushed in water form a very popular cold drink. Ripe fruits are preserved by sun-drying and a powder is prepared for out-of-season purposes. Acid types are used for pickling or for chutneys. In Africa, the dried and fermented pulp is pressed into cakes resembling gingerbread.

Young leaves are cooked and eaten in Indonesia. In Venezuela, a jujube liqueur is made and sold as *Crema de ponsigue.* Seed kernels are eaten in times of famine.

Food Value Per 100 g of Edible Portion	
**Fruits, fresh:*	
Moisture	81.6-83.0 g
Protein	0.8 g
Fat	0.07 g
Fiber	0.60 g
Carbohydrates	17.0 g
Total Sugars	5.4-10.5 g
Reducing Sugars	1.4-6.2 g
Non-Reducing Sugars	3.2-8.0 g
Ash	0.3-0.59 g
Calcium	25.6 mg
Phosphorus	26.8 mg
Iron	0.76-1.8 mg
Carotene	0.021 mg
Thiamine	0.02-0.024 mg
Riboflavin	0.02-0.038 mg
Niacin	0.7-0.873 mg
Citric Acid	0.2-1.1 mg
Ascorbic Acid	65.8-76.0 mg

Fluoride	0.1-0.2 ppm
Pectin (dry basis)	2.2-3.4%
The fresh fruits also contain some malic and	oxalic acid and quercetin.
* *Fruits, dried:*	
Calories	473/lb (1,041/kg)
Moisture	68.10 g
Protein	1.44 g
Fat	0.21 g
Carbohydrates	2.47 g
Sugar	21.66 g
Fiber	1.28 g

*Analyses made in India and Honduras.

**Analyses made in the Philippines.

Toxicity

In Ethiopia, the fruits are used to stupefy fish (possibly there is sufficient saponin for this purpose). The leaves contain saponin because they are known to produce lather if rubbed in water.

Other Uses

Wood: The wood is reddish, close-grained, fine-textured, hard, tough, durable, planing and polishing well. It has been used to line wells, to make legs for bedsteads, boat ribs, agricultural implements, house poles, tool handles, yokes, gunstocks, saddle trees, sandals, golf clubs, household utensils, toys and general turnery. It is also valued as firewood; is a good source of charcoal and activated carbon. In tropical Africa, the flexible branches are wrapped as retaining bands around conical thatched roofs of huts, and are twined together to form thorny corral walls to retain livestock.

Leaves: The leaves are readily eaten by camels, cattle and goats and are considered nutritious. Analyses show the following constituents (% dry weight): crude protein, 12.9-16.9; fat, 1.5-2.7; fiber, 13.5-17.1; N-free extract, 55.3-56.7; ash, 10.2-11.7; calcium, 1.42-3.74; phosphorus, 0.17-0.33; magnesium, 0.46-0.83; potassium, 0.47-1.57; sodium, 0.02-0.05; chlorine, 0.14-0.38; Sulphur, 0.13-0.33%. They also contain ceryl alcohol and the alkaloids, protopine and berberine.

The leaves are gathered as food for silkworms.

Dye: In Burma, the fruit is used in dyeing silk. The bark yields a non-fading, cinnamon-colored dye in Kenya.

Nectar: In India and Queensland, the flowers are rated as a minor source of nectar for honeybees. The honey is light and of fair flavor.

Lac: The Indian jujube is one of several trees grown in India as a host for the lac insect, *Kerria* *lacca*, which sucks the juice from the leaves and encrusts them with an orange-red resinous substance. Long ago, the lac was used for dyeing, but now the purified resin is the shellac of commerce. Low grades of shellac are made into sealing wax and varnish; higher grades are used for fine lacquer work, lithograph-ink, polishes and other products. The trees are grown around peasant huts and heavily inoculated with broodlac in October and November every year, and the resin is harvested in April and May. The trees must be pruned systematically to provide an adequate number of young shoots for inoculation.

Medicinal Uses: The fruits are applied on cuts and ulcers; are employed in pulmonary ailments and fevers; and, mixed with salt and chili peppers, are given in indigestion and biliousness. The dried ripe fruit is a mild laxative. The seeds are sedative and are taken, sometimes with buttermilk, to halt nausea, vomiting, and abdominal pains in pregnancy. They check diarrhea, and are poulticed on wounds. Mixed with oil, they are rubbed on rheumatic areas.

The leaves are applied as poultices and are helpful in liver troubles, asthma and fever and, together with catechu, are administered when an astringent is needed, as on wounds. The bitter, astringent bark decoction is taken to halt diarrhea and dysentery and relieve gingivitis. The bark paste is applied on sores. The root is purgative. A root decoction is given as a febrifuge, taenicide and emmenagogue, and the powdered root is dusted on wounds. Juice of the root bark is said to alleviate gout and rheumatism. Strong doses of the bark or root may be toxic. An infusion of the flowers serves as an eye lotion.

Morton, J. 1987. Phalsa. p. 276–277. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Phalsa

Grewia subinaequalis DC.

syn. *Grewia asiatica* Mast.

In the family Tiliaceae, only one genus, *Grewia*, yields edible fruit. The only species of any importance is *G. subinaequalis* DC. (syns. *G. asiatica* Mast. in part, NOT L.; *G. hainesiana* Hole), long referred to in literature as *G. asiatica* L. Phalsa is the most used vernacular name in India where there are a number of dialectal names. The plant is called *falsa* in Pakistan.

Description

A large, scraggly shrub or small tree to 15 ft (4.5 m) or more, the phalsa has long, slender, drooping branches, the young branchlets densely coated with hairs. The alternate, deciduous, widely spaced leaves are broadly heart-shaped or ovate, pointed at the apex, oblique at the base, up to 8 in (20 cm) long and 6 1/2 in (16.25 cm) wide, and coarsely toothed, with a light, whitish bloom on the underside. Small, orange-yellow flowers are borne in dense cymes in the leaf axils. The round fruits, on 1-in (2.5 cm) peduncles are produced in great numbers in open, branched clusters. Largest fruits are 1/2 to 5/8 in (1.25-1.6 cm) wide. The skin turns from green to purplish-red and finally dark-purple or nearly black. It is covered with a thin, whitish bloom and is thin, soft and tender. The soft, fibrous flesh is greenish-white stained with purplish-red near the skin and becoming suffused with this color as it progresses to overripeness. The flavor is pleasantly acid, somewhat grapelike. Large fruits have 2 hemispherical, hard, buff-colored seeds 3/16 in (5 mm) wide. Small fruits are single-seeded.

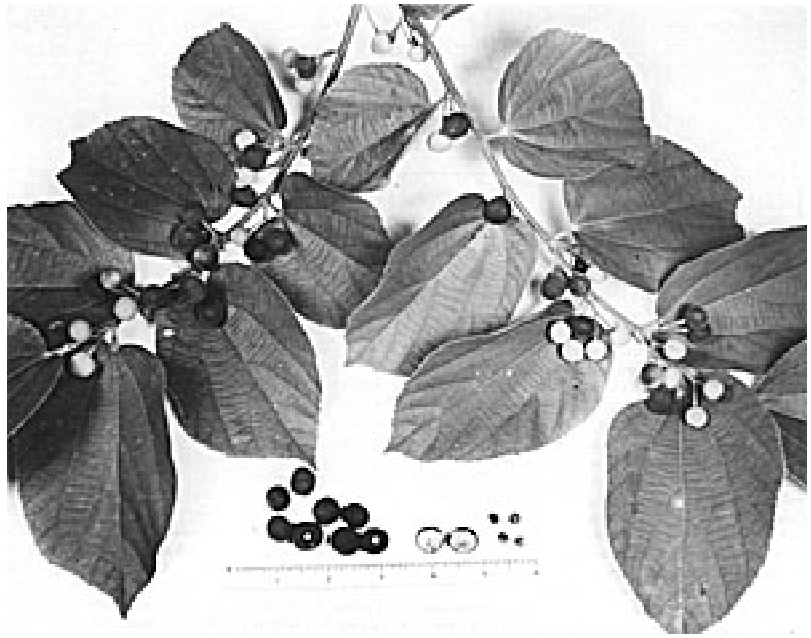


Fig. 77: The phalsa (*Grewia asiatica*) is primarily a beverage fruit in India. Uneven ripening requires many pickings.

Origin and Distribution

The phalsa is indigenous throughout much of India and Southeast Asia. It is cultivated commercially mainly in the Punjab and around Bombay. It was introduced into the Philippines before 1914 and is naturalized at low elevations in dry zones of the island of Luzon. Only a few specimens have been planted in the New World, for example, at the former Federal Experiment Station, Mayaguez, Puerto Rico, and the Agricultural Research and Education Center, Homestead, Florida.

Varieties

The tall-growing wild plants bear acid fruits which are not relished. The dwarf, shrubby type, with a blend of sweet-and-acid in the best fruits, is cultivated.

Climate

In India, the phalsa grows well up to an elevation of 3,000 ft (914 m). It can stand light frosts which cause only shedding of leaves.

Soil

The phalsa grows in most any soil–sand, clay or limestone–but rich loam improves fruit production, as does irrigation during the fruiting season and in dry periods, even though the tree is drought-tolerant. Generally, it is grown in marginal land close to city markets.

Propagation

Seeds are the usual means of propagation and they germinate in 15 days. Ground-layers, treated with hormones, have been 50% successful; air-layers, 85%. Cuttings are difficult to root. Only 20% of semi-hardwood cuttings from spring flush, treated with 1,000 ppm NAA, and planted in July (in India) rooted and grew normally.

Culture

Seedlings are transplanted from seedbeds into well-prepared holes when a year old and are usually spaced 10 to 15 ft (3-4.5 m) apart, though some experiments have favored 6 x 6 ft (1.8 x 1.8 m) or 8 x 8 ft (2.4 x 2.4 m) to maximize efficiency in harvesting. Fruiting will commence in 13 to 15 months. Annual pruning to a height of 3 to 4 ft (0.9-1.2 m) encourages new shoots and better yields than more drastic trimming.

Sprays of 10 ppm gibberellic acid have increased fruit-set. At 40 ppm, there is increased fruit size but decreased fruit-set. In fertilizer experiments, the plant has shown good vegetative response to applications of nitrogen. High levels of phosphorus increase sugar content, while potassium decreases sugar and elevates acidity.

Harvesting and Yield

Summer is the fruiting season. Only a few fruits in a cluster ripen at any one time, so continuous harvesting is necessary. The fruits keep poorly and must be marketed within 24 hours. Average yield per plant is 20 to 25 lbs (9-11 kg) in a season.

Pests and Diseases

Leaf-cutting caterpillars attack the foliage at night. A blackish caterpillar causes galls on the growing shoots. Termites often damage the roots. In some areas, leaf spot is caused by *Cercospora grewiae.*

Food Uses

The fruits are eaten fresh as dessert, are made into sirup, and extensively employed in the manufacture of soft drinks. The juice ferments so readily that sodium benzoate must be added as a preservative.

Food Value

Analyses made long ago in the Philippines show the following values: calories, 329 per lb (724 per kg); moisture, 81.13%; protein, 1.58%; fat, 1.82%; crude fiber, 1.77%; sugar, 10.27%.

Other Uses

Leaves: The fresh leaves are valued as fodder.

Bark: The bark is used as a soap substitute in Burma. A mucilaginous extract of the bark is useful in clarifying sugar. Fiber extracted from the bark is made into rope.

Wood: The wood is yellow-white, fine-grained, strong and flexible. It is used for archers' bows, spear handles, shingles and poles for carrying loads on the shoulders. Stems that are pruned off serve as garden poles and for basket-making.

Medicinal Uses: The fruit is astringent and stomachic. When unripe, it alleviates inflammation and is administered in respiratory, cardiac and blood disorders, as well as in fever.

An infusion of the bark is given as a demulcent, febrifuge and treatment for diarrhea. The root bark is employed in treating rheumatism. The leaves are applied on skin eruptions and they are known to have antibiotic action.

Sundry Chemistry

The flowers have been found to contain grewinol, a long chain keto alcohol, tetratricontane-22-ol-13-one. The seeds contain 5% of a bright-yellow oil containing 8.3% palmitic acid, 11.0% stearic acid, 13.4% oleic acid, 64.5% linoleic acid; 2.8% unsaponifiable.

Morton, J. 1987. Jamaica Cherry. p. 65–69. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Jamaica Cherry

Muntingia calabura L.

This is a minor but well-known and wholesome fruit, borne by a multipurpose tree and therefore merits inclusion. The Jamaica cherry, *Muntingia calabura* L., is a member of the family Elaeocarpaceae. It has acquired a wide assortment of vernacular names, among them *capuli* or *capulin* which are better limited to *Prunus salicifolia* (q.v.). In Florida, it has been nicknamed strawberry tree because its blooms resemble strawberry blossoms, but strawberry tree is a well-established name for the European ornamental and fruit tree, *Arbutus unedo* L., often cultivated in the western and southern United States, and should not be transferred to the Jamaica cherry.

In Mexico, local names for the latter are *capolin, palman, bersilana, jonote* and *puan;* in Guatemala and Costa Rica, *Muntingia calabura is* called *capulin blanco;* in El Salvador, *capulin de comer;* in Panama, *pasito* or *majagüillo;* in Colombia, *chitató, majagüito, chirriador, acuruco, tapabotija* and *nigua;* in Venezuela, *majagua, majaguillo, mahaujo, guácimo hembra, cedrillo, niguo, niguito;* in Ecuador, *nigüito;* in Peru, *bolina, iumanasa, yumanaza, guinda yunanasa,* or *mullacahuayo;* in Brazil, *calabura* or *pau de seda;* in Argentina, *cedrillo majagua;* in Cuba, *capulina, chapuli;* in Haiti, *bois d' orme; bois de soie marron;* in the Dominican Republic, *memiso* or *memizo;* in Guadeloupe, *bois ramier* or *bois de soie;* in the Philippines, *datiles, ratiles, latires, cereza* or *seresa;* in Thailand, *takop farang* or *ta kob farang;* in Cambodia, *kakhop;* in Vietnam, *cay trung ca;* in Malaya, *buah cheri; kerukup siam* or Japanese cherry; in India, Chinese cherry or Japanese cherry; in Ceylon, jam fruit.

Description

Fig. 78: The Jamaica cherry *(Muntingia calabura*) is a fast-growing, useful tree and the sweet fruit is popular in tropical America and Southeast Asia.

This is a very fast-growing tree of slender proportions, reaching 25 to 40 ft (7.5-12 in) in height, with spreading, nearly horizontal branches. The leaves are evergreen, alternate, lanceolate or oblong, long-pointed at the apex, oblique at the base; 2 to 5 in (5-12.5 cm) long, dark-green and minutely hairy on the upper surface, gray- or brown-hairy on the underside; and irregularly toothed. The flowers, borne singly or in 2's or 3's in the leaf axils, are 1/2 to 3/4 in (1.25-2 cm) wide with 5 green sepals and 5 white petals and many prominent yellow stamens. They last only one day, the petals falling in the afternoon. The abundant fruits are round, 3/8 to 1/2 in (1-1.25 cm) wide, with red or sometimes yellow, smooth, thin, tender skin and light-brown, soft, juicy pulp, with very sweet, musky, somewhat fig-like flavor, filled with exceedingly minute, yellowish seeds, too fine to be noticed in eating.

Origin and Distribution

The Jamaica cherry is indigenous to southern Mexico, Central America, tropical South America, the Greater Antilles, St. Vincent and Trinidad. The type specimen was collected in Jamaica. It is widely cultivated in warm areas of the New World and in India, southeast Asia, Malaya, Indonesia, and the Philippines, in many places so thoroughly naturalized that it is thought by the local people to be native.

Macmillan says that it was first planted in Ceylon about 1912. Several trees were introduced into Hawaii by the United States Department of Agriculture in 1922. Dr. David Fairchild collected seeds of a yellow-fruited form in the Peradeniya. Botanic Gardens, Ceylon, in 1926 (S.P.I. #67936). The tree has been grown in southern Florida for its fruits and as quick shade for nursery plants. It is seldom planted at present. Volunteers from bird-distributed seeds spring up in disturbed hammocks and pinelands. The author supplied seeds requested by the Kenya Agriculture Research Institute, Kihuyu, in 1982. The Jamaica cherry is said to grow better than any other tree in the polluted air of Metropolitan Manila. It runs wild on denuded mountainsides and on cliffs and is being evaluated for reforestation in the Philippines where other trees have failed to grow and also for wildlife sanctuaries since birds and bats are partial to the fruits.

The fruits are sold in Mexican markets. In Brazil, they are considered too small to be of commercial value but it is recommended that the tree be planted on river banks so that the abundance of flowers and fruits falling into the water will serve as bait, attracting fish for the benefit of fishermen. In Malaya, the tree is considered a nuisance in the home garden because fruit-bats consume the fruits and then spend the day under the eaves of houses and disfigure the porch and terrace with their pink, seedy droppings.

Climate

The Jamaica cherry is tropical to near-tropical. The mid-19th Century botanist, Richard Spruce saw it in Ecuador "in the plains on both sides of the Cordillera" growing "abundantly by the Rio San Antonio, up to 2,500 ft" (760 m). It is found up to 4,000 ft (1,300 m) in Colombia. When well-established, it is not harmed by occasional low winter temperatures in southern Florida.

Soil

The tree has the reputation of thriving with no care in poor soils and it does well in both acid and alkaline locations, and even on old tin tailings in Malaya. It is drought-resistant but not salt-tolerant.

Propagation

Brazilian planters sow directly into the field fresh seeds mixed with the sweet juice of the fruit. To prepare seeds for future planting, water is added repeatedly to the squeezed-out seeds and juice and, as the seeds sink to the bottom of the container, the water is poured off several times until the seeds are clean enough for drying in the shade.

Culture

The planting hole is prepared with a mixture of organic fertilizer and soil and with a fungicidal solution to prevent the young seedlings from damping-off. To assure good distribution of the seeds, they are mixed with water and sown with a sprinkling can. When well fertilized and watered, the seedlings will begin fruiting in 18 months and will be 13 ft (4 m) high in 2 years.

Season

Wherever it grows, fruits are borne nearly all year, though flowering and fruiting are interrupted in Florida and Sao Paulo, Brazil, during the 4 coolest months. Ripe fruits can easily be shaken from the branches and caught on cloth or plastic sheets.

Pests and Diseases

In Florida, in recent years, the fruits are infested with the larvae of the Caribbean fruit fly and are accordingly rarely fit to eat.

The foliage is subject to leaf spot caused by *Phyllosticta* sp. and *Pseudocercospora muntingiae* (formerly *Cercospora muntingiae),* and the tree is subject to crown gall caused by *Agrobacterium tumefaciens.*

Food Uses

The Jamaica cherry is widely eaten by children out-of-hand, though it is somewhat sticky to handle. It is often cooked in tarts and made into jam.

The leaf infusion is drunk as a tea-like beverage.

Food Value Per 100 g of Edible Portion

Moisture	77.8 g
Protein	0.324 g
Fat	1.56 g
Fiber	4.6 g
Ash	1.14 g
Calcium	124.6 mg
Phosphorus	84.0 mg
Iron	1.18 mg
Carotene	0.019 mg
Thiamine	0.065 mg
Riboflavin	0.037 mg
Niacin	0.554 mg
Ascorbic Acid	80.5 mg

*Analyses made in El Salvador.

Other Uses

Wood: The sapwood is yellowish, the heartwood red-dish-brown, firm, compact, fine-grained, moderately strong, light in weight, durable indoors, easily worked, and useful for interior sheathing, small boxes, casks, and general carpentry. It is valued mostly as fuel, for it ignites quickly, burns with intense heat and gives off very little smoke. Jamaicans seek out trees blown down by storms, let them dry for a while and then cut them up, preferring this to any other wood for cooking. It is being evaluated in Brazil as a source of paper pulp.

Bark: The bark is commonly used for lashing together the supports of rural houses. It yields a very strong, soft fiber for twine and large ropes.

Medicinal Uses: The flowers are said to possess antiseptic properties. An infusion of the flowers is valued as an antispasmodic. It is taken to relieve headache and the first symptoms of a cold.

Morton, J. 1987. Roselle. p. 281–286. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Roselle

Hibiscus sabdariffa L.

True roselle is *Hibiscus sabdariffa* L. (family Malvaceae) and there are 2 main types. The more important economically is *H. sabdariffa* var. *altissima* Wester, an erect, sparsely-branched annual to 16 ft (4.8 m) high, which is cultivated for its jute-like fiber in India, the East Indies, Nigeria and to some extent in tropical America. The stems of this variety are green or red and the leaves are green, sometimes with red veins. Its flowers are yellow and calyces red or green, non-fleshy, spiny and not used for food. This type at times has been confused with kenaf, *H. cannabinus* L., a somewhat similar but more widely exploited fiber source.

The other distinct type of roselle, *H. sabdariffa* var. *sabdariffa*, embraces shorter, bushy forms which have been described as races: *bhagalpuriensi*, *intermedius*, *albus*, and *ruber*, all breeding true from seed. The first has green, red-streaked, inedible calyces; the second and third have yellow-green edible calyces and also yield fiber. We are dealing here primarily with the race *ruber* and its named cultivars with edible calyces; secondarily, the green-fruited strains which have similar uses and which may belong to race *albus.*

Vernacular names, in addition to roselle, in English-speaking regions are rozelle, sorrel, red sorrel, Jamaica sorrel, Indian sorrel, Guinea sorrel, sour-sour, Queensland jelly plant, jelly okra, lemon bush, and Florida cranberry. In French, roselle is called *oseille rouge*, or *oseille de Guinée;* in Spanish, *quimbombó chino, sereni, rosa de Jamaica, flor de Jamaica, Jamaica, agria, agrio de Guinea, quetmia ácida, viña* and *viñuela;* in Portuguese, *vinagreira, azeda de Guiné, cururú azédo,* and *quiabeiro azédo;* in Dutch (Surinam), *zuring.* In North Africa and the Near East roselle is called *karkadé* or *carcadé* and it is known by these names in the pharmaceutical and food-flavoring trades in Europe. In Senegal, the common name is *bisap*. The names *flor de Jamaica* and hibiscus *flores* (the latter employed by "health food" vendors), are misleading because the calyces are sold, not the flowers.

Description

Plate XXXVI: ROSELLE, *Hibiscus sabdariffa*

H. sabdariffa var. *sabdariffa* race *ruber* is an annual, erect, bushy, herbaceous subshrub to 8 ft (2.4 m) tall, with smooth or nearly smooth, cylindrical, typically red stems. The leaves are alternate, 3 to 5 in (7.5-12.5 cm) long, green with reddish veins and long or short petioles. Leaves of young seedlings and upper leaves of older plants are simple; lower leaves are deeply 3- to 5- or even 7-lobed; the margins are toothed. Flowers, borne singly in the leaf axils, are up to 5 in (12.5 cm) wide, yellow or buff with a rose or maroon eye, and turn pink as they wither at the end of the day. At this time, the typically red calyx, consisting of 5 large sepals with a collar (epicalyx) of 8 to 12 slim, pointed bracts (or bracteoles) around the base, begins to enlarge, becomes fleshy, crisp but juicy, 1 1/4 to 2 1/4 in (3.2-5.7 cm) long and fully encloses the velvety capsule, 1/2 to 3/4 in (1.25-2 cm) long, which is green when immature, 5-valved, with each valve containing 3 to 4 kidney-shaped, light-brown seeds, 1/8 to 3/16 in (3-5 mm) long and minutely downy. The capsule turns brown and splits open when mature and dry. The calyx, stems and leaves are acid and closely resemble the cranberry *(Vaccinium spp.)* in flavor.

A minor ornamental in Florida and elsewhere is the red-leaf hibiscus, *H. acetosella* Welw. (syn. *H. eetveldeanus* Wildem. & Th.) of tropical Africa, which has red stems to 8 ft (2.4 m) high, 5-lobed, red or bronze leaves, and mauve, or red-striped yellow, flowers with a dark-red eye, succeeded by a hairy seed pod enclosed in a red, ribbed calyx bearing a basal fringe of slender, forked bracts. This plant has been often confused with roselle, though its calyx is not fleshy and only the young leaves are used for culinary purposes–usually cooked with rice or vegetables because of their acid flavor.

Origin and Distribution

Fig. 79: Seedpods of roselle *(Hibiscus sabdariffa),* enclosed in their red, fleshy, acid calyces, are piled high in the markets of Panama in January.

Roselle is native from India to Malaysia, where it is commonly cultivated, and must have been carried at an early date to Africa. It has been widely distributed in the Tropics and Subtropics of both hemispheres, and in many areas of the West Indies and Central America has become naturalized.

The Flemish botanist, M. de L'Obel, published his observations of the plant in 1576, and the edibility of the leaves was recorded in Java in 1687. Seeds are said to have been brought to the New World by African slaves. Roselle was grown in Brazil in the 17th Century and in Jamaica in 1707. The plant was being cultivated for food use in Guatemala before 1840. J.N. Rose, in 1899, saw large baskets of dried calyces in the markets of Guadalajara, Mexico.

In 1892, there were 2 factories producing roselle jam in Queensland, Australia, and exporting considerable quantities to Europe. This was a short-lived enterprise. In 1909, there were no more than 4 acres (1.6 ha) of edible roselle in Queensland. A Mr. Neustadt of San Francisco imported seeds from Australia about 1895 and shared them with the California State Agricultural Experiment Station for test plantings and subsequent seed distribution. It was probably about the same time that Australian seeds reached Hawaii. In 1904, the Hawaiian Agricultural Experiment Station received seeds from Puerto Rico. In 1913 there was much interest in interplanting roselle with Ceara rubber *(Manihot glaziovii* Muell. Arg.) on the island of Maui and there were some plantations established also on the island of Hawaii, altogether totaling over 200 acres (81 ha). The anticipated jelly industry failed to materialize and promotional efforts were abandoned by 1929.

P.J. Wester believed that roselle was brought to Florida from Jamaica about 1887. Plants were grown by Dr. H.J. Webber at the United States Department of Agriculture's Subtropical Laboratory at Eustis, Florida, in the early 1890's, but all the roselle was killed there by a severe freeze in 1895. Cook and Collins reported that roselle was commonly cultivated in southern Florida in 1903. In 1904, Wester acquired seeds from Mr. W.A. Hobbs of Coconut Grove and planted them at the United States Department of Agriculture's Subtropical Garden in Miami. He was enthusiastic about roselle's potential as a southern substitute for the cranberry. In 1907, he stated that the fresh calyces were being sold by the quart in South Florida markets. He introduced 3 edible cultivars into the Philippines in 1905. In 1920, he declared: "No plant that has ever been brought into the Philippines is more at home and few grow with so little care as the roselle, or are so productive. Still, like so many other new introductions, the roselle has been slow to gain hold in the popular taste though here and there it is now found in the provincial markets. "

In 1928, Paul C. Standley wrote: "roselle ... is grown in large quantities in Panama, especially by the West Indians. So much of the plant is seen in the markets and on the roads that one would think the market oversupplied." This situation has not changed. I saw great quantities of the whole fruits and the calyces in Panama markets in January of 1976.

Roselle became and remained a common home garden crop throughout southern and central Florida until after World War II when this area began to develop rapidly and home gardening and preserving declined. Mrs. Edith Trebell of Estero, Florida, was one of the last remaining suppliers of roselle jelly. In February, 1961, I purchased the last 2 jars made from the small crop salvaged following the 1960 hurricane and before frost killed all her plants.

In 1954, roselle was still being grown by individuals in the Midwest for its edible herbage. By 1959 and 1960, when there was widespread alarm concerning coal-tar food dyes, it was easy to arouse interest in roselle as a coloring source but difficult to obtain seeds in Florida. At that time, I purchased them from Gleckler's Seedsmen in Metamora, Ohio. Roselle had by then become nearly extinct in Puerto Rico also. From time to time over the next dozen years I was able to obtain a few seeds from old timers in Central Florida. In 1973, roselle was featured in the catalog of John Brudy's Rare Plant House, Cocoa Beach (now John Brudy Exotics, Brandon, Florida and no longer listing the seed). Reasoner's Tropical Nurseries in Bradenton was selling plants in containers and giving to purchasers a sheet of recipes. From Lawrence Adams of Arcadia, I obtained seeds which came from the Virgin Islands where this particular strain is said to mature its fruit a month early. These seeds and seeds purchased by John G. Dupuis, Jr., from Brudy were the basis of a large planting at DuPuis' Bar D Ranch in Martin County. Many packets of seeds were distributed to home growers during the following winter.

Today, roselle is attracting the attention of food and beverage manufacturers and pharmaceutical concerns who feel it may have exploitable possibilities as a natural food product and as a colorant to replace some synthetic dyes.

In 1962, Sharaf referred to the cultivation of roselle as a "recent" crop in Egypt, where interest is centered more on its pharmaceutical than its food potential. In 1971, it was reported that roselle calyces, produced and dried in Senegal, particularly around Bambey, were being shipped to Europe (Germany, Switzerland, France and Italy) at the rate of 10 to 25 tons annually.

Varieties

In 1920, Wester described 3 named, edible cultivars as being grown at that time in the Philippines:

'Rico' (named in 1912)–plant relatively low-growing, spreading, with simple leaves borne over a long period and the lobed leaves mostly 3-parted. Flower has dark-red eye and golden-yellow pollen. Mature calyx to 2 in (5 cm) long and to 1 1/4 in (3.2 cm) wide; bracts plump and stiffly horizontal. Highest yielder of calyces per plant. Juice and preserves of calyx and herbage rich-red.

'Victor'–a superior selection from seedlings grown at the Subtropical Garden in Miami in 1906. Plant taller–to 7 ft (2.13 m), more erect and robust. Flower has dark-red eye and golden-brown pollen. It blooms somewhat earlier than 'Rico'. Calyces as long as those of 'Rico' but slenderer and more pointed at apex; bracts longer, slenderer and curved upward. Juice and preserves of calyx and herbage rich-red.

'Archer' (sometimes called "white sorrel") resulted from seed sent to Wester by A.S. Archer of the island of Antigua. It is believed to be of the race *albus*. Edward Long referred to "white" as well as red roselle as being grown in most gardens of Jamaica in 1774. Plant is as tall and robust as

'Victor' but has green stems. Flower is yellow with deeper yellow eye and pale-brown pollen. Calyx is green or greenish-white and smaller than in the 2 preceding, but the yield per plant is much greater. Juice and other products are nearly colorless to amber. Green-fruited roselle is grown throughout Senegal, but especially in the Cape Vert region, mainly for use as a vegetable.

Another roselle selection which originated in 1914 at the Lamao experiment station and was named 'Temprano' because of its early flowering, Wester reported as no longer grown, the plant being less robust and less productive than the others.

A strain with dark-red, plump but stubby calyces (the sepals scarcely longer than the seed capsule) is grown in the Bahamas.

Climate

Roselle is very sensitive to frost. It succeeds best in tropical and subtropical regions from sea-level up to 3,000 ft (900 m) with a rainfall of about 72 in (182 cm) during its growing season. Where rainfall is inadequate, irrigation has given good results. It can be grown as a summer crop in temperate regions. The fruits will not ripen, but the herbage is usable.

Soil

While deep, fairly fertile sandy loam is preferable, roselle grew and produced well over many years in the oölitic limestone of Dade County. Wester observed that the high pinelands were far more suitable than low-lying muck soils. The plants tended to reseed themselves and on some properties they spread so extensively they became a nuisance and were eradicated.

Propagation

Roselle is usually propagated by seed but grows readily from cuttings. The latter method results in shorter plants preferred in India for interplanting with tree crops but the yield of calyces is relatively low.

Culture

Seedlings may be raised in nursery beds and transplanted when 3 to 4 in (7.5-10 cm) high, but seeds are usually set directly in the field, 4 to 6 to a hill, the hills 3 to 6 ft (0.9-1.8 m) apart in rows 5 to 10 ft (1.5-3 m) apart. When 2 or 3 leaves have developed, the seedlings are thinned out by 50%. If grown mainly for herbage, the seed can be sown as early as March, and no early thinning is done.

Roselle is a short-day plant and photoperiodic. Unlike kenaf, roselle crops cannot be grown successively throughout the year.

If intended solely for the production of calyces, the ideal planting time in southern Florida is mid-May. Blooming will occur in September and October and calyces will be ready to harvest in November and December. Harvesting causes latent buds to develop and extends the flowering life of the plant to late February. When the fruit is not gathered but left to mature, the plants will die in January.

Rolfs recommended whatever fertilizer would be ordinarily used for vegetables but warned that only 1/4 to 1/2 the usual amount should be applied. He wryly remarked: "As a whole, the plants are rather more vigorous than need be; consequently no attention need be paid in the direction of vigor." An excess of ammonia encourages vegetative growth and reduces fruit production. Commercial fertilizer of the formula 4-6-7 NPK has proved satisfactory.

Weeding is necessary at first, but after the plants reach 1 1/2 to 2 ft (45-60 cm) in height, weeds will be shaded out and no longer a problem. Early pruning will increase branching and development of more flowering shoots.

Harvesting

For herbage purposes, the plants may be cut off 6 weeks after transplanting, leaving only 3 to 4 in (7.5-10 cm) of stem in the field. A second cutting is made 4 weeks later and a third after another 4 weeks. Then the shorn plants are thinned out–2 of every 3 rows removed–and the remaining plants left to grow and develop fruit as a second product.

The fruits are harvested when full-grown but still tender and, at this stage, are easily snapped off by hand. They are easier to break off in the morning than at the end of the day. If harvesting is overdue and the stems have toughened, clippers must be used.

The fruits of roselle ripen progressively from the lowest to the highest. Harvesting of seeds takes place when the lower and middle tiers of the last of the fruits are allowed to mature, at which time the plants are cut down, stacked for a few days, then threshed between canvas sheets.

Yield

Calyx production per plant has ranged from 3 lbs (1.3 kg) in California to 4 lbs (1.8 kg) in Puerto Rico and 16 lbs (7.25 kg) in southern Florida. In Hawaii, roselle intercropped with rubber yielded 16,800 lbs per acre (roughly 16,800 kg/ha) when planted alone. Dual-purpose plantings can yield 19,000 lbs (17,000 kg) of herbage in 3 cuttings and, later, 13,860 lbs (6,300 kg) of calyces.

Pests and Diseases

Roselle's major enemy is the root-knot nematode, *Heterodera rudicicola.* Mealybugs may be very troublesome. In Australia, 3 beetles, *Nisotra breweri, Lagris cyanea,* and *Rhyparida discopunctulata,* attack the leaves. The "white" roselle has been found heavily infested with the cocoa beetle, *Steirastoma breve* in Trinidad, with a lighter infestation of the red roselle in an intermixed planting. Occasional minor pests are scales, *Coccus hesperidum* and *Hemichionaspis aspidistrae,* on stems and branches; yellow aphid, *Aphis gossypii,* on leaves and flower buds; and the cotton stainer, *Dysdercus suturellus,* on ripening calyces.

In Florida, mildew *(Oidium)* may require control. Late in the season, leaves on some Philippine plants have appeared soft and shriveled; and *Phoma sabdariffae* has also done minimal damage.

Keeping Quality

Rolfs, in 1929, reported that fresh roselle calyces, as harvested, were successfully shipped by rail to Washington for retail sale and he judged that they could stand rail transport to any markets east of the Mississippi.

Food Uses

Plate XXXVII: ROSELLE, *Hibiscus sabdariffa* (calyces raw and cooked)

Fig. 80: Dried roselle calyces are sold in plastic bags in Mexico, labeled "Flor de Jamaica", leading many to believe that they are flower petals. Actually, the flower falls before the red calyx enlarges and becomes fit for food use.

Roselle fruits are best prepared for use by washing, then making an incision around the tough base of the calyx below the bracts to free and remove it with the seed capsule attached. The calyces are then ready for immediate use. They may be merely chopped and added to fruit salads. In Africa, they are frequently cooked as a side-dish eaten with pulverized peanuts. For stewing as sauce or filling for tarts or pies, they may be left intact, if tender, and cooked with sugar. The product will be almost indistinguishable from cranberry sauce in taste and appearance. For making a finer-textured sauce or juice, sirup, jam, marmalade, relish, chutney or jelly, the calyces may be first chopped in a wooden bowl or passed through a meat grinder. Or the calyces, after cooking, may be pressed through a sieve. Some cooks steam the roselle with a little water until soft before adding the sugar, then boil for 15 minutes.

Roselle sauce or sirup may be added to puddings, cake frosting, gelatins and salad dressings, also poured over gingerbread, pancakes, waffles or ice cream. It is not necessary to add pectin to make a firm jelly. In fact, the calyces possess 3.19% pectin and, in Pakistan, roselle has been recommended as a source of pectin for the fruit-preserving industry.

Juice made by cooking a quantity of calyces with 1/4 water in ratio to amount of calyces, is used for cold drinks and may be frozen or bottled if not for immediate needs. In sterilized, sealed bottles or jars, it keeps well providing no sugar has been added. In the West Indies and tropical America, roselle is prized primarily for the cooling, lemonade-like beverage made from the calyces. This is still "one of the most popular summer drinks of Mexico", as Rose observed in 1899. In Egypt, roselle "ade" is consumed cold in the summer, hot in winter. In Jamaica, a traditional Christmas drink is prepared by putting roselle into an earthenware jug with a little grated ginger and sugar as desired, pouring boiling water over it and letting it stand overnight. The liquid is drained off and served with ice and often with a dash of rum. A similar spiced drink has long been made by natives of West Tropical Africa. The juice makes a very colorful wine.

John Ripperton of the Hawaiian Experiment Station maintained that, for jelly and wine-making, it is unnecessary to take out the seed capsule, but neglecting to do so may result in a "stringy" product which would be contaminated with the minute hairs from the surface of the capsule and these hairs are quite likely to be injurious unless carefully filtered out.

The calyces are either frozen or dried in the sun or artificially for out-of-season supply, marketing or export. In Mexico today, the dried calyces are packed for sale in imprinted, plastic bags. It is calculated that 11 lbs (5 kg) of fresh calyces dehydrate to 1 lb (0.45 kg) of dried roselle, which is equal to the fresh for most culinary purposes. However, dried calyces as sold for "tea" do not yield high color and flavor if merely steeped; they must be boiled.

For retailing in Africa, dried roselle is pressed into solid cakes or balls. In Senegal, the dried calyces are squeezed into great balls weighing 175 lbs (80 kg) for shipment to Europe, where they are utilized to make extracts for flavoring liqueurs. In the United States, Food and Drug Administration regulations permit the use of the extracts in alcoholic beverages.

The young leaves and tender stems of roselle are eaten raw in salads or cooked as greens alone or in combination with other vegetables or with meat or fish. They are also added to curries as seasoning. The leaves of green roselle are marketed in large quantities in Dakar, West Africa. The juice of the boiled and strained leaves and stems is utilized for the same purposes as the juice extracted from the calyces. The herbage is apparently mostly utilized in the fresh state though Wester proposed that it be evaporated and compressed for export from the Philippines.

The seeds are somewhat bitter but have been ground to a meal for human food in Africa and have also been roasted as a substitute for coffee. The residue remaining after extraction of oil by parching, soaking in water containing ashes for 3 or 4 days, and then pounding the seeds, or by crushing and boiling them, is eaten in soup or blended with bean meal in patties. It is high in protein.

Food Value

Nutritionists have found roselle calyces as sold in Central American markets to be high in calcium, niacin, riboflavin and iron.

Food Value Per 100 g of Edible Portion

*Calyces, fresh**	
Moisture	9.2 g
Protein	1.145 g
Fat	2.61 g
Fiber	12.0 g
Ash	6.90 g

Calcium	1,263 mg
Phosphorus	273.2 mg
Iron	8.98 mg
Carotene	0.029 mg
Thiamine	0.117 mg
Riboflavin	0.277 mg
Niacin	3.765 mg
Ascorbic Acid	6.7 mg

*Analyses made in Guatemala.

*Leaves, fresh***	
Moisture	86.2%
Protein	1.7-3.2%
Fat	1.1%
Carbohydrates	10%
Ash	1%
Calcium	0.18%
Phosphorus	0.04%
Iron	0.0054%
Malic Acid	1.25%

*Analyses made in the Philippines.

Seeds	
Moisture	12.9%
Protein	3.29%
Fatty Oil	16.8%
Cellulose	16.8%
Pentosans	15.8%
Starch	11.1%

Amino acids (N = 16 p. 100 According to Busson)*

Arginine	3.6
Cystine	1.3
Histidine	1.5
Isoleucine	3.0
Leucine	5.0

Lysine	3.9
Methionine	1.0
Phenylalanine	3.2
Threonine	3.0
Tryptophan	-
Tyrosine	2.2
Valine	3.8
Aspartic Acid	16.3
Glutamic Acid	7.2
Alanine	3.7
Glycine	3.8
Proline	5.6
Serine	3.5

*Calyces, fresh

The dried calyces contain the flavonoids gossypetine, hibiscetine and sabdaretine. The major pigment, formerly reported as hibiscin, has been identified as daphniphylline. Small amounts of delphinidin 3-monoglucoside, cyanidin 3-monoglucoside (chrysanthenin), and delphinidin are also present. Toxicity is slight.

Other Uses

The seeds are considered excellent feed for chickens. The residue after oil extraction is valued as cattle feed when available in quantity.

Medicinal Uses: In India, Africa and Mexico, all above-ground parts of the roselle plant are valued in native medicine. Infusions of the leaves or calyces are regarded as diuretic, cholerectic, febrifugal and hypotensive, decreasing the viscosity of the blood and stimulating intestinal peristalsis. Pharmacognosists in Senegal recommend roselle extract for lowering blood pressure. In 1962, Sharaf confirmed the hypotensive activity of the calyces and found them antispasmodic, anthelmintic and antibacterial as well. In 1964, the aqueous extract was found effective against *Ascaris gallinarum* in poultry. Three years later, Sharaf and co-workers showed that both the aqueous extract and the coloring matter of the calyces are lethal to *Mycobacterium tuberculosis*. In experiments with domestic fowl, roselle extract decreased the rate of absorption of alcohol and so lessened its effect on the system. In Guatemala, roselle "ade" is a favorite remedy for the aftereffects of drunkenness.

In East Africa, the calyx infusion, called "Sudan tea", is taken to relieve coughs. Roselle juice, with salt, pepper, asafetida and molasses, is taken as a remedy for biliousness.

The heated leaves are applied to cracks in the feet and on boils and ulcers to speed maturation. A lotion made from leaves is used on sores and wounds. The seeds are said to be diuretic and tonic in action and the brownish-yellow seed oil is claimed to heal sores on camels. In India, a decoction of the seeds is given to relieve dysuria, strangury and mild cases of dyspepsia and debility. Brazilians attribute stomachic, emollient and resolutive properties to the bitter roots.

Morton, J. 1987. Durian. p. 287–291. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Durian

Durio zibethinus L.

The family Bombacaceae is best known for showy flowers and woody or thin-shelled pods filled with small seeds and silky or cottonlike fiber. The durian, *Durio zibethinus* L., is one member that differs radically in having large seeds surrounded by fleshy arils. Apart from variants of the word "durian" in native dialects, there are few other vernacular names, though the notorious odor has given rise to the unflattering terms, "civet cat tree", and "civet fruit" in India and *"stinkvrucht "* in Dutch. Nevertheless the durian is the most important native fruit of southeastern Asia and neighboring islands.

Description

The durian tree, reaching 90 to 130 ft (27-40 m) in height in tropical forests, is usually erect with short, straight, rough, peeling trunk to 4 ft (1.2 m) in diameter, and irregular dense or open crown of rough branches, and thin branchlets coated with coppery or gray scales when young. The evergreen, alternate leaves are oblong-lance-olate, or elliptic-obovate, rounded at the base, abruptly pointed at the apex; leathery, dark-green and glossy above, silvery or pale-yellow, and densely covered with gray or reddish-brown, hairy scales on the underside; 2 1/2 to 10 in (6.25-25 cm) long, 1 to 3 1/2 in (2.5-9 cm) wide. Malodorous, whitish to golden-brown, 3-petalled flowers, 2 to 3 in (5-7.5 cm) wide, with 5-lobed, bell-shaped calyx, are borne in pendant clusters of 3 to 30 directly from the old, thick branches or trunk.

Plate XXXVIII: DURIAN, *Durio zibethinus*

Fig. 81: The heavy, spiny durian (*Durio zibethinus)* is prized in Southeast Asia and Malaysia for its custard-like, odorous flesh.

The fruits are ovoid or ovoid-oblong to nearly round, 6 to 12 in (15-30 cm) long, 5 to 6 in (12.5-15 cm) wide, and up to 18 lbs (8 kg) in weight. The yellow or yellowish-green rind is thick, tough, semi-woody, and densely set with stout, sharply pointed spines, 3- to 7-sided at the base. Handling without gloves can be painful. Inside there are 5 compartments containing the creamy-white, yellowish, pinkish or orange-colored flesh and 1 to 7 chestnut-like seeds, 3/4 to 2 1/4 in (2-6 cm) long with glossy, red-brown seedcoat. In the best fruits, most seeds are abortive. There are some odorless cultivars but the flesh of the common durian has a powerful odor which reminded the plant explorer, Otis W. Barrett, of combined cheese, decayed onion and turpentine, or "garlic, Limburger cheese and some spicy sort of resin" but he said that after eating a bit of the pulp "the odor is scarcely noticed." The nature of the flesh is more complex-in the words of Alfred Russel Wallace (much-quoted), it is "a rich custard highly flavored with almonds . . . but there are occasional wafts of flavour that call to mind cream cheese, onion-sauce, sherry wine and other incongruous dishes. Then there is a rich glutinous smoothness in the pulp which nothing else possesses, but which adds to its delicacy. It is neither acid, nor sweet, nor juicy; yet it wants none of these qualities, for it is in itself perfect. It produces no nausea or other bad effect, and the more you eat of it the less you feel inclined to stop." *(The Treasury of Botany*, Vol. 1, p. 435). Barrett described the flavor as "triplex in effect, first a strong aromatic taste, followed by a delicious sweet flavor, then a strange resinous or balsam-like taste of exquisite but persistent savor." An American chemist working at the U.S. Rubber Plantations in Sumatra in modem times, was at first reluctant to try eating durian, was finally persuaded and became enthusiastic, declaring it to be "absolutely delicious", something like "a concoction of ice cream, onions, spices, and bananas, all mixed together."

Some fruits split into 5 segments, others do not split, but all fall to the ground when mature.

Origin and Distribution

The durian is believed to be native to Borneo and Sumatra. It is found wild or semi-wild in South Tenasserim, Lower Burma, and around villages in peninsular Malaya, and is commonly cultivated along roads or in orchards from southeastern India and Ceylon to New Guinea. Four hundred years ago, there was a lively trade in durians between Lower Burma to Upper Burma where they were prized in the Royal Palace. Thailand and South Vietnam are important producers of durians. The Association of Durian Growers and Sellers was formed in 1959 to standardize quality and marketing practices. The durian is grown to a limited extent in the southern Philippines, particularly in the Provinces of Mindanao and Sulu. The tree grows splendidly but generally produces few fruits in the Visayas Islands and on the island of Luzon. There are many bearing trees in Zanzibar, a few in Pemba and Hawaii. The durian is not included in the latest *Flora of Guam* (1970) which covers both indigenous and exotic species. It has been introduced into New Guinea, Tahiti, and Ponape.

The durian is rare in the New World. Seeds from Java were planted at the Federal Experiment Station in Mayaguez, Puerto Rico in 1920. The single resulting tree bloomed heavily in February and March in 1944 but only one fruit matured in July and it had but 3 normal carpels. Nevertheless, there were 6 fully developed seeds which germinated and were planted. The tree has fruited in Dominica and Jamaica. There have been specimens in the Royal Botanic Gardens, Port-au-Spain, Trinidad, for many years though they are not very much at home there. Young trees and seeds were introduced into Honduras from Java in 1926 and 1927, and the trees have grown well at the Lancetilla Experimental Garden at Tela, but they bear poorly to moderately. Seedlings have lived only briefly in southern Florida.

Varieties

Much variation occurs in seedlings. There are over 300 named varieties of durian in Thailand. Only a few of these are in commercial cultivation. In Malaysia, 100 types are graded for size and quality. In peninsular Malaya, there are 44 clones with small differences in time and extent of flowering, floral and fruit morphology, productivity and edible quality.

Pollination

There is no evidence that the durian is wind-pollinated and it is believed that bats (mainly *Eoncyteris spelea)* transfer pollen when they visit the flowers for nectar. Honeybees are seen on the flowers too early in the afternoon to serve as pollinators. Natural pollination is possible only at night, the heavily fragrant flowers opening in late afternoon and being receptive from 5 P.M. until 6 A.M., but pollen begins to shed at 7 P.M. and other floral parts gradually fall, only the pistil remaining at 11 P.M.

The durian has a high rate of self-incompatibility. In peninsular Malaya, the norm is 20% to 25% fruit-set, and it is realized that cross-pollination is essential to obtaining good crops. Hand-pollination performed during the day on buds that would open in 24 to 36 hours gives a much higher percentage of fruit-set than pollination of opened flowers. In unopened flowers the style is 1/3 as long as in fully opened flowers and the pollen reaches the ovules more quickly.

Climate

The durian is ultra-tropical and cannot be grown above an altitude of 2,000 ft (600 m) in Ceylon; 2,300 ft (700 m) in the Philippines, 2,600 ft (800 m) in Malaysia. The tree needs abundant rainfall. In India, it flourishes on the banks of streams, where the roots can reach water.

Soil

Best growth is achieved on deep alluvial or loamy soil.

Propagation

Durian seeds lose viability quickly, especially if exposed even briefly to sunlight. Even in cool storage they can be kept only 7 days. Viability can be maintained for as long as 32 days if the seeds are surface-sterilized and placed in air-tight containers and held at 68º F (20º C).

They have been successfully shipped to tropical America packed in a barely moist mixture of coconut husk fiber and charcoal. Ideally, they should be planted fresh, flat-side down, and they will then germinate in 3 to 8 days. Seeds washed, dried for 1 or 2 days and planted have shown 77-80% germination. It is reported that, in some countries, seedling durian trees have borne fruit at 5 years of age. In India, generally, they come into bearing 9 to 12 years after planting, but in South India they will not produce fruit until they are 13 to 21 years old. In Malaya, seedlings will bloom in 7 years; grafted trees in 4 years or earlier.

Neither air-layers nor cuttings will root satisfactorily. Inarching can be accomplished with 50% success but is not a popular method because the grafts must be left on the trees for many months. Selected cultivars are propagated by patch-budding (a modified Forkert method) onto rootstocks 2 months old and pencil-thick, and the union should be permanent within 25 to 30 days. The plants can be set out in the field within 14 to 16 months. Grafted trees never grow as tall as seedlings; they are usually between 26 to 32 ft (8-10 m) tall; rarely 40 ft (12 m).

Culture

Generally, durian trees receive little or no horticultural attention in the Far East. Young grafted plants, however, need good care. They should be staked, irrigated daily in the dry season, given monthly feedings of about 1/5 oz (5 g) of a 6-6-6 fertilizer formula, and the rootstock should be pruned gradually as leaves develop on the scion. When set out in the field, the trees should be 30 to 40 ft (9 to 12 m) apart each way.

Studies in Malaya have shown that a harvest of 6,000 lbs of fruits from an acre (6,720 kg from a hectare) removes the following nutrients from the soil: N, 16.1 lbs/acre (roughly equal kg/ha); P, 2.72 lbs/acre (roughly equal kg/ha); K, 27.9 lbs/acre (roughly equal kg/ha); Ca, 1.99 lbs/acre (roughly equal kg/ha); Mg, 3.26 lbs/ acre (roughly equal kg/ha).

Season

In Ceylon, the durian generally blooms in March and April and the fruits mature in July and

August, but these periods may shift considerably, with the weather. Malaya has two fruiting seasons: early, in March and April; late, in September and October. Nearly all cultivars mature within the very short season during which the fruits are present in great numbers in local markets.

Harvesting

In rural areas, villagers clear the ground beneath the durian tree. They build grass huts nearby at harvest time and camp there for 6 or 8 weeks in order to be ready to collect each fruit as soon as it falls. Caution is necessary when approaching a durian tree during the ripening season, for the falling fruits can cause serious injury. Hunters place traps in the surrounding area because the fallen fruits attract game animals and all kinds of birds. The fruit is also placed as bait for game in the forests.

Yield

Durians mature in 3 1/2 to 4 1/2 months from the time of fruit-set. Seedling trees in India may bear 40 to 50 fruits annually. Well-grown, high-yielding cultivars should bear 6,000 lbs of fruit per acre (6,720 kg/ha).

Keeping Quality

Durians are highly perishable. They are fully ripe 2 to 4 days after falling and lose eating quality in 5 or 6 days.

Pests and Diseases

Minor pests in the Philippines are the white mealybug *(Pseudococcus lilacinus)* and the giant mealybug *(Drosicha townsendi)* which infest young and developing fruits.

Very few diseases have been reported. In West Malaysia, patch canker caused by *Phytophthora palmivora* was first noted in 1934. It is becoming increasingly common on roots and stems of durian seedlings. Infection in the field begins at the collar with oozing of brownish-red gum and extends up the trunk and down to the roots. Sometimes a tree is completely girdled at the base and dies. Testing of 13 clones showed that all but 2 were susceptible. The 2 resistant clones succumbed after the stems were wounded and inoculated. It is evident that pruning injuries have provided access for the organism. The disease is encouraged by close-planting which shades the soil and promotes dampness. Weeds, grass and mulch around the collar are also contributing factors. Budded trees are particularly susceptible because of their habit of putting forth low branches and the occurrence of cracks where these join the main stem. When these low branches are pruned, the wound must be immediately treated with a fungicide.

Food Uses

Durians are sold whole, or cut open and divided into segments, which are wrapped in clear plastic. The flesh is mostly eaten fresh, often out-of-hand. It is best after being well chilled in a refrigerator. Sometimes it is simply boiled with sugar or cooked in coconut water, and it is a popular flavoring for ice cream. Javanese prepare the flesh as a sauce to be served with rice; they also combine the minced flesh with minced onion, salt and diluted vinegar as a kind of relish; and they add half-ripe arils to certain dishes. Arabian residents prefer to mix the flesh with ice and sirup. In Palembang, the flesh is fermented in earthen pots, sometimes smoked, and eaten as a special sidedish.

Durian flesh is canned in sirup for export. It is also dried for local use and export. Blocks of durian paste are sold in the markets. In Bangkok much of the paste is adulterated with pumpkin. Malays preserve the flesh in salt in order to keep it on hand the year around to eat with rice, even though it acquires a very strong and, to outsiders, most disagreeable odor. The unripe fruit is boiled whole and eaten as a vegetable.

Fig. 82: Blocks of preserved durian paste are sold in the Bangkok market.

The seeds are eaten after boiling, drying, and frying or roasting. In Java, the seeds may be sliced thin and cooked with sugar as a confection; or dried and fried in coconut oil with spices for serving as a side-dish.

Young leaves and shoots are occasionally cooked as greens. Sometimes the ash of the burned rind is added to special cakes.

Food Value Per 100 g of Edible Portion*

	Fresh Arils	*Dried Arils*
Calories	144	
Moisture	58.0-62.9 g	18.0 g
Protein	2.5-2.8 g	
Fat	3.1-3.9 g	3.0-6.0 g
Sugars	(approx.) 12.0 g	37.0-43.0 g
Starch	(approx.) 12.0 g	8.0-13.0 g
Total Carbohydrates	30.4-34.1 g	
Fiber	1.7 g	
Ash	1.1-1.2 g	3.0 g
Calcium	7.6-9.0 mg	
Phosphorus	37.8-44.0 mg	
Iron	0.73-1.0 mg	
Carotene	0.018 mg	
(as Vitamin A)	20-30 I.U.	
Thiamine	0.24-0.352 mg	
Riboflavin	0.20 mg	

Niacin	0.683-0.70 mg
Ascorbic Acid	23.9-25.0 mg
Vitamin E	"high"

*Analyses made in Malaya, Honduras and elsewhere.

Toxicity

The seeds are believed to possess a toxic property that causes shortness of breath.

Other Uses

Rind: The dried or half-dried rinds are burned as fuel and fish may be hung in the smoke to acquire a strong flavor. The ash is used to bleach silk.

Wood: The sapwood is white, the heartwood light red-brown, soft, coarse, not durable nor termite-resistant. It is used for masts and interiors of huts in Malaya.

Medicinal Uses: The flesh is said to serve as a vermifuge. In Malaya, a decoction of the leaves and roots is prescribed as a febrifuge. The leaf juice is applied on the head of a fever patient. The leaves are employed in medicinal baths for people with jaundice. Decoctions of the leaves and fruits are applied to swellings and skin diseases. The ash of the burned rind is taken after childbirth. The leaves probably contain hydroxy-tryptamines and mustard oils.

The odor of the flesh is believed to be linked to indole compounds which are bacteriostatic. Eating durian is alleged to restore the health of ailing humans and animals. The flesh is widely believed to act as an aphrodisiac. In the late 1920's, Durian Fruit Products, Inc., of New York City, launched a product called "Dur-India" as a "health-food accessory" in tablet form, selling at $9 for a dozen bottles, each containing 63 tablets–a 3-months' supply. The tablets reputedly contained durian and a species of *Allium* from India, as well as a considerable amount of vitamin E. They were claimed to provide "more concentrated healthful energy in food form than any other product the world affords"–to keep the body vigorous and tireless; the mind alert with faculties undimmed; the spirit youthful.

A toothpaste flavored with durian is currently marketed for durian fanciers.

Related Species

There are estimated to be 28 species in the genus *Durio* in Malaysia. Only 5 species in addition to the durian bear edible fruits. These are *D. dulcis* Becc., in Sabah and Indonesian Borneo; D. *grandiflorus* Kost., in Sabah, Sarawak, and Indonesian Borneo; *D. graveolens* Becc., in peninsular Malaya and all of Borneo and Sumatra; *D. kutejensis* Becc., all over Borneo, and ranked second to the durian in edibility; and *D. oxleyanus* Griff., in peninsular Malaya and all of Borneo and Sumatra. All five are cultivated in Brunei and a few to some extent in Malaysian Borneo.

It is believed that some of the other species, especially *D. malaccensis* Planch. and *D.*

Wyatt-Smithii Kost., which are very closely allied to *D. zibethinus*, may be useful in breeding for pest- and disease-resistance and other characters.

There is evidence that natural interspecific cross-pollination is going on because a hybrid of *D. zibethinus* and *D. graveolens* has been found in northeastern Indonesian Borneo, and some trees of normally white-flowered *D. malaccensis* have been discovered in Johore State with reddish flowers, perhaps from cross-pollination by the pink or red-flowered *D. lowianus* King and *D. pinangianus*.

Morton, J. 1987. Chupa-Chupa. p. 291–292. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Chupa-Chupa

Quararibea cordata Vischer

Matisia cordata Humb. & Bonpl.

Little-known outside its natural range, this member of the Bombacaceae has nomenclatural problems. Its current botanical designation is *Quararibea cordata* Vischer (syn. *Matisia cordata* Humb. & Bonpl.), though it still is being dealt with in Brazil and Colombia under the latter binomial, and there are taxonomists who prefer not to merge *Matisia* with *Quararibea.* In addition, there is no generally accepted vernacular name. "Sapote" and "zapote" predominate in native countries but these terms, derived from the Nahuatl word for "soft, sweet", are applied to several other fruits and to one in particular, the sapote, *Pouteria sapota,* q.v. To distinguish *Quararibea cordata,* one writer proposed "South American sapote", and this has been repeated, but it is cumbersome and strictly artificial, not a name in use in any country of origin. Therefore, I have chosen *chupa-chupa,* which is a valid colloquial name in Colombia and Peru, certainly euphonius, and, as Dr. Victor Patino has stated, descriptive of the manner in which the flesh is chewed from the large seeds. In Peru and Colombia, the species may also be called *zapote chupachupa, zapote chupa, sapote de monte,* or *sapotillo.* In Brazil, it is known as *sapota, sapote-do-peru,* or *sapota-do-solimóes,* in reference to the Solimóes River.

Description

Plate XXXIX: CHUPA-CHUPA, *Quararibea cordata*

The chupa-chupa tree is fast-growing, erect, to 130 or even 145 ft (40-45 m) high in the wild, though often no more than 40 ft (12 m) in cultivation. It is sometimes buttressed; has stiff branches in tiered whorls of 5; and copious gummy yellow latex. The semi-deciduous, alternate, long-petioled leaves, clustered in rosettes near the ends of the branches, are broadly heart-shaped, normally 6 to 12 in (15-30 cm) long and nearly as wide. Short-stalked, yellowish-white or rose-tinted, 5-petalled flowers, about 1 in (2.5 cm) wide, with 5 conspicuous, protruding stamens and pistil, are borne in masses along the lesser branches and on the trunk. The fruit is rounded, ovoid or elliptic with a prominent, rounded knob at the apex and is capped with a 2- to 5-lobed, velvety, leathery, strongly persistent calyx at the base; 4 to 5 3/4 in (10-14.5 cm) long and to 3 3/16 in (8 cm) wide, and may weigh as much as 28 oz (800 g). The rind is thick, leathery, greenish-brown, and downy. The flesh, orange-yellow, soft, juicy, sweet and of agreeable flavor surrounds 2 to 5 seeds, to 1 1/2 in (4 cm) long and 1 in (2.5 cm) wide, from which long fibers extend through the flesh.

Origin and Distribution

The tree grows wild in lowland rainforests of Peru, Ecuador and adjacent areas of Brazil, especially around the mouth of the Javari River. It is common in the western part of Amazonas, southwestern Venezuela, and in the Cauca and Magdalena Valleys of Colombia. It flourishes and produces especially well near the sea at Tumaco, Colombia. The fruits are plentiful in the markets of Antioquia, Buenaventura and Bogotá, Colombia; Puerto Viejo, Ecuador; the Brazilian towns of Tefé, Esperanca, Sao Paulo de Olivenca, Tabetinga, Benjamin Constant and Atalaia do Norte; and elsewhere.

There were only 3 trees in gardens in Belém in 1979. The Instituto Nacional de Pesquisas da Amazonia had 150 fruits sent there for evaluation and 80 to 90% of the samplers rated them as of excellent flavor and expressed interest in obtaining trees. However, it is recognized that there is need for horticultural improvement. In 1964, William Whitman obtained seeds from Iquitos, Peru, raised seedlings; planted one on his own property at Bal Harbour, Florida, and distributed the rest to private experimenters. The first to fruit was that grown by B.C. Bowker, Miami, in 1973. Whitman's tree and several others have also borne fruit.

Varieties

Some of the fruits borne in Florida appear to be of better than average quality. In northern Peru, there is reportedly a type with little fiber and superior flavor.

Pollination

The flowers are pollinated by hummingbirds, bees and wasps. In the afternoon some trees become self-compatible.

Climate

The chupa-chupa is a tropical to subtropical species. In Ecuador, it ranges from sea-level to 4,000 or even 6,500 ft (1,200-2,000 m). In Florida, young trees need protection from winter cold. For best performance, the tree needs full sun and plenty of moisture.

Soil

The tree attains maximum dimensions in the low, wet, deep soils of South American forests, yet it does well in cultivation on the slopes of the Andes and seems to tolerate the dry, oolitic limestone of South Florida's coastal ridge when enriched with topsoil and fertilizer.

Propagation

The tree is commonly grown from seed but superior types should be vegetatively propagated. Side-veneer grafting can be easily done. Budding is not feasible.

Season and Harvesting

In Brazil, the tree blooms from August to November and fruits mature from February to May. Trees in Florida bloom in midwinter and ripen their fruits in November. The fruit will stay on the tree until it rots. It must be harvested with a knife or a long cutting-pole. Light color around the edge of the calyx is a sign of ripeness.

Yield

Whitman's tree bore 58 fruits in 1976. A normal crop may be 3,000. One tree in Tefé, Brazil, produced an estimated crop of 6,000 or more fruits in a season.

Pests and Diseases

The chupa-chupa is very prone to attack by fruit flies and in some locations in South America is commonly infested with their larvae. In Florida, the Keys whitefly, *Aleurodicus dispersus*, and the Cuban May beetle, *Phyllophaga bruneri*, attack the foliage.

Food Uses

This is a fruit that has always been eaten out-of-hand. Those that have the least fibrous flesh may be utilized for juice or in other ways.

Food Value Per 100 g of Edible Portion*

Moisture	85.3 g
Protein	0.129 g
Fat	0.10 g
Fiber	0.5 g
Ash	0.38 g

Calcium	18.4 mg
Phosphorus	28.5 mg
Iron	0.44 mg
Carotene	1.056 mg
Thiamine	0.031 mg
Riboflavin	0.023 mg
Niacin	0.33 mg
Ascorbic Acid	9.7 mg

*Analyses made in Ecuador.

Morton, J. 1987. Kiwifruit. p. 293–300. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Kiwifruit

Actinidia deliciosa

A late-comer on the international market, the kiwifruit long identified as *(Actinidia chinensis* Planch.), was formerly placed in the family Dilleniaceae; is now set apart in Actinidiaceae which includes only two other genera. In the August 1986 issue of *HortScience* (Vol. 21 #4: 927), there appears an announcement that China's leading authority on this fruit has renamed the stiff-haired form (which includes the kiwifruit) *A. deliciosa* (A. Chevalier) C.F. Liang et A.R. Ferguson var. *deliciosa*, and has retained *A. chinensis* for the smooth-skinned form. The Chinese name, *yang tao*, meaning "strawberry peach", was replaced by Europeans with the descriptive term, Chinese gooseberry (because of the flavor and color of the flesh). In 1962, New Zealand growers began calling it "kiwifruit" to give it more market appeal, and this name has been widely accepted and publicized despite the fact that it is strictly artificial and non-traditional. It was commercially adopted as the trade name in 1974. There are a few little-used colloquial names such as Ichang gooseberry, monkey peach and sheep peach.

Description

Plate XL: KIWIFRUIT, *Actinidia chinensis*

The kiwifruit is borne on a vigorous, woody, twining vine or climbing shrub reaching 30 ft (9 m). Its alternate, long-petioled, deciduous leaves are oval to nearly circular, cordate at the base, 3 to 5 in (7.5-12.5 cm) long. Young leaves and shoots are coated with red hairs; mature leaves are dark-green and hairless on the upper surface, downy-white with prominent, light-colored veins beneath. The fragrant, dioecious or bisexual flowers, borne singly or in 3's in the leaf axils, are 5- to 6-petalled, white at first, changing to buff-yellow, 1 to 2 in (2.5-5 cm) broad, and both sexes have central tufts of many stamens though those of the female flowers bear no viable pollen. The oval, ovoid, or oblong fruit, up to 2 1/2 in (6.25 cm) long, with russet-brown skin densely covered with short, stiff brown hairs, is capped at the base with a prominent, 5-pointed calyx when young but this shrivels and dehisce from the mature fruit while 5 small sepals persist at the apex. The flesh, firm until fully ripe, is glistening, juicy and luscious, bright-green, or sometimes yellow, brownish or off-white, except for the white, succulent center from which radiate many fine, pale lines. Between these lines are scattered minute dark-purple or nearly black seeds, unnoticeable in eating. Cross-sections are very attractive. In some inferior types, the central core is fibrous or even woody. The flavor is subacid to quite acid, somewhat like that of the gooseberry with a suggestion of strawberry.

Origin and Distribution

This interesting species is native to the provinces of Hupeh, Szechuan, Kiangsi and Fukien in the Yangtze Valley of northern China–latitude 31° N–and Zhejiang Province on the coast of eastern China. It was cultivated on a small scale at least 300 years ago, but still today most of the 1,000-ton crop is derived from wild vines scattered over 33 of the 48 counties of Zhejiang. The plants may be seen climbing tall trees or, near Lung to ping, Hupeh, sprawling over low scrub or rocks exposed to strong northeast winds and bearing heavily. The Chinese have never shown much interest in exploiting the fruit. Because of the dense population, there is little room for expansion of the industry. Nevertheless, trial shipments of canned fruits were made to West Germany in 1980.

Specimens of the plant were collected by the agent for the Royal Horticultural Society, London, in 1847 and described from his dried material, In 1900, seeds gathered in Hupeh were sent to England by E.H. Wilson. The resulting plants flourished and bloomed in 1909. When both male and female vines were planted together, fruits were produced but usually only solitary vines were grown as ornamentals. Seeds from China were introduced into New Zealand in 1906 and some vines bore fruits in 1910. Several growers raised numerous seedlings (many of which were males) and selected the best fruiting types, which were propagated around 1930. By 1940 there were many plantings, one with 200 vines, especially on the eastern coast of the North Island. The fruits were being marketed and were very popular with American servicemen stationed in New Zealand during World War II, Commercial exporting was launched in 1953, the fruits going mainly to Japan, North America and Europe, with small quantities to Australia, the United Kingdom and Scandinavia. In 1981, a survey of small holders in the Auckland suburbs revealed that the great majority of them intended to plant kiwifruit for the local market. Today, West Germany is New Zealand's biggest customer for kiwifruit. Production in 1983 was reportedly 40,000 tons as compared with 300 tons in 1937. New Zealand supplies 99% of the world production of kiwifruit and 95% of the crop is harvested within 35 miles (56 km) of the little town of Te Puke, Bay of Plenty–38º S latitude. The small industry was greatly assisted in 1971 by an arrangement with the Bay of Plenty Co-operative Dairy Company for the use of cool storage facilities and the construction of a cooperative central packing house. In 1984, there were 2,500 growers, more than 400 packing sheds and 200 "coolstores" with a capacity of 1.9 million tons. A $10,000 prize was offered for the design of a new package for export that would accommodate fruits of varying shapes and sizes.

Plants and seeds have been distributed from New Zealand to the United States of America (including Hawaii), and to Australia, South Africa, Germany, the Netherlands and Denmark. In 1981, plant exports amounted to $430,000 NZ. But in 1982 the New Zealand Kiwifruit Authority issued an appeal to cease exporting plants to reduce the likelihood of competition for foreign markets.

The United States Department of Agriculture received seeds from Consul-General Wilcox in Hankow in 1904 (P.I. 11629, 11630) and the resulting vines were fruiting at the Plant Introduction Field Station at Chico, California in 1910. In 1905, a Rev. Hugh White sent in seeds from Kiangsi (P.I. 18535). E.H. Wilson supplied seeds from western Hupeh and Szechuan (P.I. 21781). In 1917, the agricultural explorer, Frank Meyer, sent back to Washington seeds from fruits he found growing near Lung to ping, Hupeh, ranging in size from "that of a gooseberry to a good-sized plum" (P.I. 45946). A plant from this introduction was given to Mr. William Hertrich of San Gabriel, California. It had perfect flowers and bore fruit "of good size and quality." Mr. Hertrich reproduced it by cuttings and in 1919 supplied some of the plants to the Station at Chico (P.I. 46864). In 1935, a New Zealand grower sent plants of a large-fruited kiwifruit (later named 'Hayward' in New Zealand). One of the plants was reported as still flourishing and fruiting–400 lbs (160 kg) annually–in 1982. After cultural techniques were developed in the 1960's, two California growers imported several thousands of plants from New Zealand. Special kiwifruit nurseries were established in 1966 and, by 1970, there were 40 acres (20.25 ha) devoted to this crop. By 1977 there were over 2,000 acres (800 ha) planted with kiwifruit vines but only 10% of the plants had reached bearing age. In 1982, there were about 1,000 small commercial farms in the state. In 1984, kiwifruit groves in California totalled 6,000 acres (2,040 ha). Most of the crop, worth $18,000,000 to the growers, is sold locally, but some has been shipped to Japan and to the Netherlands. The trade association, Kiwi Growers of California, was organized in 1972 and incorporated in 1975 to sponsor research and exchange and publish information. Nationwide publicity and marketing is handled by Blue Anchor, Inc., the California Fruit Exchange, greatly stimulating demand despite the high retail price of the fruits. The California Kiwifruit Administration Committee has set rigid quality standards, preventing the shipping of "unclassified" grade.

The Fruit and Fruit Technology Research Institute of Stellenbosch, South Africa, obtained budwood of New Zealand cultivars in 1960 and experimental plantings were made in a number of areas around the country. The success of the vines in the northeastern Transvaal inspired the installment of a large plantation of mostly seedlings, some plants from cuttings, at Chiremba in the lower Vumba based on New Zealand and California selections. At this location, the altitude is 3,280 ft (1,000 m) and the annual rainfall is 60 in (152 cm). The mean temperatures in southern Cape areas are close to those at Sacramento, California. However, there are great extremes in South African weather and occasionally very high day temperatures which may cause sunburn on exposed fruits. Nevertheless, the South African Kiwifruit Association was formed in 1981 at the University of Natal with expectations of developing successful cultivation.

The kiwifruit was already being grown in Cambodia, Vietnam and southern Laos, France, Spain, Belgium, and Italy where plantings were first made in the late 1960's and commercial growing started in the late 1970's. Italy advanced to third place in world production by 1983, with a crop of 6,000 tons from 4,800 acres (2,000 ha). Over one-half of Italy's crop is exported to France and other European countries.

French interest in the kiwifruit has been stimulated by the low returns from apple-growing. By 1971, there were small plantings scattered around southwestern and southeastern areas of the country–valleys of the Garonne, Dordogne, Rhone and Loire rivers–totalling about 123 acres (50 ha). Greece is now producing kiwifruits for export to other European countries, filling the seasonal gap when fruits from New Zealand are not available. A recent development is the raising of kiwifruits in greenhouses in the Channel Islands, especially as an alternative to tomatoes suffering from European competition.

The vine was introduced into the Philippines at Baguio in 1923. It succeeds there only above 3,280 ft (1,000 m) and has not been exploited. Large plantings are being made in Chile, not far from Santiago.

Varieties

There are 4 main Chinese classes of kiwifruit:

1) **'Zhong Hua'** ("Chinese gooseberry")–round to oval, or oblate; weight varies from 6.5 to 80 g, averaging 30 to 40 g. Sugar content is 4.6 to 13.1%; ascorbic acid, 25.5 to 139.7 mg per 100 g. This is the most commonly grown.

Three subvarieties are: "Yellow flesh"–average weight, 30.2 g; sugar content, 9.0%; ascorbic acid 101.9 mg per 100 g. "Green flesh"–average weight 18.4 g; sugar content, 5.4 %; ascorbic acid, 55.7 mg per 100 g. "Yellow-green" and "Green-yellow"–average weight 31 to 48 g; sugar content 5.4%; ascorbic acid 85.5 mg per 100 g. Not suitable for canning sliced or for jam.

2) **'Jing Li'** ("northern pear gooseberry")–elongated oval with green flesh. Leaves usually hairless.

3)**'Ruan Zao'** ("Soft date gooseberry")–small, with green flesh; quite sweet. Good for jam. Usually grows in the hills.

4) **'Mao Hua'**–may be tight- or loose-haired; has green, sweet flesh. The leaves are elongated oval, relatively broad and thick.

Selections made by growers for fresh fruit market:

1) **'Qing Yuan #17'–**fruit weighs a maximum of 70.3 g; skin is yellow-brown, smooth, thin; flesh is juicy and of excellent flavor; sugar content 8.2%; ascorbic acid, 169.7 mg per 100 g. Rated as of superior quality.

2) **'Qing Yuan #22'**–fruit has maximum weight of 67 g, average is 47.3 g; skin is yellow-brown, smooth, thin; sugar content 7.9%; ascorbic acid, 11.42 mg per 100 g. Of high quality.

3) **'Qing Yuan #28'**–fruit cylindrical; weighs a maximum of 46 g; averages 40.6 g. Skin is smooth; flesh fine-textured and juicy. Sugar content 9.1%; ascorbic acid 103.2 mg per 100 g. Of medium quality.

4) **'Qing Yuan #18'**–fruit cylindrical; maximum weight 56 g, average 36 g; flesh very tender, medium juicy, of good flavor. Ascorbic acid content 178.9 mg per 100 g. Good fresh and for processing.

5) **'Qing Yuan #20'**–small, elongated cylindrical; maximum weight 26 g; average 21.5 g. Sugar content 12.4%; ascorbic acid, 189.2 mg per 100 g. Excellent quality.

6) **'Long Quan #3'**–oblate; average weight 31 g. Flesh yellow, fine-textured, juicy, and of good flavor. Sugar content, 9.5%; ascorbic acid, 99.7 mg per 100 g. Above average quality.

Selections made by growers for processing because of uniform shape and size, yellow or reddish-brown flesh, minimum woodiness at base, high ascorbic acid content:

1) **'Qing Yuan #27'**–cylindrical; average weight, 27.9 g; flesh yellow, fine-textured; seeds few; core small. Good for processing.

2) **'Qing Yuan #29'**–average weight, 27 g; flesh yellow, fine-textured, with small core.

3) **'Qing Yuan #6'**–average weight 27.3 g. Flesh pale-yellow and fine-textured. Sugar content 7.6%; ascorbic acid 140 mg per 100 g. Of superior quality for processing.

4) **'Huang Yan'**–yellow-skinned, cylindrical; average weight 21.9 g; flesh yellow-white, fine-textured, and of good flavor, with medium-large core. Sugar content 7.4%; ascorbic acid 170.8 mg per 100 g. Above average quality for processing.

The leading cultivars in New Zealand are:

'Abbott' ('Green's'; 'Rounds')–a chance seedling, discovered in the 1920's; introduced into cultivation in the 1930's. Fruit oblong, of medium size, with brownish skin and especially dense, long, soft, hairs; flesh is light-green and of good flavor. Of good keeping quality. Resembles 'Allison'. Ripens in early May. Vine is vigorous, precocious, productive. Petals do not overlap; styles are horizontal. Most exports to the United Kingdom have been of this cultivar.

'Allison' ('Large-fruited')–a chance seedling discovered in 1920's; introduced in early 1930's. Fruit oblong, slightly broader than 'Abbott'; of medium size, with densely hairy, brownish-skin; flesh is light-green, of good flavor. Fruit is of good keeping quality. Vine very vigorous, prolific; blooms later than 'Abbott'; fruits ripen early May. Flowers have broader, more overlapping petals than 'Abbott' and they are crinkled on the margins. Styles elevate to 30 or 60º angle as flower ages.

Formerly very popular but has lost ground to 'Hayward'.

'Bruno' ('McLoughlin'; Longs'; 'Long-fruited'; 'Te puke')–a chance seedling; discovered in the 1920's; introduced in the 1930's. Fruit large, elongated cylindrical, broadest at apex; has darker-brown skin than other cultivars and dense, short, bristly hairs. Flesh is light-green, of good flavor. Ripens in early May. Vine is vigorous and productive, blooms with or slightly after 'Allison'. Sometimes exported. Flowers borne singly or sometimes in pairs. Petals narrower and overlap less; styles longer and stouter than those of 'Abbott', more regularly arranged than those of 'Allison'.

'Hayward' ('Giant'; 'Hooper's Giant'; 'McWhannel's')–chance seedling in Auckland; discovered in 1920's; introduced into cultivation in early 1930's; introduced into the United States as P.I. 112053 before being named in New Zealand and was called 'Chico' in California. Fruit exceptionally large, broad-oval, with slightly flattened sides; skin light greenish-brown with dense, fine, silky hairs. Flesh light green; of superior flavor and fruit is of good keeping quality. Ripens in early May. Vine is moderately vigorous, blooms very late; is moderately prolific, partly because of scanty pollination and late-blooming males must be planted with it. Flowers borne singly or, rarely, in pairs. The petals are broad, overlapping, cupped, and the styles more erect than those of other cultivars though they vary from horizontal to vertical. This is the leading cultivar in New Zealand; the only commercial cultivar in California; produces 72% of Italy's crop.

'Monty' ('Montgomery')–a chance seedling in New Zealand, discovered in the early 1950's; introduced into cultivation about 1957. Fruit oblong, somewhat angular, widest at apex; of medium size; skin brownish with dense hairs. Flesh is light-green. Fruit ripens in early May. Vine is highly vigorous and productive, sometimes excessively so. Petals overlap only slightly at the base.

'Greensill'–a more recent selection; it is the most cylindrical of all, flattened on both ends, slightly wider at base than at apex; a little shorter than 'Allison' but thicker. Petals narrow, constricted, do not overlap at the base; styles are mostly erect.

Plant breeders are endeavoring to develop an acceptable hairless kiwifruit and several thousand seedlings of a promising clone were set out in an experimental plot in Pukekohe, New Zealand, in 1980.

Male plants commonly used for pollination are:

'Matua', with short hairs on peduncles and flowers in groups of 1 to 5, usually 3.

'Tomuri', with long hairs on peduncles, flowers in groups of 1 to 7, usually 5.

Climate

The kiwifruit vine grows naturally at altitudes between 2,000 and 6,500 ft (600-2,000 m). The Kwangsi latitude is approximately that of Galveston, Texas; the climate has been likened to that of Virginia or North Carolina, with heavy rainfall and an abundance of snow and ice in the winter.

In the Bay of Plenty region the winter mean minimum daily temperatures are from 40º to 42º F (4.44º-5.56º C); mean maximum, 57º to 60º F (13.89º-15.56º C); in summer, mean minimum is 56º to 57º F (13.33º-13.89º C); mean maximum, 75º to 77º F (23.89º-25º C). Annual rainfall is 51 to 64 in (130-163 cm) and relative humidity 76 to 78%.

In California, the kiwifruit is an appropriate crop wherever citrus fruits, peaches and almonds are successful, though the leaves and flowers are more sensitive to cold than those of orange and peach trees. Autumn frosts retard new growth and kill developing flower buds, or, if they occur after the flowers have opened, will prevent the setting of fruits. Late winter frosts are said to improve the flavor of full-grown fruits.

Kiwifruit vines in leaf are killed by drops in temperature below 29º F (-1.67º C), while dormant mature vines can survive temperatures down to 10º F (-12.22º C). In France, 1-year-old plants have been killed to the ground by frosts. California growers report that the kiwifruit requires a temperature drop to 32º F (0º C) to cause it to drop its leaves and then 400 hours of dormancy, or 40 days of 40º F (4.44º C), in order to set fruit properly. At Pietermaritzburg, South Africa, where there are only 150 to 200 hours of chilling weather, the vines are slow to put out new spring leaves.

Alternating warm and cold spells during the winter will reduce flowering. A seedling selection at the Citrus and Subtropical Fruit Research Institute, Nelspruit, has borne well and appears to be more tolerant of mild winters than other cultivars which are not successful in this warm region of the eastern Transvaal. There have been several attempts to grow kiwifruits in northern and central Florida, and a few vines are growing experimentally in the southern part of the state and even on the Florida Keys but, so far, only the plants at Tallahassee have fruited to any extent.

Soil

For good growth, the vine needs deep, fertile, moist but well-drained soil, preferably a friable, sandy loam. Heavy soils subject to water logging are completely unsuitable. In Kiangsi Province, China, the wild plants flourish in a shallow layer of "black wood earth" on top of stony, red subsoil.

Pollination

The flowers are mostly insect-pollinated. For small, single-row plantings, one male vine to every 5 females is necessary. In commercial plantings, 10 to 12% of the vines must be males, that is, about 1 male for every 8 or 9 female vines, and the males should be staggered evenly throughout the block plantations. The time of flowering must be ascertained so that the male and female plants will coincide. The female plants yield no nectar. It is recommended that there be 3 1/3 beehives per acre (8 per ha) when 10 to 15% of the flowers are open in order to assure adequate pollination. In anticipation of a shortage of hives for expanding culture, work was begun in New Zealand about 1980 to perfect means of collecting and drying pollen and preparing a suspension for spraying onto the blooming vines by tractor-drawn equipment. Pollen is commercially available in California also for artificial pollination.

Propagation

Inasmuch as seedlings show great variation, it is not recommended that the vine be grown from seed except in experimental plots for clone selection or to produce rootstocks for budding or grafting. To obtain the small seeds, ripe fruits are pulped in an electric blender and then the pulp is strained through a fine screen. The seeds, mixed with moist sand, are placed in a plastic bag, plastic box or other covered container, and kept in a refrigerator (below freezing temperature) for 2 weeks. Then the seed/sand mixture can be planted in nursery flats of sterilized soil, or directly in the garden or field, no deeper than 1/8 in (3 mm) and kept moist. Germination will take 2 to 3 weeks. The seedlings should be thinned out to prevent overcrowding and can be successfully transplanted when 3 in (7.5 cm) high if the soil is taken up with the root system intact. If intended for rootstocks, they should be set 12 to 15 in (30-45 cm) apart in nursery rows. When 1-year-old, the plants are ready for budding.

Budwood is taken from the current season's growth and defoliated, leaving only 1/2 in (1.25 cm) of the petiole of each leaf, and is inserted in the rootstock about 4 in (10 cm) above the ground, using the "T" or shield method. When the buds have "taken", the stock is cut back to just above the union.

For grafting, scions are taken from a parent vine while it is dormant and should be trimmed at both ends, leaving 2 or 3 buds. The scion is joined to the stock by either the whip or tongue process about 4 in (10 cm) from the ground.

Soft-wood cuttings, trimmed to leave only 2 leaves, are treated with hormones and rooted under intermittent mist. Dormant cuttings have a low percentage of success. In New Zealand, cuttings are not popular because they do not develop a strong root system and are prone to attack by crown-gall. Root-grafting was formerly practiced but abandoned because of susceptibility to crown-gall at the graft union.

Old vines bearing inferior fruits can be reworked by budding or, preferably cleft-grafting, Which must be done before new growth begins or the vine will bleed sap. Some growers graft a branch of a compatible male onto a female vine to promote pollination. The increasing demand for plants of cv. 'Hayward' in South Africa has led to *in vitro* propagation using vegetative buds of female plants.

Culture

The kiwifruit is alleged to be a difficult crop to establish, and many new plantations in California have been costly failures. The soil should be well worked to a fine tilth for easy penetration by the shallow, fibrous root system. It is important to fumigate in advance of planting. The land should be level to give all plants equal moisture. There should be good drainage and protection from strong winds which severely damage tender spring shoots. The vines are set not opposite each other but alternated and a generally used spacing has been 18 to 20 ft (5.56-6 m) apart in rows 15 ft (4.5 m) apart. In 1983 it was announced that between-plant spacing was being reduced to 8.2 ft (2.5 m). It has been customary to train the vines to grow on strong horizontal trellises with wood "T" supports 6 to 7 ft (1.8-2.1 m) high, holding 3 wires 2 ft (60 cm) apart. One New Zealand grower has developed a metal arch system which provides headroom under the canopy for pruning and harvesting, and also provides frost protection by allowing cold air to flow downward and settle on the ground, and this air movement helps reduce the frequency of disease. Also, it has been found that A-frame pergolas are producing 3 times as much fruit as the traditional flat trellises.

By the common method, the plants are staked until they reach the wire and, as they develop, they must be kept under control, otherwise a tangled mass of unwieldy vegetation will result. Training of the vines is very important. There should be a single leader and fruiting arms every 18 to 28 in

(45-71 cm). Summer pruning is for the purpose of heading the fruiting arms and suppressing shoots. Shoots from summer pruning will not bear fruit until the following year after dormancy. Male plants will yield more pollen in the spring if new shoots are topped to leave 5 to 7 buds during the summer. Renewing of fruiting arms is done every 4 years, in the winter. The vines should be trained to fruit above the foliage instead of beneath it because excessive shading from the canopy results in poor shoot development, delayed blooming, dehydration and dying of flowerbuds, reduced size of fruits. This is more critical in New Zealand than in California where the light is more intense and penetrating.

The mature plants require a minimum of 150 lbs nitrogen per acre (about 150 kg/ha). In New Zealand, they are usually fertilized twice a year, once in spring and once in early summer, using a total of 500 lbs (225 kg) nitrogen, 220 lbs (100 kg) P_2O5, 121 lbs (55 kg) K2O, per hectare–equivalent to 202 lbs (92 kg) nitrogen, 89 lbs (4.5 kg) P2O5, 49 lbs (22.2 kg) K2O per acre.

Apart from land cost, it takes a minimum of $3,500 to bring each acre into production. The first 2 years are the most critical, coping with the variable growth habits of individual plants, but the vines become more manageable with age. One producer in California, who also raises and sells grafted plants, believes that many people have set out plants that are too young. He sells only 2-year-old vines, bare-root for planting in the dormant season, which gives the roots maximum freedom unlike those which develop in containers. In France, where cuttings from New Zealand are kept in cool storage during the winter and planted out in the spring, vines have made 5 to 6 ft (1.5-1.8 m) of growth in the first 2 months.

Kiwifruit vines can stand wet seasons that destroy peach orchards. Drip irrigation is now being used in California plus overhead sprinklers which have the additional value of plant protection during cold spells and protection from heat in dry seasons. A mature orchard is said to require 40 in (1,000 mm) of water during the 8-month growing season, more than 1/2 of it in the 3 summer months. Some growers plant a permanent cover crop of inoculated clover to control dust, aid water penetration and provide additional nitrogen for the kiwifruit crop. However, clover must be mowed at pollinating time to prevent the flowers from attracting the bees away from the kiwi vines.

Season

New Zealand production begins in May and the fresh or stored fruits are exported through November. In California, the vines put out new leaves in mid-March, bloom in early May and the fruit ripens in November after the leaves have fallen. The marketing season extends from November through April because the fruits hold so well in storage. The French season corresponds to that of California.

Harvesting and Packing

In New Zealand, a minimum picking-maturity standard is 6.25% soluble solids. California kiwifruits are harvested when they attain 6.5 to 8% soluble solids. They are picked by hand, either by breaking the stalk at its natural abscission point or are clipped very close to the base of the fruit to avoid stem punctures. They are carried in field boxes to packing stations. In well-equipped packing plants, the fruits are mechanically conveyed across a brushing machine that removes the hairs and, in some plants, the styles and sepals as well. The fruits are graded for size (25 to 54 per flat). For shipment, about 7 lbs (3 1/4 kg) of fruits are arranged in a plastic tray covered with perforated polyethylene and packed in a fiberboard or wooden box.

Yield

In California, 4-year-old vines have yielded 14,000 lbs per acre (15.7 MT/ha). Vines 8 years old have yielded 18,000 lbs per acre (20 MT/ha), which is nearly the maximum for mature plants (8 to 10 years old).

The bearing habits of the vine are variable–a light crop one season is likely to be followed by a heavy crop the next season, and *vice versa*.

Keeping Quality

Firm fruits can be kept 8 weeks at room temperature, 65º to 70º F (18.33º-21.11º C). Fully ripe fruits can be kept for a week or more in the home refrigerator. Fruits harvested at the firm stage will keep for long periods at 31º to 32º F (-0.56º-0º C) and at least 90% relative humidity, wrapped in unsealed polyethylene in containers. Lower relative humidity, even 85%, will cause a weight loss of as much as 4.5% in 6 weeks. Fruits that are cooled to a temperature of 32º F (0º C) within 12 hours after harvesting, will keep in good condition for as long as 6 months under commercial refrigeration. Experiments have shown that an atmosphere modified with 10 to 14% CO_2 will increase cold storage life by 2 months, providing the fruits enter storage within a week after harvest and are removed from the controlled atmosphere shortly in advance of marketing. Some studies by Arpaia *et al.*, indicate that optimum storage atmosphere may be obtained with 5% CO_2 and 2% O_2, with C_2H_4 excluded and/or removed to keep it below 0.05 mcg per liter. Kiwifruits; freeze at storage temperatures between 28º and 30º F (-1.8º and -2.1º C).

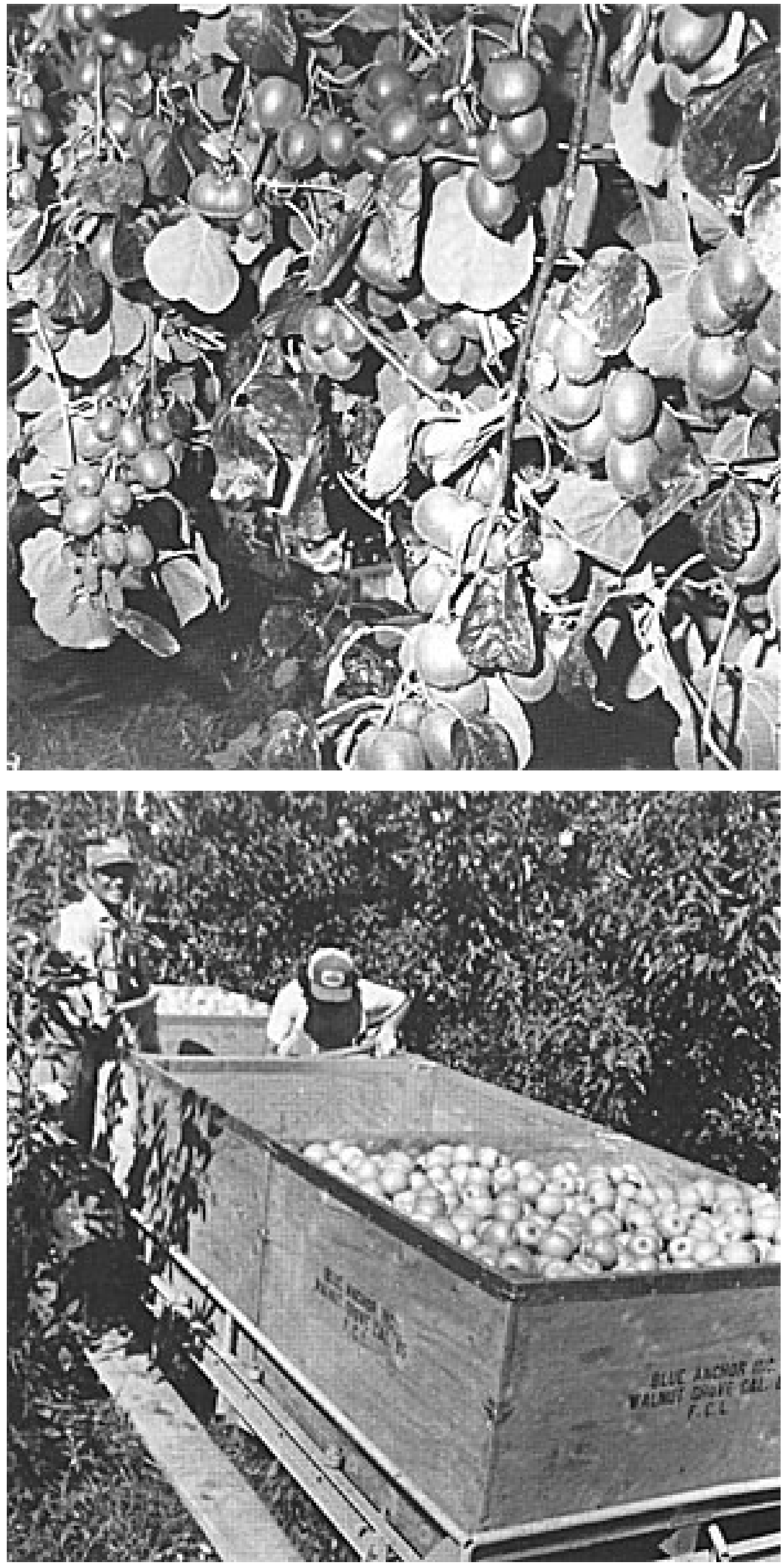


Fig. 83: Kiwifruits on the vine and harvested fruits *en route* to packing house. Courtesy Blue Anchor, Inc., Sacramento, California.

For consumption fresh or for processing, kiwifruits are customarily kept refrigerated for at least 2 weeks to induce softening and then allowed to further soften at room temperature to improve flavor. The fruits will ripen too rapidly and lose quality if stored with other fruits, such as apples, pears, peaches, Plums, etc., because of the ethylene these fruits emit.

Pests and Diseases

Kiwifruit vines are subject to attack by rootknot nematodes–*Meloidogyne hapla* and, to a lesser extent, *Heterodera marioni*–in New Zealand. Because of the surface hairs, the fruit is not damaged by fruit flies. The leaf roller, *Ctenopseustis obliquana,* which scars the surface of the fruit, sometimes eats holes where 2 or more fruits touch each other. In New Zealand, crawlers of the greedy scale insect, *Hemiberlesia repac*, have been conveyed to the plants by wind. This pest infests the leaves and fruit and kills the growing tips of the vines. The passionvine hopper sucks the sap of the vine and deposits honeydew on the fruit, and sooty mold growing on this sticky substance renders the fruit unmarketable. A small moth native to New Zealand–*Stathmopoda skellone*–may occur in abundance some seasons and do damage to the fruit under the sepals or where fruits touch each other. Silvering and browning of the leaves may occur in late summer or early fall because of infestation by thrips, *(Heliothrips haemorrhoidalis).* Other pests in New Zealand include the salt marsh caterpillar and mites. In Chiremba, South Africa, red scale has been observed but it is easily controlled by spraying. In 1984, the New Zealand Pesticides Board approved Ivon Watkins-Dow's Lorsban insecticides for spraying on kiwifruit crops for export, and also cleared 4 herbicides for kiwifruit orchards.

A major disease of the vine is crown gall caused by *Agrobacterium tumefaciens,* but many suspected cases have turned out to be merely natural callousing. Crown gall can be avoided in budded or grafted plants by leaving the upper roots exposed. The roots may be attacked by *Phytophthora cactorum* and *P. cinnamomi,* and also by oak root fungus (*Armillaria mellea) which* is fatal. In humid climates, *Botrytis cinerea infects* the flowers and contaminates the young fruits. New Zealand growers may apply 8 or 9 sprays during the dormant period to achieve control of pests and diseases.

Post-harvest fruit decay is caused by *Alternaria* spp. and *Botrytis* spp. The greatest enemy is gray mold rot arising from *Botrytis cinerea* which enters through even minute scratches on the skin during storage at high humidity. *Alternaria alternata* mold is superficial and can be avoided if styles and sepals are completely removed during the brushing operation. *Alternaria*-caused hard, dry rot often is found on stored fruits that have been sunburned in the orchard. Such fruits should be culled during grading. Blue mold, resulting from infection by *Penicillium expansum,* may occur on injured fruits.

Leaf scorch results from hot dry winds in summer and early fall.

Food Uses

The Chinese have never been overly fond of the kiwifruit, regarding it mainly as a tonic for growing children and for women after childbirth. It is ripe for eating when it yields to slight pressure. For home use, the fruits are hand-picked. In addition to eating out-of-hand, they are served as appetizers, in salads, in fish, fowl and meat dishes, in pies, puddings, and prepared as cake-filling. Ice cream may be topped with kiwifruit sauce or slices, and the fruit is used in breads and various beverages. Kiwifruit cannot be blended with yogurt because an enzyme conflicts with the yogurt process. A cookbook, *Kiwifruit Recipes, is* published by the Kiwi Growers of California.

For commercial canning, the partly softened fruits are peeled by a mechanical steam peeler or by immersing in a boiling 15% lye solution for 90 seconds. Then they are washed in cold water, trimmed by hand, rinsed, and cooked in sirup in standard #2 1/2 vacuum-sealed cans.

For preservation by freezing, the fruits are similarly peeled, sliced and immersed for 3 minutes in a solution of 12% sucrose, 1% ascorbic acid, and 0.25% malic acid, quick-frozen, then put into polyethylene bags and stored at 0º F (-17.78º C). Experiments have shown drying to be practical if the lye-peeled whole fruits are first dipped in a sugar solution to improve flavor, then dehydrated at temperatures below 150º F (65.56º C).

Only overripe or poorly shaped fruits are utilized for flavoring ice cream and for commercial juice production blended with apple to reduce acidity. The fruits so used are not peeled but put through a processing machine that removes the hairs, skin and seeds. In 1983, 2,378 gals (9,000 liters) of kiwifruit concentrate from 1,000,000 fruits were sold in Germany, and 13,210 gals (50,000 liters) were to be provided in 1984.

Slightly underripe fruits, which are high in pectin, must be chosen for making jelly, jam and chutney. Freeze-dried kiwifruit slices are shipped to health food outlets in Sweden and Japan. In the latter country, they are sometimes coated with chocolate. The peeled whole fruits may be pickled with vinegar, brown sugar and spices. Cull fruits can be made into wine. The Kiwifruit Wine Company of New Zealand, Ltd., has a contract to sell "Durham Light", a medium-sweet wine, throughout Japan. The Gibson Wine Company in Elk Grove, California, is making kiwifruit wine with an 11.5% alcohol content.

In the home kitchen, meat can be tenderized by placing slices of kiwifruit over it or by rubbing the meat with the flesh. After 10 minutes the fruit must be lifted or scraped off, otherwise the enzymatic action will be excessive. The meat should then be cooked immediately.

Food Value Per 100 g of Edible Portion*

	Fresh	*Canned*	*Frozen*
Calories	66		66
Moisture	81.2 g	73.0 g	80.7 g
Protein	0.79 g	0.89 g	0.95 g
Fat	0.07 g	0.06 g	0.08 g
Carbohydrates	17.5 g	25.5 g	17.6 g
Ash	0.45 g	0.45 g	0.53 g
Calcium	16 mg	23 mg	18 mg
Iron	0.51 mg	0.40 mg	0.51 mg
Magnesium	30 mg	30 mg	27 mg
Phosphorus	64 mg	48 mg	67 mg
Thiamine	0.02 mg	0.02 mg	0.01 mg

Niacin	0.50 mg	0.40 mg	0.22 mg
Riboflavin	0.05 mg	0.02 mg	0.03 mg
Vitamin A	175 I.U.	155 I.U.	117 I.U.
Ascorbic Acid	105 mg	103 mg	218 mg
			(natural and
			added by
			pre-dip)

*Analyses made at the University of California.

Quinic acid predominates in young fruits, disappears with the formation of ascorbic acid. Boiling for 2 hours reduces ascorbic acid content by 20%. The same amount is lost when frozen fruits are thawed at room temperature.

Kiwifruits, even when ripe, contain the proteolytic enzyme actinidin, which is said to aid digestion. It can be extracted and purified as a powder for tenderizing meat. The tannin content is low, 0.95%, in mature fruits. According to a recent report from New Zealand, the kiwifruit is rich in folic acid, potassium, chromium and Vitamin E.

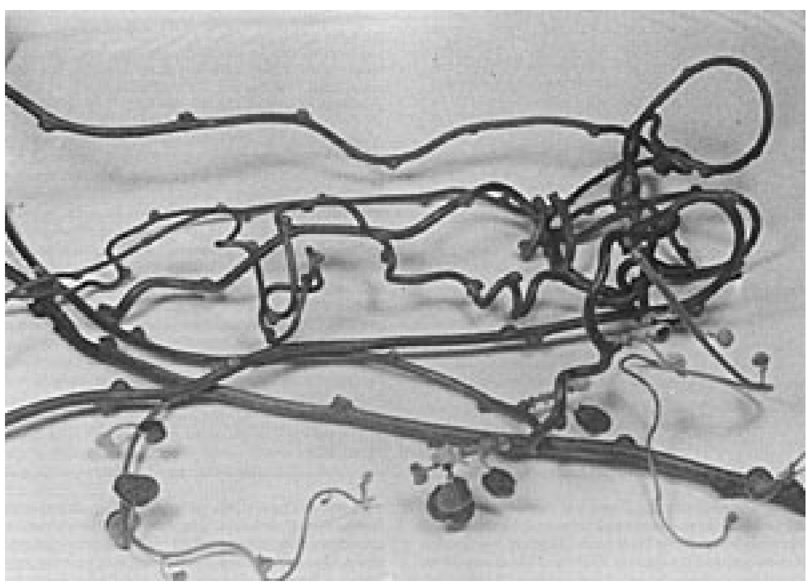
Toxicity

The hairs on the skin can cause throat irritation if ingested. It might be wise to avoid excessive consumption of raw kiwifruits until more is known of the body's reaction to actinidin.

Medicinal Uses

The branches and leaves are boiled in water and the liquid used for treating mange in dogs. In China, the fruit and the juice of the stalk are esteemed for expelling "gravel". The scraped stems of the vine are used as rope in China, and paper has been made from the leaves and bark. If the bark at the base of the vine, close to the roots, is removed in one piece and placed in hot ashes, it will roll into a firm tube which can be used as a pencil.

Related Species



The United States Department of Agriculture has, in the past, made various introductions of other species, especially *A. arguta* Planch. ex Miq., *A. kolomikta* Maxim., and *A. polygama* Maxim., which are often grown as ornamental vines in the northern states.

A. arguta, KOKUWA, or TARA VINE, from Japan, Korea and Manchuria, has greenish-yellow fruit, or sometimes dark-green blushed with red; oblong or oval, about 1 in (2.5 cm) long, tipped with the persistent style. The skin is smooth and very thin; the flesh is green and sweet when fully ripe, and the seeds are minute. The fruits are edible but somewhat purgative.

Fig. 83-a: A by-product of kiwifruit culture: California growers have found the vine trimmings unsuitable for mulch or disposal by burning. They are shipping them to florists. Being naturally coiled and curiously twisted, they are attractive and useful in enhancing flower arrangements. Some that are fairly fresh may put out a temporary flurry of downy green leaves and tendrils. (Stems courtesy Flower Wagon, Miami, FL).

The vine was growing in a private garden in Marblehead, Massachusetts, in 1888. The United States Department of Agriculture received seeds from that vine in 1908; but had been sent seeds from Germany in 1901; and more seeds came from Korea in 1909. This species has been cultivated as an ornamental and screening vine in subtemperate zones of this country since these early dates. Currently, Henry Field's Seed and Nursery Company, Shenandoah, Iowa, is glamorizing the "Hardy Kiwi" as a new "tropical fruit ... surviving down to 25° below zero". The Richard Owen Nursery in Bloomington, Illinois, is advertising "*A. arguta annasnaja"* as a "Hardy Kiwi" 3/4 to 1 1/2 in (2-4 cm) in diameter, ripening in late September or early October.

It is true that the wild fruits of *A. arguta* are gathered and sold in northern China, and the success of the kiwifruit has aroused some interest in the fruits of *A. arguta* in cool areas of the United States. However, most seedlings are non-fruiting males, and female or bisexual specimens are rare and may be unreliable bearers. Much experimental work may be necessary to determine whether or not the kokuwa can be developed into a practical fruit source.

In June, 1923, Dr. David Fairchild applied pollen of the kiwifruit on the flowers of a vine of *A. arguta* in a garden in Maryland and he harvested some fruits in October of that year. He had hopes for the future of his hybrid and distributed cuttings and seeds. Later, he sadly reported that all his "hybrid plants made poor growths and never bore. "

A. kolomikta, ranging from Japan to Manchuria and western China, has blue, oblong-ovoid fruits, of sweet flavor. Cats are very partial to the plant.

A. polygama, SILVER VINE, is native from Japan to western China. It has beaked, yellow, bitter fruits to 1 1/2 in (4 cm) long. The Japanese eat the salted fruits and the leaves. This species is prized in horticulture for the silvery tone of the young growth of male plants. The bark, twigs and leaves contain actinidine and also metatabilacetone, similar to catnip oil, and they lure and intoxicate cats. They are said to be used for taming lions and tigers in captivity.

Morton, J. 1987. Mangosteen. p. 301–304. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mangosteen

Garcinia mangostana L.

One of the most praised of tropical fruits, and certainly the most esteemed fruit in the family Guttiferae, the mangosteen, *Garcinia mangostana* L., is almost universally known or heard of by this name. There are numerous variations in nomenclature: among Spanish-speaking people, it is called *mangostan;* to the French, it is *mangostanier, mangoustanier, mangouste* or *mangostier;* in Portuguese, it is *mangostao, mangosta* or *mangusta;* in Dutch, it is *manggis* or *manggistan;* in Vietnamese, *mang cut;* in Malaya, it may be referred to in any of these languages or by the local terms, *mesetor, semetah*, or *sementah;* in the Philippines, it is *mangis* or *mangostan.* Throughout the Malay Archipelago, there are many different spellings of names similar to most of the above.

Description

The mangosteen tree is very slow-growing, erect, with a pyramidal crown; attains 20 to 82 ft (6-25 m) in height, has dark-brown or nearly black, flaking bark, the inner bark containing much yellow, gummy, bitter latex. The evergreen, opposite, short-stalked leaves are ovate-oblong or elliptic, leathery and thick, dark-green, slightly glossy above, yellowish-green and dull beneath; 3 1/2 to 10 in (9-25 cm) long, 1 3/4 to 4 in (4.5-10 cm) wide, with conspicuous, pale midrib. New leaves are rosy. Flowers, 1 1/2 to 2 in (4-5 cm) wide and fleshy, may be male or hermaphrodite on the same tree. The former are in clusters of 3-9 at the branch tips; there are 4 sepals and 4 ovate, thick, fleshy petals, green with red spots on the outside, yellowish-red inside, and many stamens though the aborted anthers bear no pollen. The hermaphrodite are borne singly or in pairs at the tips of young branchlets; their petals may be yellowish-green edged with red or mostly red, and are quickly shed.

Plate XLI: MANGOSTEEN, *Garcinia mangostana*—Painted by Dr. M.J. Dijkman

The fruit, capped by the prominent calyx at the stem end and with 4 to 8 triangular, flat remnants of the stigma in a rosette at the apex, is round, dark-purple to red-purple and smooth externally; 1 1/3 to 3 in (3.4-7.5 cm) in diameter. The rind is 1/4 to 3/8 in (6-10 mm) thick, red in cross-section, purplish-white on the inside. It contains bitter yellow latex and a purple, staining juice. There are 4 to 8 triangular segments of snow-white, juicy, soft flesh (actually the arils of the seeds). The fruit may be seedless or have 1 to 5 fully developed seeds, ovoid-oblong, somewhat flattened, 1 in (2.5 cm) long and 5/8 in (1.6 cm) wide, that cling to the flesh. The flesh is slightly acid and mild to distinctly acid in flavor and is acclaimed as exquisitely luscious and delicious.

Origin and Distribution

The place of origin of the mangosteen is unknown but is believed to be the Sunda Islands and the Moluccas; still, there are wild trees in the forests of Kemaman, Malaya. Corner suggests that the tree may have been first domesticated in Thailand, or Burma. It is much cultivated in Thailand–where there were 9,700 acres (4,000 ha) in 1965–also in Kampuchea, southern Vietnam and Burma, throughout Malaya and Singapore. The tree was planted in Ceylon about 1800 and in India in 1881. There it succeeds in 4 limited areas–the Nilgiri Hills, the Tinnevelly district of southern Madras, the Kanya-kumani district at the southernmost tip of the Madras peninsula, and in Kerala State in southwestern India. The tree is fairly common only in the provinces of Mindanao and Sulu (or Jolo) in the Philippines. It is rare in Queensland, where it has been tried many times since 1854, and poorly represented in tropical Africa (Zanzibar, Ghana, Gabon and Liberia). There were fruiting trees in greenhouses in England in 1855. The mangosteen was introduced into Trinidad from the Royal Botanic Garden at Kew, England, between 1850 and 1860 and the first fruit was borne in 1875. It reached the Panama Canal Zone and Puerto Rico in 1903 but there are only a few trees in these areas, in Jamaica, Dominica and Cuba, and some scattered around other parts of the West Indies. The United States Department of Agriculture received seeds from Java in 1906 (S.P.I. #17146). A large test block of productive trees has been maintained at the Lancetilla Experimental Station at Tela, Honduras, for many years. Quite a few trees distributed by the United Fruit Company long ago have done well on the Atlantic coast of Guatemala. In 1924, Dr. Wilson Popenoe saw the mangosteen growing at one site in Ecuador. In 1939, 15,000 seeds were distributed by the Canal Zone Experiment Gardens to many areas of tropical America. It is probable that only a relatively few seedlings survived. It is known that many die during the first year. Dr. Victor Patiño has observed flourishing mangosteen trees at the site of an old mining settlement in Mariquita, Colombia, in the Magdalena Valley and the fruits are sold on local markets. Dierberger Agricola Ltda., of Sao Paulo, included the mangosteen in their nursery catalog in 1949.

Despite early trials in Hawaii, the tree has not become well acclimatized and is still rare in those islands. Neither has it been successful in California. It encounters very unfavorable soil and climate in Florida. Some plants have been grown for a time in containers in greenhouses. One tree in a very protected coastal location and special soil lived to produce a single fruit and then succumbed to winter cold.

Despite the oft-repeated Old World enthusiasm for this fruit, it is not always viewed as worth the trouble to produce. In Jamaica, it is regarded as nice but overrated; not comparable to a good field-ripe pineapple or a choice mango.

Varieties

According to Corner, the fruit from seedling trees is fairly uniform; only one distinct variation is known and that is in the Sulu Islands. The fruit is larger, the rind thicker than normal, and the flesh more acid; the flavor more pronounced. In North Borneo, a seemingly wild form has only 4 carpels, each containing a fully-developed seed, and this is probably not unique.

Climate

The mangosteen is ultra-tropical. It cannot tolerate temperatures below 40º F (4.44º C), nor above 100º F (37.78º C). Nursery seedlings are killed at 45º F (7.22º C).

It is limited in Malaya to elevations below 1,500 ft (450 m). In Madras it grows from 250 to 5,000 ft (76-1,500 m) above sea-level. Attempts to establish it north of 200 latitude have all failed.

It ordinarily requires high atmospheric humidity and an annual rainfall of at least 50 in (127 cm), and no long periods of drought. In Dominica, mangosteens growing in an area having 80 in (200 cm) of rain yearly required special care, but those in another locality with 105 in (255 cm) and soil with better moisture- holding capacity, flourished.

Soil

The tree is not adapted to limestone and does best in deep, rich organic soil, especially sandy loam or laterite. In India, the most productive specimens are on clay containing much coarse material and a little silt. Sandy alluvial soils are unsuitable and sand low in humus contributes to low yields. The tree needs good drainage and the water table ought to be about 6 ft (1.8 m) below ground level. However, in the Canal Zone, productive mangosteen groves have been established where it is too wet for other fruit trees–in swamps requiring drainage ditches between rows and in situations where the roots were bathed with flowing water most of the year, in spite of the fact that standing water in nursery beds will kill seedlings. The mangosteen must be sheltered from strong winds and salt spray, as well as saline soil or water.

Propagation

Technically, the so-called "seeds" are not true seeds but adventitious embryos, or hypocotyl tubercles, inasmuch as there has been no sexual fertilization. When growth begins, a shoot emerges from one end of the seed and a root from the other end. But this root is short-lived and is replaced by roots which develop at the base of the shoot. The process of reproduction being vegetative, there is naturally little variation in the resulting trees and their fruits. Some of the seeds are polyembryonic, producing more than one shoot. The individual nucellar embryos can be separated, if desired, before planting.

Inasmuch as the percentage of germination is directly related to the weight of the seed, only plump, fully developed seeds should be chosen for planting. Even these will lose viability in 5 days after removal from the fruit, though they are viable for 3 to 5 weeks in the fruit. Seeds packed in lightly dampened peat moss, sphagnum moss or coconut fiber in airtight containers have remained viable for 3 months. Only 22% germination has been realized in seeds packed in ground charcoal for 15 days. Soaking in water for 24 hours expedites and enhances the rate of germination. Generally, sprouting occurs in 20 to 22 days and is complete in 43 days.

Because of the long, delicate taproot and poor lateral root development, transplanting is notoriously difficult. It must not be attempted after the plants reach 2 ft (60 cm). At that time the depth of the taproot may exceed that height. There is greater seedling survival if seeds are planted directly in the nursery row than if first grown in containers and then transplanted to the nursery. The nursery soil should be 3 ft (1 m) deep, at least. The young plants take 2 years or more to reach a height of 12 in (30 cm), when they can be taken up with a deep ball of earth and set out. Fruiting may take place in 7 to 9 years from planting but usually not for 10 or even 20 years.

Conventional vegetative propagation of the mangosteen is difficult. Various methods of grafting have failed. Cuttings and air-layers, with or without growth-promoting chemicals, usually fail to root or result in deformed, short-lived plants. Inarching on different rootstocks has appeared promising at first but later incompatibility has been evident with all except G. *xanthochymus* Hook. f. (G *tinctoria* Dunn.) or G. *lateriflora* Bl., now commonly employed in the Philippines.

In Florida, approach-grafting has succeeded only by planting a seed of *G. xanthochymus* about 1 1/4 in (3 cm) from the base of a mangosteen seedling in a container and, when the stem of the *G. xanthochymus* seedling has become 1/8 in (3 mm) thick, joining it onto the 3/16 to 1/4 in (5-6 mm) thick stem of the mangosteen at a point about 4 in (10 cm) above the soil. When the graft has healed, the *G. xanthochymus* seedling is beheaded. The mangosteen will make good progress having both root systems to grow on, while the *G. xanthochymus* rootstock will develop very little.

Culture

A spacing of 35 to 40 ft (10.7-12 m) is recommended. Planting is preferably done at the beginning of the rainy season. Pits 4 x 4 x 4 1/2 ft (1.2 x l.2 x l.3 m) are prepared at least 30 days in advance, enriched with organic matter and topsoil and left to weather. The young tree is put in place very carefully so as not to injure the root and given a heavy watering. Partial shading with palm fronds or by other means should be maintained for 3 to 5 years. Indian growers give each tree regular feeding with well-rotted manure–100 to 200 lbs (45-90 kg)–and peanut meal–10 to 15 lbs (4.5-6.8 kg) total, per year.

Some of the most fruitful mangosteen trees are growing on the banks of streams, lakes, ponds or canals where the roots are almost constantly wet. However, dry weather just before blooming time and during flowering induces a good fruit-set. Where a moist planting site is not available, irrigation ditches should be dug to make it possible to maintain an adequate water supply and the trees are irrigated almost daily during the dry season.

In Malaya and Ceylon, it is a common practice to spread a mulch of coconut husks or fronds to retain moisture. A 16-in (40-cm) mulch of grass restored trees that had begun dehydrating in Liberia. It has been suggested that small inner branches be pruned from old, unproductive trees to stimulate bearing. In Thailand, the tree is said to take 12 to 20 years to fruit. In Panama and Puerto Rico trees grown from large seed and given good culture have borne in six years.

Season and Harvesting

At low altitudes in Ceylon the fruit ripens from May to July; at higher elevations, in July and August or August and September. In India, there are 2 distinct fruiting seasons, one in the monsoon period (July-October) and another from April through June. Puerto Rican trees in full sun fruit in July and August; shaded trees, in November and December.

Cropping is irregular and the yield varies from tree to tree and from season to season. The first crop may be 200 to 300 fruits. Average yield of a full-grown tree is about 500 fruits. The yield steadily increases up to the 30th year of bearing when crops of 1,000 to 2,000 fruits may be obtained. In Madras, individual trees between the ages of 20 and 45 years have borne 2,000 to 3,000 fruits. Productivity gradually declines thereafter, though the tree will still be fruiting at 100 years of age.

Ripeness is gauged by the full development of color and slight softening. Picking may be done when the fruits are slightly underripe but they must be fully mature (developed) or they will not ripen after picking. The fruits must be harvested by hand from ladders or by means of a cutting pole and not be allowed to fall.

Keeping Quality

In dry, warm, closed storage, mangosteens can be held 20 to 25 days. Longer periods cause the outer skin to toughen and the rind to become rubbery; later, the rind hardens and becomes difficult to open and the flesh turns dry.

Ripe mangosteens keep well for 3 to 4 weeks in storage at 40º to 55º F (4.44º-12.78º C). Trials in India have shown that optimum conditions for cold storage are temperatures of 39º to 42º F (3.89º-5.56º C) and relative humidity of 85 to 90%, which maintain quality for 49 days. It is recommended that the fruits be wrapped in tissue paper and packed 25-to-the-box in light wooden crates with excelsior padding. Fruits picked slightly unripe have been shipped from Burma to the United Kingdom at 50º to 55º F (10º-12.78º C). From 1927 to 1929, trial shipments were made from Java to Holland at 37.4º F (approximately 2.38º C) and the fruits kept in good condition for 24 days.

Pests and Diseases

Few pests have been reported. A leaf-eating caterpillar in India may perhaps be the same as that which attacks new shoots in the Philippines and which has been identified as *Orgyra* sp. of the tussock moth family, Lymantridae. A small ant, *Myrnelachista ramulorum,* in Puerto Rico, colonizes the tree, tunnels into the trunk and branches, and damages the new growth. Mites sometimes deface the fruits with small bites and scratches. Fully ripe fruits are attacked by monkeys, bats and rats in Asia.

In Puerto Rico, thread blight caused by the fungus, *Pellicularia koleroga, is* often seen on branchlets, foliage and fruits of trees in shaded, humid areas. The fruits may become coated with webbing and ruined. In Malaya, the fungus, *Zignoella garcineae,* gives rise to "canker"–tuberous growths on the branches, causing a fatal dying-back of foliage, branches and eventually the entire tree. Breakdown in storage is caused by the fungi *Diplodia gossypina, Pestalotia* sp., *Phomopsis* sp., *Gloeosporium* sp., and *Rhizopus nigricans.*

A major physiological problem called "gamboge" is evidenced by the oozing of latex onto the outer surface of the fruits and on the branches during periods of heavy and continuous rains. It does not affect eating quality. Fruit-cracking may occur because of excessive absorption of moisture. In cracked fruits the flesh will be swollen and mushy. Bruising caused by the force of storms may be an important factor in both of these abnormalities. Fruits exposed to strong sun may also exude latex. Mangosteens produced in Honduras often have crystal-like "stones" in the flesh and they may render the fruit completely inedible.

Food Uses

To select the best table fruits, choose those with the highest number of stigma lobes at the apex, for these have the highest number of fleshy segments and accordingly the fewest seeds. The numbers always correspond. Mangosteens are usually eaten fresh as dessert. One need only hold the fruit with the stem-end downward, take a sharp knife and cut around the middle completely through the rind, and lift off the top half, which leaves the fleshy segments exposed in the colorful "cup"–the bottom half of the rind. The segments are lifted out by fork.

The fleshy segments are sometimes canned, but they are said to lose their delicate flavor in canning, especially if pasteurized for as much as 10 minutes. Tests have shown that it is best to use a 40% sirup and sterilize for only 5 minutes. The more acid fruits are best for preserving. To make jam, in Malaya, seedless segments are boiled with an equal amount of sugar and a few cloves for 15 to 20 minutes and then put into glass jars. In the Philippines, a preserve is made by simply boiling the segments in brown sugar, and the seeds may be included to enrich the flavor.

The seeds are sometimes eaten alone after boiling or roasting.

The rind is rich in pectin. After treatment with 6% sodium chloride to eliminate astringency, the rind is made into a purplish jelly.

Food Value Per 100 g of Edible Portion*

Calories	60-63
Moisture	80.2-84.9 g
Protein	0.50-0.60 g
Fat	0.1-0.6 g
Total Carbohydrates	14.3-15.6 g
Total Sugars	16.42-16.82 g
(sucrose, glucose and fructose)	
Fiber	5.0-5.1 g
Ash	0.2-0.23 g
Calcium	0.01-8.0 mg
Phosphorus	0.02-12.0 mg
Iron	0.20-0.80 mg
Thiamine	0.03 mg
Ascorbic Acid	1.0-2.0 mg

*Minimum/maximum values from analyses made in the Philippines and Washington, D.C.

Phytin (an organic phosphorus compound) constitutes up to 0.68% on a dry-weight basis. The flesh amounts to 31% of the whole fruit.

Other Uses

Mangosteen twigs are used as chewsticks in Ghana. The fruit rind contains 7 to 14% catechin tannin and rosin, and is used for tanning leather in China. It also yields a black dye.

Wood: In Thailand, all non-bearing trees are felled, so the wood is available but usually only in small dimensions. It is dark-brown, heavy, almost sinks in water, and is moderately durable. It has been used to make handles for spears, also rice pounders, and is employed in construction and cabinetwork.

Medicinal Uses: Dried fruits are shipped from Singapore to Calcutta and to China for medicinal use. The sliced and dried rind is powdered and administered to overcome dysentery. Made into an ointment, it is applied on eczema and other skin disorders. The rind decoction is taken to relieve diarrhea and cystitis, gonorrhea and gleet and is applied externally as an astringent lotion. A portion of the rind is steeped in water overnight and the infusion given as a remedy for chronic diarrhea in adults and children. Filipinos employ a decoction of the leaves and bark as a febrifuge and to treat thrush, diarrhea, dysentery and urinary disorders. In Malaya, an infusion of the leaves, combined with unripe banana and a little benzoin is applied to the wound of circumcision. A root decoction is taken to regulate menstruation. A bark extract called "amibiasine", has been marketed for the treatment of amoebic dysentery.

The rind of partially ripe fruits yields a polyhydroxy-xanthone derivative termed mangostin, also ß-mangostin. That of fully ripe fruits contains the xanthones, gartanin, 8-disoxygartanin, and normangostin. A derivative of mangostin, mangostin-e, 6-di-*O*-glucoside, is a central nervous system depressant and causes a rise in blood pressure.

Morton, J. 1987. Mamey. p. 304–307. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mamey

Mammea americana L.

The mamey stands almost midway between "major" and "minor" tropical fruits and is unique in remaining virtually static in the past 40 years, receiving little attention at home or abroad. Botanically, it is identified as *Mammea americana* L., of the family Guttiferae, and therefore related to the mangosteen, q.v. Among alternative names in English are mammee, mammee apple, St. Domingo apricot and South American apricot. To Spanish-speaking people, it is known as *mamey de Santo Domingo, mamey amarillo, mamey de Cartagena, mata serrano, zapote mamey,* or *zapote de Santo Domingo.* In Portuguese it is called *abricote, abrico do Pará, abrico selvagem,* or *pecego de Sao Domingos.* In French, it is *abricot d' Amerique, abricot des Antilles, abricot pays, abricot de Saint-Dominque* or *abricotier sauvage.*

This species is often confused with the sapote, or *mamey colorado, Pouteria sapota,* q.v., which is commonly called *mamey* in Cuba; and reports of its occurring wild in Africa are due to confusion with the African mamey, *M. africana* Sabine (syn. *Ochrocarpus africana* Oliv.).

Description

The mamey tree, handsome and greatly resembling the southern magnolia, reaches 60 to 70 ft

Plate XLII: MAMEY, *Mammea americana*

(18-21 m) in height, has a short trunk which may attain 3 or 4 ft (0.9-1.2 m) in diameter, and ascending branches forming an erect, oval head, densely foliaged with evergreen, opposite, glossy, leathery, dark-green, broadly elliptic leaves, up to 8 in (20 cm) long and 4 in (10 cm) wide. The fragrant flowers, with 4 to 6 white petals and with orange stamens or pistils or both, are 1 to 1 1/2 in (2.5-4 cm) wide when fully open and borne singly or in groups of 2 or 3 on short stalks. They appear during and after the fruiting season: male, female and hermaphrodite together or on separate trees.

The fruit, nearly round or somewhat irregular, with a short, thick stem and a more or less distinct tip or merely a bristle-like floral remnant at the apex, ranges from 4 to 8 in (10-20 cm) in diameter, is heavy and hard until fully ripe when it softens slightly. The skin is light-brown or grayish-brown with small, scattered, warty or scurfy areas, leathery, about 1/8 in (3 mm) thick and bitter. Beneath it, a thin, dry, whitish membrane, or "rag", astringent and often bitter, adheres to the flesh. The latter is light- or golden-yellow to orange, non-fibrous, varies from firm and crisp. and sometimes dry to tender, melting and juicy. It is more or less free from the seed though bits of the seed-covering, which may be bitter, usually adhere to the immediately surrounding wall of flesh. The ripe flesh is appetizingly fragrant and, in the best varieties, pleasantly subacid, resembling the apricot or red raspberry in flavor. Fruits of poor quality may be too sour or mawkishly sweet. Small fruits are usually single-seeded; larger fruits may have 2, 3 or 4 seeds. The seed is russet-brown, rough, ovoid or ellipsoid and about 2 1/2 in (6.25 cm) long. The juice of the seed leaves an indelible stain.

Origin and Distribution

The mamey is native to the West Indies and northern South America. It was recorded as growing near Darién, Panama, in 1514, and in 1529 was included by Oviedo in his review of the fruits of the New World. It has been nurtured as a specimen in English greenhouses since 1735. It grows well in Bermuda and is quite commonly cultivated in the Bahama Islands and the Greater and Lesser Antilles. In St. Croix it is spontaneous along the roadsides where seeds have been tossed. In southern Mexico and Central America, it is sparingly grown except in the lowlands of Costa Rica, El Salvador and in Guatemala where it may be seen planted as a windbreak and ornamental shade tree along city streets, and is frequently grown for its fruit on the plains and foothills of the Pacific coast. Cultivation is scattered in Colombia, Venezuela, Guyana, Surinam and French Guiana, Ecuador and northern Brazil.

Introduced into the tropics of the Old World, it is of very limited occurrence in West Africa (particularly Sierra Leone), Zanzibar, southeastern Asia, Java, the Philippines, and Hawaii. All seedlings planted in Israel have died in the first or second year. From time to time, seedlings have been planted in California, but most have succumbed the first winter. Dr. Robert Hodson, of the University of California, stated in 1940: "I know of only one large and old tree of *Mammea americana* growing out of doors in southern California, and it has never fruited."

The mamey may have been brought to Florida first from the Bahamas, but the United States Department of Agriculture received seeds from Ecuador in 1919 (S.P.I. #47425). One of the largest fruiting specimens in Florida is at the Fairchild Tropical Garden, Miami, standing on a site formerly part of an early nursery, and thought to be over 60 years of age. Another, as old or older, on a private estate in Palm Beach, was fruiting heavily before 1940. The most northerly reached 30 feet (9 m) and fruited in Dr. Talmadge Wilson's garden at Stuart but was killed by lightning about 1956. There was a 35-foot (10.5 m) fruiting tree in the Edison Botanical Garden at Fort Myers, its trunk at least 20 in (50 cm) thick, but it was removed after severe hurricane damage in 1960 and replaced by a young one. A number of fruiting trees on private property in the Miami area have been destroyed to make room for construction. The Fairchild Tropical Garden has distributed numerous seedlings from their large tree but most apparently fail to survive the winter in the hands of new owners Many seeds were planted as nursery stock by Robert Newcomb of Homestead who offered grafted plants for sale from 1953 to 1956 and then, discouraged by winter-killing, gave his remaining plants to a garden club on Key Largo. Hurricane "Donna" of 1960 doubtless eliminated most of these.

Climate

The mamey is limited to tropical or near-tropical climates. In Central America, it thrives from near sea-level to 3,300 ft (1,000 m). Three trees at the Agricultural Research and Education Center, Homestead, in southern Florida, were killed by a temperature drop to 28º F (-2.22º C) in January 1940.

Soil

The mamey tree favors deep, rich, well-drained soil, but is apparently quite adaptable to even shallow, sandy terrain, and it grows naturally in limestone areas of Jamaica, also does well in the oolitic limestone of the Bahamas and southeastern Florida.

Propagation

Seeds are the usual means of dissemination and they germinate in 2 months or less and sprout readily in leaf-mulch under the tree. Seedlings bear in 6 to 8 years in Mexico, 8 to 10 years in the Bahamas. Vegetative propagation is preferable to avoid disappointment in raising male trees and to achieve earlier fruiting. In English greenhouse culture, half-ripe cuttings with lower leaves attached are employed. Both Robert Newcomb and Albert Caves of Palm Lodge Tropical Grove, Homestead, successfully grafted the mamey onto self-seedlings.

Culture

The mamey generally receives little or no cultural attention, apart from protection from cold during the first few winters in other than strictly tropical climates. It seems remarkably resistant to pests and diseases.

Season

In Barbados, the fruits begin to ripen in April and continue for several weeks. The season extends from May through July in the Bahamas, some fruits being offered in the Nassau native market and on roadside stands. In southern Florida, mameys ripen from late June through July and August. In Puerto Rico, some trees produce two crops a year. Central Colombia has two crops occurring in June and December.

Harvesting

Ripeness may be indicated by a slight yellowing of the skin or, if this is not apparent, one can scratch the surface very lightly with a fingernail. If green beneath, the fruit should not be picked, but, if yellow, it is fully mature. If fruits are allowed to fall when ripe, they will bruise and spoil. They should be clipped, leaving a small portion of stem attached.

Yield

The productivity of individual trees varies considerably. In Puerto Rico, high-yielding trees may bear 150 to 200 fruits per crop, totalling 300 to 400 fruits per year.

Food Uses

To facilitate peeling, the skin is scored from the stem to the apex and removed in strips. The rag must be thoroughly scraped from the flesh which is then cut off in slices, leaving any part which may adhere to the seed, and trimming off any particles of seed-covering from the roughened inner surface of the flesh.

The flesh of tender varieties is delicious raw, either plain, in fruit salads, or served with cream and sugar or wine. In Jamaica, it may be steeped in wine and sugar for a while prior to eating. In the Bahamas, some prefer to let the flesh stand in lightly salted water "to remove the bitterness" before cooking with much sugar to a jam-like consistency. I have often stewed the flesh, without pretreatment, adding a little sugar and possibly a dash of lime or lemon juice. Once, some of the pulp, stewed without citrus juice, was left in a covered plastic container in a refrigerator for one month. At the end of this time, there was no loss of flavor, no fermentation or other evidence of spoilage; and the fruit was eaten with no ill effect. In this connection, it is interesting to note that an antibiotic principle in the mamey was reported by the Agricultural Experiment Station, Rio Piedras, Puerto Rico, in 1951.

Sliced mamey flesh may also be cooked in pies or tarts, and may be seasoned with cinnamon or ginger. Canned, sliced mamey has in the past been exported from Cuba. The mamey is widely made into preserves such as spiced marmalade and pastes (resembling guava paste) and used as a filler for products made of other fruits. Slightly under-ripe fruits, rich in pectin, are made into jelly. Wine is made from the fruit and fermented "toddy" from the sap of the tree in Brazil.

In the Dominican Republic, the uncooked flesh, blended with sugar, is made into frozen sherbet. The juice or sirup of stewed flesh, is seasoned with sugar and lemon juice to make "ade". When cooking the flesh for any purpose, one is advised to skim off any foam that forms on the surface of the water, as this is usually bitter.

Food Value Per 100 g of Fresh Pulp*

Calories	44.5-45.3
Moisture	85.5-87.6 g
Protein	0.470-0.088 g
Fat	0.15-0.99 g
Total Carbohydrates	11.52-12.67 g
Fiber	0.80-1.07 g
Ash	0.17-0.29 g
Calcium	4.0-19.5 mg
Phosphorus	7.8-14.5 mg
Iron	0.15-2.51 mg
Vitamin A (ß-Carotene)	0.043-0.37 mg
Thiamine	0.017-0.030 mg
Riboflavin	0.025-0.068 mg
Niacin	0.160-0.738 mg
Ascorbic Acid	10.2-22.0 mg
Amino Acids:	
Tryptophan	5 mg
Methionine	5-6 mg
Lysine	14-35 mg

*Analyses made in Cuba and Central America.

Toxicity

Rural folk in the Dominican Republic have some doubt of the wholesomeness of mamey flesh. In the *Description and History of Vegetable Substances Used in the Arts and Domestic Economy*, published in London in 1829, it is stated: "To people with weak stomachs, it is said to be more delicious than healthful." The Bahamian practice of soaking the pulp in salted water may be a safety precaution inasmuch as bitterness is not only disliked but distrusted. The old Jamaican custom of steeping in wine might also be considered a safeguard. Kennard and Winters observe that, in Puerto Rico, "Although the fruit is widely eaten, it is recommended that only moderate amounts be consumed." A former Spanish professor at the University of Miami related that, when he was about 19 in Mayaguez, Puerto Rico, he ate half of a large mamey from a tree in his home yard, after peeling and scraping off the rag but not removing any adherent seed-covering. Then he ate the pulp of one star apple. An hour later, he had stomach cramps and, later, his abdomen was reddened and oddly reticulated. He attributed this reaction to the mamey and was convinced there was "something poisonous about it."

Morris *et al.* (1952) commented that, while the delicious mamey "has formed part of the diet of the inhabitants of the Caribbean Islands for many generations, it is well known that this fruit produces discomfort, especially in the digestive system, in some persons." They reported also that "a concentrated extract of the fresh fruit" proved fatally toxic to guinea pigs, and was also found poisonous to dogs and cats. The extract was made from the edible portion only. The authors likened the mamey to the akee *(Blighia sapida)*, q.v., as a human hazard, and Djerassi, *et al.*, aver that "reports of poisoning in humans are known."

Other Uses

Insecticidal value: That various parts of the mamey tree contain toxic properties has been long recognized and was first reported by Grosourdy in *El Médico Botanico Criollo* in 1864. A Colombian decoction of mamey resin was displayed at the Paris Exposition in 1867. It is significant that in the United States Department of Agriculture's record of mamey seed introduction from Ecuador in 1919, only the insecticidal and medicinal uses of the species were noted. There was no comment on edible uses of the fruit.

In Puerto Rico, there, is a time-honored practice of wrapping a mamey leaf like a collar around young tomato plants when setting them in the ground to protect them from mole crickets and cutworms. The leaf must be placed at just the right height, half above ground and half below.

In Mexico and Jamaica, the thick, yellow gum from the bark is melted with fat and applied to the feet to combat chiggers and used to rid animals of fleas and ticks. A greenish-yellow, gummy resin from the skin of immature fruits, and an infusion of half-ripe fruits are similarly employed. The bark is strongly astringent and a decoction is effective against chiggers. In El Salvador, a paste made of the ground seeds is used against poultry lice, mites and head lice. In the Dominican Republic, mamey seeds, avocado seeds, and *Zamia* seeds fried in oil, are mashed and applied to the head as a "therapeutic shampoo", probably to eliminate lice.

At the Federal Experiment Station, Mayaguez, Puerto Rico, the insecticidal activity of various parts of the mamey tree and the fruit have been under active investigation. The seed kernel, most potent, was found, in feeding experiments and when tested as a contact poison applied as a dust or spray, to be effective in varying degree against armyworms, melonworms, cockroaches, ants, drywood termites, mosquitoes and their larvae, flies, larvae of diamond-back moth, and aphids. In certain tests, mamey seeds appeared to be 1/5 as toxic as pyrethrum and less toxic to plant pests than nicotine sulfate and DDT. When powdered seeds and sliced unripe fruit infusions, 1 lb (0.45 kg) in a gallon (3.78 liters) of water, were tested on dogs, both products were as effective as DDT and faster in killing fleas and ticks but not as long-lasting in regard to reinfestation. None of the dogs was poisoned despite the presence of healing sores and minor abrasions of the skin, but, after similar trials on mice, 4 out of 70 died. The active ingredients of the infusion are the resin from the unripe skin and the developing seeds. In Ecuador, animals with mange or sheep ticks are washed with a decoction made by boiling the seed but, in one instance, a dog with mange and ulcers died 48 hours after two applications.

The dried and powdered immature fruit, the bark, wood, roots and flowers have shown poor insecticidal activity; the seed hulls appeared inert. The powdered leaves were found 59% effective against fall armyworms and 75% against the melonworm. Various extracts from the fruit, bark, leaves or roots are toxic to webbing clothes moths, black carpet beetle larvae and also to milkweed bugs.

In fish-poisoning experiments, Pagan and Morris reported mamey seed extracts to be 1/30 as toxic as rotenone; 1/60 to 1/80 as potent as powdered dried derris root. Feeding trails have shown the seeds to be very toxic to chicks and they are considered a hazard to hogs in the Virgin Islands.

The crude resinous extract from powdered mamey seeds, given orally, has produced symptoms of poisoning in dogs and cats and a dose of 200 mg per km weight has caused death in guinea pigs within 8 hours. The crystalline insecticidal principle from the dried and ground seeds, potent even after several months of storage, has been named *mammein* and assigned the formula $C_{22}H_{28}O_5$. The stability of this principle was demonstrated by M.P. Morris who found no significant difference in toxicity of powdered fresh mamey fruit and mamey powder stored for 6 years in steel drums. Neither was the potency of mamey extract destroyed by subjection to 392º F (200º C).

Extensive chemical experiments with the extracted compound are reported by S.P. Marfey who considered the mamey a potential substitute for pyrethrum and rotenone.

The main constituent of a wax isolated from the seed oil is the symmetrical C48 homolog, tetracosanyl tetracosanoate.

Wood: In Central America, the tree is protected because the fruit is valued. Elsewhere, if the mamey is common, it may be felled for its timber. The heartwood is reddish- or purple-brown; the sapwood much lighter in color. The wood is heavy, hard, but not difficult to work, fine-grained and strong; has an attractive grain and polishes well. It is useful in cabinetwork, valued for pillars, rafters, decorative features of fine houses, interior sheathing, turnery and for fenceposts since it is fairly decay-resistant. It is, however, highly susceptible to termites. Some of the wood is consumed as fuel.

Bark: The tannin from the bark is sometimes used for home treatment of leather in the Virgin Islands.

Medicinal Uses: In Venezuela, the powdered seeds are employed in the treatment of parasitic skin diseases. In Brazil, the ground seeds, minus the embryo, which is considered convulsant, are stirred into hot water and the infusion employed as an anthelmintic for adults only.

In the French West Indies, an aromatic liqueur called *Eau de Creole,* or *Creme de Creole, is* distilled from the flowers and said to act as a tonic or digestive.

An infusion of the fresh or dry leaves (one handful in a pint [0.47 liter] of water) is given by the cupful over a period of several days in cases of intermittent fever and it is claimed to have been effective where quinine has failed.

Morton, J. 1987. Ketembilla. p. 311–315. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Ketembilla

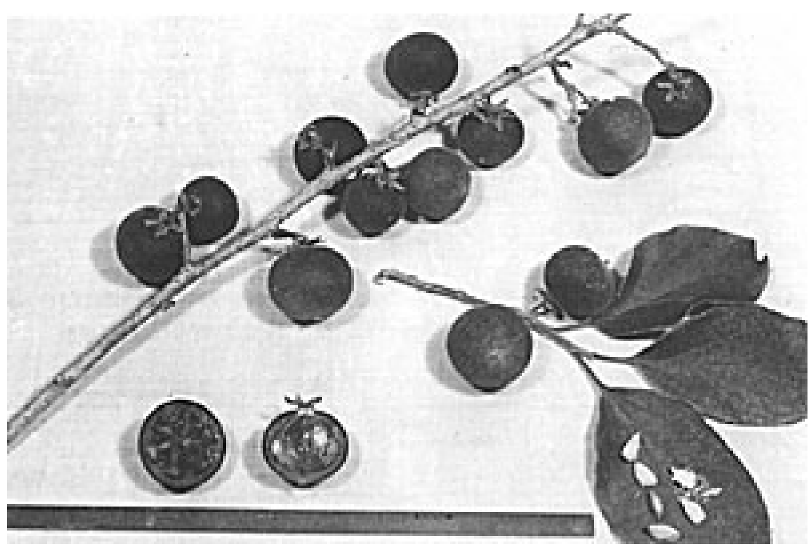
Dovyalis hebecarpa Warb.

Aberia gardneri Clos.

Roumea hebecarpa Gard.

Somewhat better-known than the kei apple, q.v., the ketembilla, *Dovyalis hebecarpa* Warb. (syns. *Aberia gardneri Clos.; Roumea hebecarpa* Gard.), is often called Ceylon gooseberry; sometimes ketambilla, or kitembilla; and it is known as *aberia* in Cuba and Central America.

Description



The shrub or small tree reaches no more than 15-20 ft (4.5-6 m) in height but its long, slender, arching, wide-spreading branches may cover 30 ft (9 m) of ground. Sharp spines to 1 1/2 in (4 cm) long, are plentiful on the trunk and lower branches. The alternate leaves are elliptical to ovate, pointed, 2 3/4 to 4 in (7-10 cm) long, wavy-margined, gray-green, finely velvety, with pinkish, woolly petioles, and thin in texture. Male, female and hermaphrodite flowers are borne on separate trees. They are petalless, greenish-yellow, nearly 1/2 in (1.25 cm) wide and clustered in the leaf axils. The fruit, borne in great abundance, is globose, 1/2 to 1 in (1.25-2.5 cm) wide. Its thin, bitter skin turns from somewhat orange to dark purple on ripening and is coated with short, grayish-green, velvety hairs, unpleasant in the mouth. The pulp is very juicy, extremely acid, purple-red, enclosing 9 to 12 hairy seeds about 1/4 in (6 mm) long.

Fig. 84: Ripe fruits of the ketembilla are furry-skinned, extremely acid and slightly bitter.

Fig. 85: Formerly grown for jelly-making, the too-vigorous, productive ketembilla or Ceylon gooseberry *(Dotyalis hebecarpa)* is no longer planted in southern Florida.

Origin and Distribution

The ketembilla is native to Ceylon. It was introduced into the United States by Dr. David Fairchild and was one of the few fruits he admitted he never liked very much. The first fruiting specimens in the western hemisphere were apparently those growing in southern Florida. P.J. Wester carried seeds to the northern islands of the Philippines where it began fruiting in 1916. From Florida, also, the plant was introduced into the Atkins Garden of Harvard University at Cienfuegos, Cuba. Seeds from the Garden were shipped to the Hawaiian Sugar Planters' Association in 1920, and to the Lancetilla Experimental Garden at Tela, Honduras, in 1927. Seeds from Florida were supplied to the Mayaguez and Trujillo Experimental Stations in Puerto Rico where the plants were 16 ft (5 in) high by 1929 and 1930. Plants were distributed widely throughout the Hawaiian Islands and use of the fruits was officially encouraged.

Florida pioneers grew the species and utilized the fruits until the plants took up too much space. When South Florida began to develop rapidly after World War II, most people had no room for such an aggressive plant. One enthusiast maintained a small commercial plot in West Palm Beach for juice production.

In 1935, horticulturists in Israel imported seeds from Ceylon and plants grew and fruited well in a variety of locations. Commercial exploitation was anticipated but was suspended during World War II because of the shortage of sugar for preserving.

Climate

In the Philippines, the ketembilla flourishes from sea-level to 2,600 ft (800 m). In Malaya, it is found from near-sea-level up to 4,000 ft (1,200 m). It has never survived at Singapore. Fruiting is not consistent at Tela, Honduras. However, it does do well planted at appropriate elevations in either dry or moist climates.

Soil

In Florida, the plant grows entirely too vigorously on sand or limestone, but a rich soil is best for maximum fruit production and plenty of water is desirable during fruit development.

Season

In Israel, fruit ripens from winter to spring. In Florida, there are two crops a year–spring and fall, but the fruits may be infested with the larvae of the Caribbean fruit fly, *Anastrepha suspensa*, and unusable.

Food Uses

In Florida, in the past, the ketembilla was used primarily for jelly. Recipes developed in Hawaii include juice, spiced jelly, ketembilla-papaya jam, ketembilla-guava jelly, and ketembilla-apple butter. In Israel, the fruit is valued mainly as a source of jelly for export

Food Value Per 100 g of Edible Portion*

Moisture	81.9-83.6 g
Protein	0.174-0.206 g
Fat	0.64-1.02 g
Crude Fiber	1.7-1.9 g
Ash	0.61-0.63 g
Calcium	12.6-13.3 mg
Phosphorus	24.5-26.8 mg
Iron	0.91-1.41 mg
Carotene	0.125-0.356 mg
Thiamine	0.017 mg
Riboflavin	0.033-0.042 mg
Niacin	0.261-0.316 mg
Ascorbic Acid	91.7-102.5 mg

(Slightly unripe fruits are high in pectin.)

*Analyses made in Honduras.

Other Uses

In the West Indies and Central America, honeybees are seen to work the blossoms eagerly from July to December.

Related Species

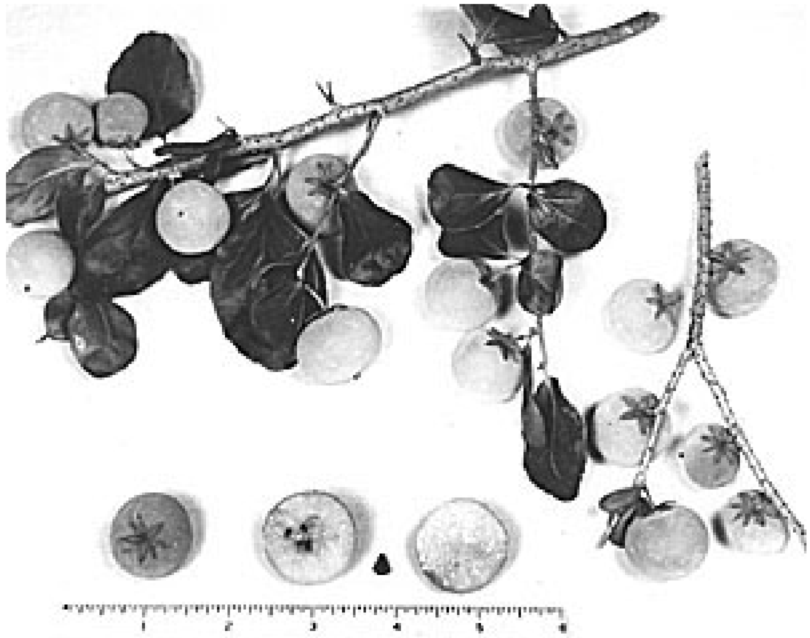


Fig. 86: The Abyssinian gooseberry *(Dovyalis abyssinica)*, more attractive in color and of more pleasing flavor than the ketembilla, is still too astringent to be popular.

The **Abyssinian gooseberry,** *D. abyssinica* Warb. (syns. *D. engleri* Gilg; *Aberia abyssinica* Clos.) is a bushy, more or less thorny, shrub or tree to 30 ft (9 in) high, with alternate leaves, ovate-lanceolate to oblong, 1 to 3 1/2 in (2.5-9 cm) long, 3/4 to 1 1/2 in (2-4 cm) wide; glabrous or slightly hairy, light-green, glossy, wavy, and sometimes finely toothed. Male and female flowers are borne on separate plants. They are small, greenish-white, and emerge at the leaf axils, the male clustered, the female singly. The fruits are oblate, 1/2 to 1 in (1.25-2.5 cm) wide, with thin, tender, apricot-colored skin and concolorous, apricot-flavored, juicy, melting, astringent, acid pulp containing several flat seeds.

Fig. 87: An apparent chance cross between the ketembilla and the Abyssinian gooseberry, known only as "Dovyalis hybrid", was briefly promoted in southern Florida. The fruits are large but astringent.

This species is native and common in forests of East Africa (Ethiopia, Kenya, Uganda) at elevations between 6,000 and 8,000 ft (1,800-2,400 m). Seeds were obtained by the United States Department of Agriculture from the Atkins Garden in Cuba in 1935 (S.P.I. #112086) and planted at the then Plant Introduction Station in Miami. Three seedlings were supplied to the University of Florida's experiment station in Homestead, two of which died and the survivor was a male. Two plants remaining at the United States Department of Agriculture showed considerable hardiness with only minor injury in cold spells just below freezing. Some die-back was attributed to infestation by scale insects or root damage by nematodes. These plants had female flowers but never bore fruit until there occurred accidental pollination by a ketembilla 50 to 60 ft (15-18 m) distant. A heavy crop of fruits was borne in 1951. A dozen seedlings were sent to Homestead. A scion from one of the 2 female plants was grafted onto the male plant at the Homestead station and bore fruit less than a year later. The attractive fruits caused considerable interest, grafted plants were sold by nurseries and someone proceeded to invent the frivolous term, "Florida apricot".

The seedlings from the 1951 crop planted at Homestead fruited in October 1953. Both foliage and fruit suggest that hybridization had taken place between the ketembilla and the Abyssinian gooseberry. One of the seedlings bore perfect flowers in small clusters.

The hybrid fruit is oblate, 3/4 to 1 3/8 in (2-3.5 cm) across, with a velvety skin, brownish-orange or burnt-orange, dappled with many flecks of yellow. The flesh is burnt-orange or orange-yellow, juicy, very sour, more or less acrid, the flavor modifying somewhat when the fruit becomes extra-ripe and dark-red in color. There are 3 to 9 flat, pointed, nearly white seeds to 5/16 in (8 mm) long, mostly underdeveloped and not very noticeable when the fruit is eaten. Plants reproduced by cuttings or air-layers (though producing strong, spiny shoots) were soon being offered by local nurserymen as *"Dovyahs* hybrid", no other name having been adopted. In 1960, 1 proposed "ketcot" as concisely representing its 2 parents and Dr. George H. Lawrence, then Director of the Bailey Hortorium wanted to record this in Hortus as soon as it became popularized, which it never was.

The hybrid proved to be remarkably hardy, more stalwart and vigorous than either parent, forming massive, formidable mounds to 15 ft (4.5 m) high, the branches weighed down with excessive crops. One practical disadvantage is that the green, 6-pointed calyx, 3/8 in (1 cm) wide, remains on the plant as the fruit is picked, leaving a cavity in the base of the fruit. It is, therefore, not marketable as a fresh fruit but can be used to make sirup, jam or other preserves.

I was informed in 1962 that a hybrid of *D. abyssinica* and the ketembilla had originated in the Kitchen Door Nursery, North Miami. It was given the name "Kandy" after a village in Ceylon, and had survived several winters in Winter Haven.

Despite productivity and hardiness and the promotion of less-spiny, less rampant plants grafted on ketembilla, few homeowners have welcomed the *"Dovyahs* hybrid" and its position has remained static over the past 25 years.

Morton, J. 1987. Kei Apple. p. 315–319. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Kei Apple

Dovyalis caffra Warb.

Aberia caffra Harv. & Sond.

The kei apple, *Dovyalis caffra* Warb. (syn. *Aberia caffra* Harv. & Sond.) is also known as *umkokolo* in Africa and this is abbreviated to *umkolo* in the Philippines. The generic name has been rendered *Doryalis* by many writers but botanists now agree that this form was not the original spelling.

Description

The shrub or small tree, growing to a height of 30 ft (9 m) with a spread of 25 ft (7.5 m), usually has many sharp spines 1 to 3 in (2.5-7.5 cm) long, though it is often entirely spineless if not trimmed. The leaves, often clustered on short spurs, are oblong-obovate, 1 to 3 in (2.5-7.5 cm) long, glossy and short-petioled. Pale-yellow male and female flowers are usually borne on separate trees. They are small, petalless, and clustered in the leaf axils. The aromatic fruit is oblate or nearly round, 1 to 1 1/2 in (2.5-4 cm) long, with bright-yellow, smooth but minutely downy, somewhat tough skin, and mealy, apricot-textured, juicy, highly acid flesh. There are 5 to 15 seeds arranged in double rings in the center. They are flat, pointed and surrounded by threadlike fibers. The tree is spectacular when its branches are laden with these showy fruits.

Fig. 88: The kei apple tree (*Dovyalis caffra*) is drought-tolerant, salt-resistant and strikingly fruitful, but the fruit is intensely acid.

Origin and Distribution

The kei apple is native to the Kei River area of southwest Africa and abundant in the wild around the eastern Cape, Kaffraria and Natal. It is cultivated in the Transvaal. In 1838, it was introduced into England and from there distributed to Egypt, Algeria, southern France and Italy, the Philippines, northwestern Australia, Jamaica, southern California and Florida. The United States Department of Agriculture obtained plants from Reasoner Bros., Oneco, Florida in 1901 (S.P.I. #6857); seeds from South Africa in 1901 (S.P.I. #7955 & #7956); seeds from the Cape Town Public Gardens in 1906 (S.P.I. #18667); seeds from the Middle Egypt Botanic Gardens in 1912 (S.P.I. #34250); and seeds from Hubert Buckley, St. Petersburg, Florida (S.P.I. #145592) and the resulting seedlings were being distributed from the Plant Introduction Garden, Coconut Grove, in 1942 and 1943. A few specimens were planted in experimental stations in Puerto Rico and St. Croix, and in private gardens in southern and central Florida, and the plant was adopted as a coastal, rough hedge in southern California. It has been grown as a hedge and for its fruit in some parts of Costa Rica. It was in the past extensively cultivated as a hedge around citrus groves in Israel, but the fruits were not liked, they accumulated on the ground and became breeding places for the Mediterranean fruit fly. Therefore, nearly all the plants were destroyed.

Climate

The kei apple is subtropical; does poorly at sea-level in the Philippines but thrives at and above 2,600 ft (800 m). Introductions have failed to survive in Malaya. In Florida, the plant has been grown in a small way as far north as Gainesville, enduring brief drops in temperature to 20º F (-6.67º C) but descents to 16º F (-8.80º C) have been lethal in this state and in California.

Soil

The kei apple does well in almost any soil that does not have a high water table. It is extremely drought-resistant and tolerates saline soil and salt spray and is accordingly valued as a coastal hedge in the Mediterranean region and in California.

Propagation

Propagation is ordinarily by seeds, though layering is successfully done in Australia. Seeds germinate readily when fresh and seedlings begin to bear in 4 or 5 years. For fruit production, Wilson Popenoe recommended a spacing of no less than 12 to 15 ft (3.5-4.5 m). Hedge plants can be set 3 to 5 ft (0.9-1.5 m) apart. According to Popenoe there should be 1 male for every 20 or 30 females. However, certain female trees have borne profusely in the absence of male pollinators. A kei apple hedge must be trimmed twice a year. If neglected and allowed to become leggy, it can be cut to the ground and given a new start. Weeding should not be a problem, for the kei apple exhibits allelopathy, that is, its roots excrete growth inhibitors which prevent the occurrence of other plants in its vicinity. Investigators in Egypt have demonstrated that the roots, stem and fruit, but not the leaves and branches, possess antibiotic properties.

Season

Generally, the plants bloom in spring and the fruits ripen from August to October. The thorns make harvesting difficult. The top may have to be thinned out in order to facilitate fruit-picking.

Food Uses

Most people consider the fruit too acid for eating out-of-hand even when fully ripe. It is best cut in half, peeled, seeded, sprinkled with sugar and allowed to stand for a few hours before serving as dessert or in fruit salads. The halves can stand only a few minutes of cooking before they turn into sauce. Simmered briefly in sirup, they make excellent shortcake. Kei apples are customarily made into jam and jelly, and, when underripe, pickles.

Food Value

Fresh ripe fruits contain 83 mg ascorbic acid per 100 g and 3.7% pectin. Scientists in Egypt have reported 15 amino acids: alanine, 0.41%; arginine, 0.36%; aspartic acid, 0.96%; glutamic acid, 2.00%; glycine, 0.39%; histidine, 0.10%; isoleucine, 0.25%; leucine, 0.75%; lysine, 0.36%; methionine + valine, 0.28%; phenylalanine, 0.40%; proline, trace; serine, 0.48%; threonine, 0.34%.

Related Species

In the family Flacourtiaceae, there are several species of *Flacourtia* that have been distributed as fruit producers. None has any great merit, and four shall be treated as minor subjects here.

The **louvi,** *F. inermis* Roxb., is called *rukam masam, rokam masam, lovi-lovi, lobeh-lobeh, tomi* and thornless *rukam* in Malaya. The tree is short-trunked, bushy, to 25 or 30 ft (7.6-9 in) tall, and thornless. The evergreen, alternate leaves, bright-red when young, are glossy on the upper surface, dull beneath; 3 1/2 to 10 in (9-25 cm) long and 2 to 5 in (5-12.5 cm) wide. Unlike other species, the tree has bisexual flowers. They are petalless with green sepals and many yellow stamens and borne in small clusters along the branches. The fruit is round but slightly flattened at the apex, 3/4 to 1 in (2-2.5 cm) wide, smooth, bright-red, thin-skinned. The flesh is whitish tinged with pink, astringent, acid or occasionally sweet. There are 4 to 14 hard, sharp, irregular seeds under 1/4 in (6 mm) wide. The tree is of unknown origin; cultivated in Ceylon, Malaya and Indonesia. Its lifespan is said to be about 20 years. It is propagated by seed in Malaya, by air-layering or budding in Java. Flowering occurs several times a year. Yield from dooryard trees varies from 81 to 241 lbs (36.8-109.5 kg) a year. Those given good cultural attention may bear a total of 374-576 lbs (170-261.8 kg). The fruits are not favored raw but are seeded and cooked with apples to add color, or are made into pie, jam, jelly, sirup, chutney and pickles.

The **paniala,** *F. jangomas* Raeusch. (syn. *F. cataphracta* Roxb.) is also called *puneala, puneala* plum, *jaggam,* Chinese plum, Indian plum; in Malaya, *kerkup, kerkup besar, kerkup bakoh;* in Thailand, *ta-khop-thai;* in Vietnam, *mu cuon, mung quan, bo quan,* and *prunier malgache.* The shrub or erect, low-branched tree, 20 to 40 ft (6-12 in) high, has flaking bark and sharp spines on the trunk. The leaves are alternate, deciduous, pale pink when young, spirally arranged, oval-lanceolate, long-pointed, toothed, very thin, glossy on both surfaces; 2 to 4 in (5-10 cm) long, 1/2 to 2 in (1.25-5 cm) wide. Male and female flowers are on separate trees. They are greenish, heavily fragrant, borne in small clusters on new branchlets. The fruits are round or slightly oval, 3/4 to 1 in (2-2.5 cm) long, dark-maroon to nearly black; the flesh greenish to white or amber, varying from acid to sweet, and containing 7 to 12 flat, hard, pale-yellow seeds.

Fig. 89: The paniala *(Flacourtia jangomas)* of southern Asia and the Philippines, has wine-red, plumlike fruits, unfortunately very astringent.

The tree is native to North Bengal, East Bengal and Chittagong in India; commonly cultivated throughout Southeast Asia, eastern Malaya, and also in the Philippines. It has been planted in a very limited way in Surinam, Trinidad, Puerto Rico and southern Florida. The seeds are slow to germinate, therefore propagation is usually by inarching or budding onto self-seedlings.

For eating out-of-hand, the fruit is rolled between the hands to reduce astringency, and is better-liked than that of other species. It is stewed as dessert, made into juice, sirup, jam, marmalade and pickles and also used in chutneys. When slightly underripe, it is used to make jelly. The acid young shoots are eaten in Indonesia.

Philippine analyses show: moisture, 78.28%; protein, 0.03%; fat, 0.39%; sugar, 4.86%; ash, 0.94%; acidity, 1.16%. The fruit is fairly rich in pectin; contains 9.9% tannin on a dry-weight basis.

The wood, red or scarlet, is close-grained, hard, brittle, durable and polishes well. It is used for agricultural implements.

The fruits are eaten to overcome biliousness, nausea and diarrhea. The leaf decoction is taken to halt diarrhea. Powdered, dried leaves are employed to relieve bronchitis and coughs. The leaves and bark are applied on bleeding gums and aching teeth, and the bark infusion is gargled to alleviate hoarseness. Pulverized roots are poulticed on sores and skin eruptions and held in the mouth to soothe toothache.

The **ramontchi** is *F. ramontchi* L'Her. *F. indica* has been frequently recorded as a synonym but Indian botanists disagree and treat *F. indica* Merr. as a distinct species. The common name for the ramontchi in India is governor's plum; in Malaya, it is *kerkup kechil* or lesser *kerkup;* in Thailand, *ta-khop-pa;* in the Philippines, *bitongol, bolong,* or *palutan;* in Africa, it is called *kokowi,* Madagascar plum or Indian plum.

The tree is bushy and spreading but may reach 50 ft (15 m) and usually has sharp spines on the trunk and on main branches which tend to arch and droop at the tips. The evergreen, alternate leaves, red when young, are obovate to oblong-obovate, 1 to 2 in (2.5-5 cm) long and finely toothed. Male and female flowers are borne on separate trees. They are white, about 3/16 in (5 mm) wide, and appear singly or paired in the leaf axils. The fruit is round, 1/2 to 1 in (1.25-2.5 cm) thick, smooth, glossy, dark red-purple, with light-brown, acid to sweet, astringent, slightly bitter, flesh and 6 to 10 small, flat seeds.

Fig. 90: The ramontchi, or governor's plum (*F. ramontchi),* closely resembles the paniala. The fruit is sweet but astringent and slightly bitter. The leaves are useful as fodder.

The ramontchi is native to tropical Africa, Madagascar, India, parts of Malaya and Southeast Asia, and much of Malaysia including the Philippines. It has been planted in Florida, Puerto Rico, Trinidad, Guatemala, Honduras and Venezuela and advocated as a source of fruit. It has never become popular anywhere, but jelly can be made from it by not squeezing the jelly bag and thus avoiding excessive astringency. The fruit is usually infested by fruit flies. Analyses made in the Philippines show: moisture, 66.42%; protein, 0.69%; fat, 1.67%; sugar, 7.68%; ash, 1.09%; acidity, 1.78%.

In Florida, birds scatter the seeds and volunteers invade natural areas. In Puerto Rico, the tree is considered useful as a tall barrier hedge or windbreak. Farmers in India lop the branches for fodder. The wood is used only for fuel.

The leaves and roots are believed to be effective against snakebite and the pulverized bark, mixed with sesame oil, is applied on rheumatic parts. Filipinos use the bark infusion as a gargle. A root infusion is taken in cases of pneumonia. The leaf juice is given as a febrifuge and remedy for coughs, dysentery and diarrhea. The dried leaves are regarded as carminative, expectorant, tonic and astringent.

The **rukam,** *F. rukam* Zoll. & Mor., also called *rukam manis, rukam gajah* and Indian prune in Malaya; *khropdong* in Thailand, is a much-branched, crooked tree to 40 or even 65 ft (12-20 m), sometimes thornless in cultivation but usually heavily armed with forked, woody spines on the trunk and old branches. The leaves are evergreen, spiralled, red when young, elliptic-oblong, 3 to 6 in (7.5-15 cm) long, 1 1/4 to 2 1/2 in (3.2-6.25 cm) wide, coarsely toothed, slightly shiny. Flowers are in small clusters in the leaf axils. Male and female are usually on separate trees; occasionally both occur on the same plant. There are no petals; the male have many stamens.

The fruits, borne on old branches or on the trunk, are nearly round, slightly flattened at the apex, 1/2 to 1 in (1.25-2.5 cm) wide, dark purple-red, smooth, with whitish, juicy, acid flesh. There are 4 to 7 flat seeds.

The tree is native to India, Southeast Asia, Malaysia and Oceania; cultivated in southern Malaya and Indonesia. It is adapted to elevations up to 5,200 ft (1,600 m). Seeds came to the USDA from Bangkok in 1920 (S.P.I. #51772). A few specimens have been grown in Florida.

The fruits are eaten raw, especially after rolling them between the palms to reduce astringency. They are also cooked, made into pie, jam and chutney. The young shoots are marketed and eaten raw in Java.

Analyses made in the Philippines show: calories 82.80 per 100 g; moisture, 76.93%; protein, 1.72%; fat, 1.26%; reducing sugars, 4.32%; fiber, 3.71%; other carbohydrates, 11.29%; ash, 0.771%; acidity, 1.29%.

The heavy, strong wood is made into rice pounders in Java; pestles in the Philippines; and clubs in Samoa.

The juice of immature fruit is taken to halt diarrhea and dysentery. Leaf juice is applied on inflamed eyelids, and dried, pulverized leaves are spread on wounds. The root decoction is given to women after childbirth. The inner bark is used against filariasis in Samoa.

Morton, J. 1987. Passionfruit. p. 320–328. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Passionfruit

Passiflora edulis Sims

Of the estimated 500 species of *Passiflora*, in the family Passifloraceae, only one, *P. edulis* Sims, has the exclusive designation of passionfruit, without qualification. Within this species, there are two distinct forms, the standard purple, and the yellow, distinguished as *P. edulis* f. *flavicarpa* Deg., and differing not only in color but in certain other features as will be noted further on.

General names for both in Spanish are *granadilla, parcha, parchita, parchita maracuyá,* or *ceibey* (Cuba); in Portuguese, *maracuja peroba;* in French, *grenadille,* or *couzou*. The purple form may be called purple, red, or black granadilla, or, in Hawaii, *lilikoi;* in Jamaica, mountain sweet cup; in Thailand, *linmangkon.* The yellow form is widely known as yellow passionfruit; is called yellow *lilikoi* in Hawaii; golden passionfruit in Australia; *parcha amarilla* in Venezuela.

Description

Fig. 91: Purple passionfruit (*Passiflora edulis*) is subtropical, important in some countries, while the more tropical yellow passionfruit excels in others. Both yield delicious juice.

The passionfruit vine is a shallow-rooted, woody, perennial, climbing by means of tendrils. The alternate, evergreen leaves, deeply 3-lobed when mature, are finely toothed, 3 to 8 in (7.5-20 cm) long, deep-green and glossy above, paler and dull beneath, and, like the young stems and tendrils, tinged with red or purple, especially in the yellow form. A single, fragrant flower, 2 to 3 in (5-7.5 cm) wide, is borne at each node on the new growth. The bloom, clasped by 3 large, green, leaflike bracts, consists of 5 greenish-white sepals, 5 white petals, a fringelike corona of straight, white-tipped rays, rich purple at the base, also 5 stamens with large anthers, the ovary, and triple-branched style forming a prominent central structure. The flower of the yellow is the more showy, with more intense color. The nearly round or ovoid fruit, 1 1/2 to 3 in (4-7.5 cm) wide, has a tough rind, smooth, waxy, ranging in hue from dark-purple with faint, fine white specks, to light-yellow or pumpkin-color. It is 1/8 in (3 mm) thick, adhering to a 1/4 in (6 mm) layer of white pith. Within is a cavity more or less filled with an aromatic mass of double-walled, membranous sacs filled with orange-colored, pulpy juice and as many as 250 small, hard, dark-brown or black, pitted seeds. The flavor is appealing, musky, guava-like, subacid to acid.

Origin and Distribution

The purple passionfruit is native from southern Brazil through Paraguay to northern Argentina. It has been stated that the yellow form is of unknown origin, or perhaps native to the Amazon region of Brazil, or is a hybrid between *P. edulis* and *P. ligularis* (q.v.). Cytological studies have not borne out the hybrid theory. Speculation as to Australian origin arose through the introduction of seeds from that country into Hawaii and the mainland United States by E.N. Reasoner in 1923. Seeds of a yellow-fruited form were sent from Argentina to the United States Department of Agriculture in 1915 (S.P.I. No. 40852) with the explanation that the vine was grown at the Guemes Agricultural Experiment Station from seeds taken from fruits purchased in Covent Garden, London. Some now think the yellow is a chance mutant that occurred in Australia. However, E.P. Killip, in 1938, described P. *edulis* in its natural range as having purple or yellow fruits.

Brazil has long had a well-established passionfruit industry with large-scale juice extraction plants. The purple passionfruit is there preferred for consuming fresh; the yellow for juice processing and the making of preserves.

In Australia, the purple passionfruit was flourishing and partially naturalized in coastal areas of Queensland before 1900. Its cultivation, especially on abandoned banana plantations, attained great importance and the crop was considered relatively disease-free and easily managed. Then, about 1943, a widespread invasion of *Fusarium* wilt killed the vines and forced the undertaking of research to find fungus-resistant substitutes. It was discovered that the neglected yellow passionfruit is both wilt-and nematode-resistant and does not sucker from the roots. It was adopted as a rootstock and plants propagated by grafting were soon made available to planters in Queensland and northern New South Wales.

The Australian taste is strongly prejudiced in favor of the purple passionfruit and growers have been reluctant to relinquish it altogether. Only in the last few decades have they begun to adopt hybrids of the purple and yellow which have shown some ability to withstand the serious virus disease called "woodiness".

New Zealand, in the early 1930's, had a small but thriving purple passionfruit industry in Auckland Province but in a few years the disease-susceptibility of this type brought about its decline. Good local marketing and export prospects have brought about a revival of efforts to control infestations and increase acreage, mostly in the Bay of Plenty region. Today, fruits and juice are exported. A profitable purple passionfruit industry has developed also in New Guinea.

In Hawaii, seeds of the purple passionfruit, brought from Australia, were first planted in 1880 and the vine came to be popular in home gardens. It quickly became naturalized in the lower forests and, by 1930, could be found wild on all the islands of the Hawaiian chain. In the 1940's, a Mr. Haley attempted to market canned passionfruit juice in a small way but the product was unsatisfactory and his effort was terminated by World War II. A processor on Kauai produced a concentrate in glass jars and this project, though small, proved successful. In 1951, when Hawaiian passionfruit plantings totalled less than 5 acres (2 ha), the University of Hawaii chose this fruit as the most promising crop for development and undertook to create an industry based on quick-frozen passionfruit juice concentrate. From among Mr. Haley's vines, choice strains of yellow passionfruit were selected. These gave four times the yield of the purple passionfruit and had a higher juice content. By 1958, 1,200 acres (486 ha) were devoted to yellow passionfruit production and the industry was firmly established on a satisfactory economic level.

Commercial culture of purple passionfruit was begun in Kenya in 1933 and was expanded in 1960, when the crop was also introduced into Uganda for commercial production. In both countries, the large plantations were devastated several times by easily-spread diseases and pests. It became necessary to abandon them in favor of small and isolated plantings which could be better protected.

South Africa in 1947 produced 2,000 tons of purple passionfruit for domestic consumption. Production was doubled by 1950. In 1965, passionfruit plantations were initiated over large areas of the Transvaal to meet the market demand and apparently there have been no serious setbacks as yet, from disease or other causes.

India, for many years, has enjoyed a moderate harvest of purple passionfruit in the Nilgiris in the south and in various parts of northern India. In many areas, the vine has run wild. The yellow form was unknown in India until just a few decades ago when it was introduced from Ceylon and proved well adapted to low elevations around Madras and Kerala. It was quickly approved as having a more pronounced flavor than the purple and producing within a year of planting heavier and more regular crops.

The purple passionfruit was introduced into Israel from Australia early in the 20th Century and is commonly grown in home gardens all around the coastal plain, with small quantities being supplied to processing factories.

Passionfruit vines are found wild and cultivated to some extent in many other parts of the Old World–including the highlands of Java, Sumatra, Malaya, Western Samoa, Norfolk Islands, Cook Islands, Solomon Islands, Guam, the Philippines, the Ivory Coast, Zimbabwe and Taiwan. From several of these sources, considerable quantities of yellow passionfruit juice and pulp are exported to Australia, causing some protests from Queensland growers. The yellow passionfruit was introduced into Fiji from Hawaii in 1950, was distributed to farmers in 1960 and became the basis of a small juice-processing industry. Fiji has exported to Australia, New Zealand, and Canada as well as to nearby islands.

In South America, interest in yellow passionfruit culture intensified in Colombia and Venezuela in the mid-1950's and in Surinam in 1975. In Colombia, there are commercial plantations mainly in the Cauca Valley.

Since the introduction of the yellow passionfruit from Brazil into Venezuela in 1954, it has achieved industrial status and national popularity. Much effort is being devoted to improving the yield to better meet the demand for the extracted juice, passionfruit ice cream, and other appealing products such as bottled passionfruit-and-rum cocktail.

The purple passionfruit was naturalized in the Blue Mountains of Jamaica by 1913, and both the purple and the yellow are planted to some extent in Puerto Rico.

Various species of *Passiflora* have reached the United States Plant Introduction Station (now the Subtropical Horticulture Research Unit) in Miami, Florida, in the routine course of plant accession. Some vines were known to exist and bear fruit year after year here and there in the southern and central areas of the state since 1887 or earlier. In 1953, I requested seeds of good strains of the purple and yellow forms from the Queensland Department of Agriculture and Stock and gave seeds to experimenters. In 1955, one yellow-fruited vine from these seeds was flourishing at Pinecrest and, from the reports of hunters camping beyond that locality, it appears that bird-transported seeds have produced fruiting vines in outlying Everglades hammocks. In 1957, a very fruitful specimen was thriving at the home of Benjamin Blumberg in Coconut Grove, and an escape was bearing unusually large fruits in the treetops of a natural hammock a few miles away. At this time, the purple passionfruit was being grown successfully by a homeowner further north, at Land O'Lakes, Pasco County, and the seeds were advertised for sale. There were small plantations of purple passionfruit in San Diego County, California, the fruits being sold on the fresh fruit market and also processed for juice. However, there was little interest in developing either form as a crop in the United States. At the University of Florida's Subtropical Experiment Station in Homestead, Florida, limited trials with the purple and yellow forms resulted in words of discouragement, the purple vine in particular having proved so susceptible to disease. Certain vines at the Plant Introduction Station had died from *Fusarium* attack and the survivors showed poor fruiting performance.

Dr. Robert Knight and Harold F. Winters of the United States Department of Agriculture prepared two reports on the pollination of the yellow passionfruit and the problems affecting yield. They expressed a dim view of economical juice production and the need for extensive field studies. They offered plant material to anyone qualified to undertake such work. The Minute Maid Company established a test plot of the yellow form at Indiantown in 1965. They found the fruit entirely satisfactory for processing but abandoned the project 2 years later, stating: "The yields are not as large as in more tropical areas where the plant remains productive all year round. Our plants went out of production during the winter season. During the windy spring months of March and April, the vines are badly damaged and no flowers are set until sometime in May. We also found that the passionfruit were expensive to harvest. The fruit has to fall on the ground and sometimes it gets hung up in the vines. There is a continual collection of small quantities of fruit throughout the [bearing] year * Special equipment is needed to obtain the juice from the fruit without bits of the calyx showing up as objectionable black specks. This equipment is costly and can only be justified when a large volume of fruit is being processed."

In 1965, the Laboratorie de Recherche des Produits Nestlé, Vevey, Switzerland, placed the passionfruit among the three insufficiently-known tropical fruits having the greatest potential for nectar processing for the European market. It is obvious, then, that in spite of the handicaps of passionfruit culture, the crop offers revenue-earning opportunities for developing countries with low labor costs.

Varieties

The yellow form has a more vigorous vine and generally larger fruit than the purple, but the pulp of the purple is less acid, richer in aroma and flavor, and has a higher proportion of juice-35-38%. The purple form has black seeds, the yellow, brown seeds.

The following are some of the older cultivars as well as some of the more recent:

'Australian Purple', or 'Nelly Kelly'–a purple selection of mild, sweet flavor, grown in Australia and Hawaii.

'Common Purple'–the form growing naturalized in Hawaii; thick-skinned, with small seed cavity, but of fine flavor and low acidity.

'Kapoho Selection'–a cross of 'Sevcik' and other yellow strains in Hawaii. A heavy bearer of large fruits but subject to brown rot; many fruits contain little or no pulp and the juice has the off-flavor of 'Sevcik' though not as pronounced.

'Pratt Hybrid'–apparently a natural cross between the 'Common Purple' and a yellow strain; subject to rot, but juice is of fine color and flavor, low in acid.

'Sevcik Selection'–a golden form of the yellow selected in Hawaii; a heavy bearer, but subject to brown rot and the juice has a peculiar woody flavor.

'University Round Selection'–Hawaiian crosses of 'Waimanalo' and 'Yee'–fruit smaller than 'Yee'; not as attractive but yields 10% more juice of very good flavor.

'University Selection No. B-74'–a Hawaiian hybrid between 'Pratt' and 'C-77', usually yellow, occasionally with red tinges; resembles 'Waimanalo'; has good juice yield and very good flavor.

'Waimanalo Selection'–consists of 4 strains: 'C-54', 'C-77', 'C-80', of similar size, shape, color and very good flavor, and 'C-39' as pollinator.

'Yee Selection'–yellow, round, very attractive, highly disease-resistant, but fruit has thick rind and low yield of juice which is of very good flavor.

What may be a great improvement over any of the above is the cultivar known as **'Noel's Special'.** It is a yellow passionfruit selected in 1968 from open-pollinated seedlings of a vine discovered at an abandoned farm on Hilo, Hawaii, by Noel Fujimoto in the early 1950's. The fruit is round, averages 3.17 oz (90 g); the cavity is filled with dark-orange pulp yielding 43 to 56% bright-orange, richly flavored juice. The vine is vigorous, begins to bear in one year, and is tolerant to brown spot. It produces 88% marketable fruit in a season–a higher proportion than any other cultivar.

In 1967, two purple X yellow hybrids–'3-1' and '3-26', developed at the Redlands Horticulture Research Station, Queensland, had nearly replaced the purple passionfruit in commercial plantations on the coast of southern Queensland and New South Wales. They have a longer fruiting season than the purple, are high-yielding, with high pulp content, keep very well, and meet with little market resistance. Australian breeders continued to strive for a type that would have the needed characteristics and reproduce true from seed. Hybrid '23-E' followed. By 1981, hybrid '3-1' had succumbed to a new, more virulent strain of "woodiness" virus and had to be abandoned. Other popular hybrids are **'Lacey'** and **'Purple-gold'.**

In early 1980, several purple passionfruit hybrids, all insect-pollinated, were introduced into the island of Niue, as possible substitutes for the yellow form cultivated commercially there for export since 1955, with the view of eliminating the labor of hand-pollination required by the yellow for top production. However, the hybrids are more susceptible to mealybug infestation.

One New Zealand grower has exported purple passionfruits to the United States under the trade name of **'Bali Hai'.**

Commercial cultivars of the purple form in Brazil include **'Ouropretano', 'Muico', 'Peroba',** and **'Pintado';** of the yellow form, **'Mirim'** or **'Redondo',** and **'Guassu'** or **'Grande'.**

In the Cauca Valley of Colombia, the best-performing yellow passionfruit is the **'Hawaiiana'.** Venezuelan growers favor the 'Hawaiiana', 'Brasilera amarilla', and the purple-fruited 'Brasilera rosada'.

A highly promising hybrid, 'M-21471A' has been developed by Dr. R.J. Knight at the United States Department of Agriculture's Subtropical Horticulture Research Station, Miami. The fruit is maroon, weighs about 3 oz (85 g); is close to the purple parent in quality; is self-compatible and resists soil-borne diseases like its yellow parent. F_1 hybrids may be reddish-purple with more conspicuous white dots than on the purple parent, and sometimes there is a tinge of yellow in the background. F2 hybrids show three variations of purple and are difficult to distinguish from the purple parent.

Pollination

Yellow passionfruit flowers are perfect but self-sterile. In controlled pollination studies at the College of Agriculture of Jaboticabal, Sao Paulo, Brazil, it was found that the yellow passionfruit has three types of flowers according to the curvature of the style: TC (totally curved), PC (partially curved), and SC (upright-styled). TC flowers are most prevalent. Carpenter bees *(Xylocopa megaxylocopa frontalis* and *X. neoxylocopa)* efficiently pollinated TC and PC flowers. Honey bees

(*Apis mellifera adansonii)* were much less efficient. Wind is ineffective because of the heaviness and stickiness of the pollen. SC flowers have fertile pollen but do not set fruit. To assure the presence of carpenter bees, it is wise to have decaying logs among the vines to provide nesting places. Carpenter bees will not work the flowers if the nectary is wet. If rain occurs in 1 1/2 hrs after pollination, there will be no fruit set, but if 2 hrs pass before rain falls, it will have no detrimental effect. In the absence of carpenter bees in Fiji, farmers cross-pollinate by hand, treating 600 flowers an hour, with 70% fruit set and 60% of fruit reaching maturity.

Fig. 92: Flowers of the purple passionfruit are fragrant and lovely, though those of the yellow are richer in color.

The purple form blooms in spring and early summer (July-November) in Queensland and again for a shorter period in fall and early winter (February-April). In Florida, blooming occurs from mid-March through April. The flowers open early in the morning (about dawn) and close before noon, and are self-compatible. The yellow form has one flowering season in Queensland (October-June). In Florida, blooming has occurred from mid-April to mid-November. The flowers open around noon and close about 9 to 10 PM and are self-incompatible.

In crossing the yellow and purple forms, it is necessary to use the purple as the seed parent because the flowers of the yellow are not receptive to the pollen of the purple, and an early-blooming yellow must be utilized in order to have a sufficient overlapping period for pollen transfer. Dr. R.J. Knight has suggested lengthening the overlap by exposing the yellow to artificial light for 6 weeks before the normal flowering season. However, despite the seasonal and hourly differences, natural hybrids between the two forms occur in South Africa, Queensland and in Hawaii. Growers of purple passionfruit in South Africa are warned not to take seed from any vine in proximity to a planting of yellow passionfruit, otherwise the seedlings are apt to produce hybrid fruit of inferior quality.

In some areas, trellis-grown vines of the yellow passionfruit require hand-pollination to assist fruit set. In the home garden, at least two vines of different parentage should be planted and allowed to intertwine for cross-pollination.

Climate

The purple passionfruit is subtropical. It grows and produces well between altitudes of 2,000 and 4,000 ft (650-1,300 m) in India. In Java, it grows well in lowlands but will flower and fruit only above 3,200 ft (1,000 m). In west-central Florida, at 28º N latitude and slightly above sea-level, 3-year-old vines have survived freezing temperatures with the lower 3 ft (.9 m) of the stems wrapped in fiberglass 4 in (10 cm) thick. The upper parts suffered cold injury, were cut back, the vines were heavily fertilized, recovered rapidly and fruited heavily the second summer thereafter.

The yellow passionfruit is tropical or near-tropical. In Western Samoa, it is grown from near sea-level up to an elevation of 2,000 ft (600 m).

Both forms need protection from wind. Generally, annual rainfall should be at least 35 in (90 cm), but in the Northern Transvaal, in South Africa, there is reduced transpiration because of high atmospheric humidity and commercial culture is carried on with precipitation of only 24 in (60 cm). It is reported that annual rainfall in passionfruit-growing areas of India ranges between 40 and 100 in (100-250 cm).

Soil

Passionfruit vines are grown on many soil types but light to heavy sandy loams, of medium texture are most suitable, and pH should be from 6.5 to 7.5. If the soil is too acid, lime must be applied. Good drainage is essential to minimize the incidence of collar rot.

Propagation

Plate XLIII: YELLOW PASSIONFRUIT, *Passiflora edulis* var. *flavicarpa*

Passionfruit vines are usually grown from seeds. With the yellow form, seedling variation provides cross-pollination and helps overcome the problem of self-sterility. Some say that the fruits should be stored for a week or two to allow them to shrivel and become perfectly ripe before seeds are extracted. If planted soon after removal from the fruit, seeds will germinate in 2 to 3 weeks. Cleaned and stored seeds have a lower and slower rate of germination. Sprouting may be hastened by allowing the pulp to ferment for a few days before separating the seeds, or by chipping the seeds or rubbing them with fine sandpaper. Soaking, often recommended, has not proved helpful. Seeds are planted 1/2 in (1.25 cm) deep in beds, and seedlings may be transplanted when 10 in (25 cm) high. If taller–up to 3 ft (.9 in)–the tops should be cut back and the plants heavily watered.

Some growers prefer layers or cuttings of matured wood with 3 to 4 nodes. Cuttings should be well rooted and ready for setting out in 90 days. Rooting may be hastened by hormone treatment. Grafting is an important means of perpetuating hybrids and reducing nematode damage and diseases by utilizing the resistant yellow passionfruit rootstock. If seeds are available in the early spring, seedlings for rootstocks can be raised 4 in (10 cm) apart in rows 24 in (60 cm) apart and the grafted plants will be ready to set out in late summer. If seeds cannot be obtained until late summer, the seedlings are raised and grafted in pots and set out in the spring. Scions from healthy young vines are preferred to those from mature plants. The diameter of the selected scion should match that of the rootstock. Either a cleft graft, whip graft, or side-wedge graft may be made.

If approach-grafting is to be done, a row of potted scions must be placed close alongside the row of rootstocks so that the union can be made at about 3/4 of the height of the plant.

Culture

Root-pruning should precede transplanting of seedlings by 2 weeks. Transplanting is best done on a cool, overcast day. The soil should be prepared and enriched organically a month in advance if possible. Grafted vines must be planted with the union well above ground, not covered by soil or mulch, otherwise the disease resistance will be lost. Mounding of the rows greatly facilitates fruit collection.

In plantations, the vines are set at various distances, but studies in Venezuela indicate that highest yields in yellow passionfruit are obtained when the vines are set 10 ft (3 m) apart each way. In South Africa, purple passionfruit vines are set 8 ft (2 1/2 m) apart in cool areas, and 12 to 15 ft (3 1/2-4 1/2 m) apart in warm areas. Spacing of purple passionfruit in Kenya has been 10 ft (3 m) between vines and 6 ft (1.8 m) between rows. Recent 3-year trials of 4 ft (1.2 m) between rows, with light pruning the 2nd and 3rd years, resulted in the highest yield (50% of the crop being home the first year). But it is recognized that such close planting can lead to disease problems and replanting after the 3rd year.

Commercially, vines are trained to strongly-supported wire trellises at least 7 ft (2.13 m) high. However, for the benefit of the homeowner, it should be pointed out that the yellow passionfruit is more productive and less subject to pests and diseases if allowed to climb a tall tree.

After a vine of either the yellow or purple passionfruit attains 2 years of age, pruning once a year will stimulate new growth and consequently more flower and fruit production. The average life of a plantation in Fiji is only 3 years. Judicious pruning of lateral branches after fruiting aids in disease control and can extend plantation life to 5 or 6 years. In South Africa, at elevations between 4,000 and 4,800 ft (1,200-1,460 m), plantations are kept in full production for as long as 8 years.

Regular watering will keep a vine flowering and fruiting almost continuously. Least flowers develop during the winter season due to short day length. Water requirement is high when fruits are approaching maturity. If soil is dry, fruits may shrivel and fall prematurely. Fertilizer (10-5-20 NPK) should be applied at the rate of 3 lbs (1.36 kg) per plant 4 times a year, under normal conditions. In India, trials of purple passionfruit on red sandy loam with a pH of 6.5 and high organic content, the optimum fertilizer treatment was found to be 290 lbs (132 kg) N and 69 1/2 lbs (31.6 kg) P per ha per year. French horticulturists have reported that, in plantations on the Ivory Coast, annual supplements of 8 oz (220 g) urea and 7 1/2 oz (210 g) potassium sulfate per plant per year of age will have a highly favorable effect on production. It is said that 32 to 36 oz (900-1,000 g) of nitrogen are required to produce 66 lbs (30 kg) of fruits, but excessive nitrogen will cause premature fruit drop. Passionfruit vines should always be watched for deficiencies, particularly in potassium and calcium, and of less importance, magnesium.

The passionfruit vine, especially the yellow, is fast-growing and will begin to bear in 1 to 3 years. Ripening occurs 70 to 80 days after pollination. Injuries to the base of the vine, which allow entrance of disease organisms, can be avoided by hand-weeding or the application of herbicides around the main stems. These practices will also protect the shallow root system. In Surinam, good weed control under trellises has been achieved by covering the soil with black plastic.

Seasons and Harvesting

The different flowering seasons of the purple and yellow passionfruits have been mentioned under "Pollination". In some areas, as in India, the vines bear throughout the year but peak periods are, first, August to December, and, second, March to May. At the latter time, the fruits are somewhat smaller, with less juice. In Hawaii, passionfruits mature from June through January, with heaviest crops in July and August and October and November. With variations according to cultivar, and with commercial cultivation both above and below the Equator, there need never be a shortage of raw material for processing.

Plate XLIV: YELLOW PASSIONFRUIT, *Passiflora edulis* var. *flavicarpa*

Ripe fruits fall to the ground and will roll in between mounded rows. They do not attract flies or ants but should be collected daily to avoid spoilage from soil organisms. In South Africa, they are subject to sunburn damage on the ground and, for that reason, are picked from the vines 2 or 3 times a week in the summertime before they are fully ripe, that is, when they are light-purple. At this stage, they will reach the fresh fruit market before they wrinkle. In winter, only one picking per week is necessary. For juice processing, the fruit is allowed to attain a deep-purple color. In India and Israel the fruits are always picked from the vine rather than being allowed to fall. It has been found that fallen fruits are lower in soluble solids, sugar content, acidity and ascorbic acid content.

The fruits should be collected in lugs or boxes, not in bags which will cause "sweating". If not sent immediately to processing plants, the fruits should be spread out on wire racks where there will be good air circulation.

Yield

Many factors influence the yield of passionfruit vines. In general, yields of commercial plantations range from 20,000 to 35,000 lbs per acre (roughly the same number of kg per ha). In Fiji, with hand pollination, 173 acres (70 ha) will yield 33 tons (30 MT) of fruits. Hybrids in Australia have raised yields far beyond those obtained with the purple passionfruit.

On the average, a bushel of passionfruits in Australia weighs 36 lbs (16 kg); yields 13 1/3 lbs (6 kg) of pulp from which is obtained 1 gal (3.785 liters)–that is 10.7 lbs (4.5 kg) of juice, and 2.6 lbs (1.18 kg) of seeds. With some strains, the juice yield is much higher.

Storage

Underripe yellow passionfruits can be ripened and stored at 68º F (20º C) with relative humidity of 85 to 90%. Ripening is too rapid at 86º F (30º C). Ripe fruits keep for one week at 36º to 45º F

(2.22º-7.22º C). Fruits stored in unperforated, sealed, polyethylene bags at 74º F (23.1º C), have remained in good condition for 2 weeks. Coating with paraffin and storing at 41º to 44.6º F (5º to 7º C) and relative humidity of 85 to 90%, has prevented wrinkling and preserved quality for 30 days.

Pests and Diseases

In Hawaii and Australia, infestations of the passion vine mite *(Brevipalpus phoenicis)* occur during dry weather in the warm season, defoliate the younger portions of the vines but not the terminus, and make brown blemishes on the fruits. The passion vine bug *(Leptoglossus australis)* feeds on flowers and young, green fruits in Queensland. The green vegetable bug, or stinkbug, *(Nezara viridula) is* a similar but lesser menace to the plant and young fruits. Both the immature and the adult stages suck the sap of the growing tips, as do the brown stinkbug *(Boerias maculata),* the large black stinkbug *(Anoplocnemis* sp.) and the small black stinkbug *(Leptoglossus membranaceus).* In Florida, the yellow passionfruit is commonly found to be superficially punctured by a stinkbug *(Chrondrocera laticornis),* affecting only its appearance. Thrips *(Thysanoptera* sp.) injure and cause stunting of young seedlings in nurseries. In dry weather, they also feed on leaves and fruits, leaving them defaced and prone to shrivel and fall prematurely. In East Africa, injury from the tobacco white fly *(Bemisia tabaci)* may lead to galls on the leaves. Leaf beetles *(Haltica* sp.) and weevils *(Systates* spp.) chew the foliage, and cutworms behead seedlings in nurseries. Two lepidopterous pests, *Dione,* or *Agraulis, vanillae* and *Mechanitis variabilis* are common in Colombia.

Among scales attacking the vine and petioles, white peach scale *(Pseudaulacaspis pentagona)* is most troublesome in Queensland. Not as prevalent are round purple scale *(Chrysomphalus ficus)* and granadilla purple scale *(Parasaissetia nigra).* These pests may cause dieback of the entire plant if not controlled. Red scale *(Aonidiella aurantii)* is common on mature passion vines in Queensland. Soft brown scale (*Coccus hesperidum)* is occasionally troublesome. The passion vine leaf hopper *(Scolypopa australis)* requires protective measures. The citrus mealybug *(Planococcus citri)* is a major Queensland pest in summer. Spraying, unfortunately, kills its chief predator, the mealybug ladybird, *Cryptolaemus montrouzieri.* The aphids, *Aphis gossypii* and *Myzus Persicae,* transmit the virus which causes "woodiness" (see below).

There has been no report of attack by the Caribbean fruit fly *(Anastrepha suspensa)* in Florida, though *Anastrepha* infestation was on one occasion observed by Curtis Dowling in *Passflora* fruits in Costa Rica. In Brazil, fruit flies of the genus *Anastrepha,* and in Hawaii the Oriental fruit fly and the melon fly, deposit eggs in the very young, tender fruits. In these, the larvae seem able to develop and cause the immature fruits to shrivel and fall. If fruits are punctured when nearly mature, the only effect is an external scar. The same is reported concerning the dominant Queensland fruit fly *(Dacus tryoni)* and the less common Mediterranean fruit fly *(Ceratitis capitata)* in Australia.

In South Africa, purple passionfruit vines are damaged by several species of nematodes. The most important, which causes extreme thickening of the roots, is the root-knot nematode, *Meloidogyne javanica.* Others include the spiral nematode *(Scutellonema truncatum* and *Helicotylenchus* sp.), and the lesion nematode *(Pratylenchus* sp.). The yellow passionfruit is nematode-resistant.

The main diseases of purple passion fruit in Australia are brown spot, *Septoria* spot and base rot, *Phytophthora* blight, *Fusarium* wilt, woodiness, and damping-off. Brown spot, caused by *Alternaria passiflorae* in warm weather, is a major affliction of the purple passionfruit also in New Zealand and East Africa. In Hawaii, brown spot is the leading disease of the yellow passionfruit and *A. tenuis was* found to be the dominant species associated with the disease in 1969. *A.* macrospora has occasioned severe leaf spot and branch lesions in India. A similar disease causing spotting and crinkling of leaves and fruit first appeared in Ceylon in 1970. Septoria spot, from the fungus *Septoria passiflorae,* most common in summer and fall, is evidenced by more numerous and smaller spots than brown spot, on all parts of the vine and on the fruits, and it is spread by rain, dew and overhead irrigation. Some believe this fungus to be also the source of base rot, often induced by injury from mowers or other mechanical equipment.

Phytophthora cinnamoni, the source of collar rot in Fiji, makes it necessary to replace yellow passionfruit plantings there every 30 to 35 months. *P. nicotinae v*ar. *parasitica* has been linked to fatal blight, or stem rot, and fruit rot in purple passionfruit vine, but not in the yellow, in wet periods of summer and fall in Queensland and South Africa. *P. cinnamoni* and *P. nicotinae* are responsible for root rot in New Zealand and Western Australia, and the latter is identified with wilt in South Africa and Sarawak, and with damping-off and leaf blight in both the purple and the yellow passionfruits in India.

Fusarium wilt, arising from the soil-borne fungus, *Fusarium oxysporium* f. sp. *passiflorae,* can be reduced only by grafting the purple, or, better still, purple-yellow hybrids, onto the *Fusarium*-resistant yellow passionfruit rootstock. However, Bedoya *et al*. have reported that, in the zones of Palmira, Cerrito and Ginebra of the Cauca Valley of Colombia, but not in the zone of Unión, collar rot limits the life of yellow passionfruit plantations to 3 years, and they found, in inoculation experiments, that *Fusarium solani* produced the symptoms. The first signs are chlorosis, necrosis and defoliation; next there is splitting of the trunk and separation of the bark. The root becomes progressively discolored and red rays extend to the surface of the soil.

Nectria haematococca, or *Hypomyces solani,* the ascogenous state of *Fusarium solani,* has been determined to be the organism girdling the collar zone and bringing on sudden wilt of the purple passionfruit vine in Uganda.

The virus disease, "woodiness", or "bullet", appearing as small misshapen fruits with thick rind and small pulp cavity, has been the most serious plague of the purple passionfruit in Australia and East Africa, but it has little effect on the yellow form. The "woodiness" virus (PWV) is also the source of tip blight in the coastal districts of central Queensland. This virus has a wide host range, not only in the genus *Passiflora,* but also weedy species in the families Amaranthaceae, Chenopodiaceae, Cucurbitaceae and Solanaceae.

There are a number of different strains of the "woodiness" virus. For many years, inoculation of passionfruit vines with mild strains protected them from further infection, and commercial hybrids containing small doses of mild strains were released to farmers. But, in 1978, a new, more virulent, strain of virus appeared and overcame the "mild strain protection". The New South Wales Passionfruit Growers Association, in response to this new threat, established, in 1979, a Passionfruit Scion Accreditation Scheme to "improve the quality of planting material by field selection and provide scionwood free of the severe strain of woodiness virus", for a standard fee. Generally, 100 scions can be taken from each accredited vine in a season. By 1981, 16,000 scions had been supplied to commercial growers.

In 1973, two mosaic viruses–PPMV-K and PFMVMY–said to differ from other reported *Passiflora* viruses, were found to be prevalent in commercial plantings of the yellow passionfruit in the Bantung district of Selangor, Malaya. Damping-off is caused by *Rhizoctonia solani* and *Pythium* spp. in Queensland. Thread blight of yellow passionfruit vine in Fiji and Western Samoa, seen as patches of black, papery, shredded leaves with gray to tan layer of merged "threads" beneath, has been attributed to *Rhizoctonia solani* (also called *Thanatephorus cucumeris).* It may invade the entire vine.

Food Uses

The fruit is of easy preparation. One needs only cut it in half lengthwise and scoop out the seedy pulp with a spoon. For home use, Australians do not trouble to remove the seeds but eat the pulp with cream and sugar or use it in fruit salads or in beverages, seeds and all. Elsewhere it is usually squeezed through two thicknesses of cheesecloth or pressed through a strainer to remove the seeds. Mechanical extractors are, of course, used industrially. The resulting rich juice, which has been called a natural concentrate, can be sweetened and diluted with water or other juices (especially orange or pineapple), to make cold drinks. In South Africa, passionfruit juice is blended with milk and an alginate; in Australia the pulp is added to yogurt. After primary juice extraction, some processors employ an enzymatic process to obtain supplementary "secondary" juice from the double juice sacs surrounding each seed. The high starch content of the juice gives it exceptional viscosity. To produce a freeflowing concentrate, it is desirable to remove the starch by centrifugal separation in the processing operation.

Passionfruit juice can be boiled down to a sirup which is used in making sauce, gelatin desserts, candy, ice cream, sherbet, cake icing, cake filling, meringue or chiffon pie, cold fruit soup, or in cocktails. The seeded pulp is made into jelly or is combined with pineapple or tomato in making jam. The flavor of passionfruit juice is impaired by heat preservation unless it is done by agitated or "spin" pasteurization in the can. The frozen juice can be kept without deterioration for 1 year at 0º F (-17.78º C) and is a very appealing product. The juice can also be "vacuum-puff" dried or freeze-dried. Swiss processors have marketed a passionfruit-based soft drink called "Passaia" for a number of years in Western Europe. Costa Rica produces a wine sold as "Parchita Seco."

Food Value Per 100 g of Edible Portion (Purple passionfruit, pulp and seeds)*

Calories	90
Moisture	75.1 g
Protein	2.2 g
Fat	0.7 g
Carbohydrates	21.2 g
Fiber	?
Ash	0.8g
Calcium	13 mg
Phosphorus	64 mg

Iron'	1.6 mg
Sodium	28 mg
Potassium	348 mg
Vitamin A	700 I.U.
Thiamine	Trace
Riboflavin	0.13 mg
Niacin	1.5 mg
Ascorbic Acid	30 mg

*According to U.S. Dept. Agr., ARS.

The yellow passionfruit has somewhat less ascorbic acid than the purple but is richer in total acid (mainly citric) and in carotene content. It is an excellent source of niacin and a good source of riboflavin. Free amino acids in purple passionfruit juice are: arginine, aspartic acid, glycine, leucine, lysine, proline, threonine, tyrosine and valine. Carotenoids in the purple form constitute 1.160%; in the yellow, 0.058%; flavonoids in the purple, 1.060%; in the yellow, 1.000%; alkaloids in the purple, 0.012%; in the yellow, 0.700% (mainly harman), and the juice is slightly sedative. Starch content of purple passionfruit juice is 0.74%; of the yellow, 0.06%.

Toxicity

A cyanogenic glycoside is found in the pulp of passionfruits at all stages of development, but is highest in very young, unripe fruits and lowest in fallen, wrinkled fruits, the level in the latter being so low that it is of no toxicological significance.

Other Uses

Commercial processing of the yellow passionfruit yields 36% juice, 51% rinds, and 11% seeds.

Rind: The rinds have a very low pectin content–only 2.4% (14% on a dry weight basis). Nevertheless, it has been determined in Fiji that extraction of pectin from the rinds–up to 5 tons (4.5 MT) annually–reduces the otherwise burdensome problem of waste disposal. The rind residue contains about 5 to 6% protein and could be used as a filler in poultry and stock feed. In Brazil, pectin is extracted from the purple form which has a better quality pectin than that in the yellow. In Hawaii, the pectin is not extracted. Instead, the rinds are chopped, dried, and combined with molasses as cattle or pig feed. They can also be converted into silage.

Seeds: The seeds yield 23% oil which is similar to sunflower and soybean oil and accordingly has edible as well as industrial uses. Up to 3,400 gallons (13,000 liters) can be obtained per year in Fiji. The seed meal contains about 12% protein and 50 to 55% fiber. It has been judged unsuitable for cattle feed.

Analyses of the fresh rind show: moisture, 78.43-85.24%; crude protein, 2.04-2.84%; fat, 0.05-0.16%; crude starch, 0.75-1.36%; sugars (sucrose, glucose, fructose), 1.64%; crude fiber, 4.57-7.13%; phosphorus, 0.03-0.06%; silica, 0.01-0.04%; potassium, 0.60-0.78 %; organic acids (citric and malic), 0.15%; ascorbic acid, 78.3-166.2%. The outer skin of the purple form contains

1.4 mg per 100 g of the anthocyanin pigment, pelargonidin 3-diglucoside. There is also some tannin.

The composition of the air-dried seeds is reported as: moisture, 5.4%; fat, 23.8%; crude fiber, 53.7%; protein, 11.1%; N-free extract, 5.1%; total ash, 1.84%; ash insoluble in HC1, 0.35%; calcium, 80 mg; iron, 18 mg; phosphorus, 640 mg per 100 g.

The seed oil contains 8.90% saturated fatty acids; 84.09% unsaturated fatty acids. The fatty acids consist of: palmitic, 6.78%; stearic, 1.76%; arachidic, 0.34%; oleic, 19.0%; linoleic, 59.9%; linolenic, 5.4%.

Medicinal Uses: There is currently a revival of interest in the pharmaceutical industry, especially in Europe, in the use of the glycoside, *passiflorine,* especially from *P. incarnata* L., as a sedative or tranquilizer. Italian chemists have extracted *passiflorine* from the air-dried leaves of *P. edulis.*

In Madeira, the juice of passionfruits is given as a digestive stimulant and treatment for gastric cancer.

Morton, J. 1987. Giant Granadilla. p. 328–330. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Giant Granadilla

Passiflora quadrangularis L.

Passiflora macrocarpa M.T. Mast.

The largest fruit in its genus, the giant granadilla, *Passiflora quadrangularis* L. (syn. *P. macrocarpa* M.T. Mast.), is often called merely *granadilla*, or *parcha*, Spanish names loosely applied to various related species; or it may be distinguished as *granadilla real*, *grandadilla grande*, *parcha granadina* or *parcha de Guinea*. In El Salvador, it is known as *granadilla de fresco* or *granadilla para refrescos;* in parts of Colombia, it is *badea* or *corvejo;* in the State of Tachira, Venezuela, *badea;* in Bolivia, *granadilla real* or *sandía de Pasión*. In Brazil, it is *maracuya-acu*, *maracuja-assu*, *maracuja silvestre*, *maracuya grande*, *maracuja suspiro*, *maracuja mamao*, or *maracuja de caiena*. In Surinam, it is *grote* or *groote markoesa;* in Peru and Ecuador, *tumbo* or *tambo*. In the Philippines, its local names are *parola*, *kasaflora*, and square-stemmed passion flower. To Indonesians, it is familiar as *markiza*, *markoesa*, *markeesa*, or *manesa*, and to the Malays, *timun belanda*, *marquesa* or *mentimun*. In Thailand, it is *su-khontha-rot;* in Vietnam, *dua gan tay, or barbadine,* the French name.

Description

Plate XLV: GIANT GRANADILLA, *Passiflora quadrangularis*

The vine is fast-growing, large, coarse, herbaceous but woody at the base, arising from a fleshy root that becomes enlarged with age, and climbing trees to a height of 33 to 50 ft (10-15 m) or even 150 ft (45 m) in Java. It has thick 4-angled stems prominently winged on the angles, and axillary tendrils to 12 in (30 cm) long, flanked by leaflike, ovate or ovate-lanceolate stipules 3/4 to 1 3/8 in(2-3.5 cm) long, sometimes faintly toothed. The alternate leaves are broad-ovate or oblong-ovate, 3 1/4 to 6 in (8.25-15 cm) wide, 4 to 8 in (10-20 cm) long; rounded or cordate at the base, abruptly pointed at the apex, sometimes toothed near the base; thin, with conspicuous veins sunken on the upper surface, prominent beneath. The solitary, fragrant flowers, up to 4 3/4 or 5 in (12-12.5 cm) wide, have a bell-shaped calyx, the 5 sepals greenish or reddish-green on the outside, white, pink or purple inside; the 5 petals, to 1 3/4 in (4.5 cm) long, white-and-pink; the corona filaments 2-ranked, to 2 3/8 in (6 cm) long, purple-and-white below, blue in the middle, and pinkish-blue above, around the typical complex of pistil, style and stigmas.

The pleasantly aromatic, melon-like fruit is oblong-ovoid, 4 3/4 to 6 in (12-15 cm) wide, and 8 to 12 in (10-30 cm) long; may be faintly ribbed or longitudinally 3-lobed; has a thin, delicate skin, greenish-white to pale- or deep-yellow, often blushed with pink. Beneath it is a layer of firm, mealy, white or pink flesh, 1 to 1 1/2 in (2.5-4 cm) thick, of very mild flavor, and coated with a parchment-like material on the inner surface. The central cavity contains some juice and masses of whitish, yellowish, partly yellow or purple-pink, sweet-acid arils (commonly referred to as the pulp), enclosing flattened-oval, purplish-brown seeds to 1/2 in (1.25 cm) long.

Origin and Distribution

The giant granadilla is generally agreed to be a native of tropical America, though the actual place of origin is unknown. It was growing in Barbados in 1750 and is present in several other Caribbean Islands and in Bermuda. It is commonly cultivated, and sometimes an escape from cultivation or truly wild, from Mexico to Brazil and Peru. At some point in the 18th Century, it was introduced into Malaya, where it thrives in both the north and the south. In Vietnam, it is limited to the southern half of the country. Perhaps it had reached Indonesia earlier, for it is more common and even naturalized there. It is also cultivated in the lowlands of India, Ceylon and the Philippines; in tropical Africa, and throughout Queensland, Australia. In tropical North Queensland it has run wild, growing lushly in jungle areas. It flourishes and fruits heavily especially in the Cairns district. It was being grown in Hawaii in 1888 and by 1931 had become naturalized in moist places. The United States Department of Agriculture received seeds from Trinidad in 1909 and the vine is very occasionally planted in southern Florida, but is too cold-sensitive to survive in California.

Varieties

There are various strains producing fruits of different sizes and quality. Wester stated that some are insipid, while one of superior flavor had originated at Cotabato. One strain with especially large fruits and good flavor was formerly considered a separate species (*P. macrocarpa),* but it hybridizes readily with smaller strains and there are intermediate types. An ornamental form, 'Variegata', has leaves splashed with yellow.

Pollination

The vine may produce few or no fruits in a dry atmosphere, or in the absence of insect pollinators. Also the pollen may ripen before the stigma is ready to receive it, and, at times, bees may steal the pollen too early in the morning. Hand-pollination is regularly practiced in Queensland and has been successful in limited experiments in Florida. It should be done in the late morning, no later than 4 to 6 hours after the flowers open.

Climate

The ideal climate for the giant granadilla is one that is truly tropical, warm both day and night, with little fluctuation, and with high humidity. It is grown between 700 and 1,500 ft (213 and 457 m) elevations in Jamaica and Hawaii, and up to 3,000 ft (914 m) in India; to 5,000 or, at most, 7,200 ft (1,800 or 2,200 m) in Ecuador. Vines several years old have been killed by winter cold on the Riviera.

Soil

For maximum growth and productivity, the vine requires deep, fertile, moist but well-drained soil. Australians have observed good growth on volcanic, alluvial, and sandy soil, and even decomposed granite. Vines planted in highly alkaline situations in Israel have died after evidencing acute chlorosis.

Propagation

The giant granadilla grows readily from seeds, which germinate in 2 to 3 weeks and the seedlings can be set out when 6 to 12 in (15-30 cm) high. Cuttings of mature wood 10 to 12 in (25-30 cm) or even 2 to 3 ft (.6-.9 m) long, are partially defoliated and deeply planted in well-watered sand. There will be sufficient vegetative growth and root development to permit transplanting in 30 days. Air- or ground-layers are also satisfactory.

Culture

In commercial plantings in Indonesia, the vines are set 6.5 to 10 ft (2-3 m) apart each way. When the plants reach about 6.5 ft (2 m) in height, they must be trained to a strong, horizontal trellis. Pruning may be necessary if the growth becomes too dense. Regular applications of fertilizer high in organic matter, and copious watering are necessary.

Harvesting and Yield

In Indonesia and Queensland, a productive vine will fruit more or less continually all year and the annual yield may range from 25 to 35 fruits in the larger types to 70 to 120 fruits in medium to small types. Venezuelan horticulturists report that their main blooming period is May to October and the fruits ripen in 62 to 85 days from flower-opening, the crop being harvested mainly from July through October. The yield of 2- to 3-year-old vines varies from 16 to 50 fruits. The fruits are ready for harvesting when the skin becomes translucent and glossy and is beginning to turn yellowish at the apex. It is clipped from the vine. Very careful handling and packing are essential.

Pests and Diseases

Young plants in nurseries may be severely defoliated by *Disonycha glabrata* in Venezuela.

In Queensland, the principal pest of the giant granadilla is the green vegetable bug, *Nezara viridula*, which punctures young fruits and sucks out the juice, causing them to wither and fall; or hard lumps will form in the flesh. To avoid damage by fruit flies, the fruits are sometimes bagged.

Leaf spot, from fungal infection, occurs occasionally in Queensland but it is considered of little importance. Stem-end rot in East Africa has been attributed to the fungus, *Botryodiplodia theobromae.*

Food Uses

The flesh of the ripe fruit, with the inner skin removed, is cut up and added to papaya, pineapple and banana slices in fruit salads, seasoned with lemon or lime juice. It is cooked with sugar and eaten as dessert, or is canned in sirup; sometimes candied; but it is so bland that it needs added flavoring. In Indonesia, the flesh and arils are eaten together with sugar and shaved ice. Australians add a little orange juice and usually serve the dish with cream. They also use the stewed flesh and raw arils together as pie filling. The whole arils can be eaten raw without removing the seeds.

Jelly can be made from the unpeeled flesh boiled for 2 hours and the pulp simmered separately. The juice strained from both is combined and, with added sugar and lemon juice, is boiled until it jells.

The pulp (arils) yields a most agreeable juice for cold drinks. It is bottled in Indonesia and served in restaurants. Wine is made in Australia by mashing several of the whole ripe fruits, adding sugar and warm water and allowing the mix to ferment for 3 weeks, adding 2 pints of brandy, and letting stand for 9 to 12 months.

The young, unripe fruit may be steamed or boiled and served as a vegetable, or may be cut up, breaded and cooked in butter with milk, pepper and nutmeg. In Java ripe fruits are scarce because of squirrels and other predators.

The root of old vines is baked and eaten in Jamaica as a substitute for yam.

Food Value Per 100 g of Edible Portion*

	Thick Flesh	*Arils and Seeds*
Moisture	94.4 g	78.4 g

Protein	0.112 g	0.299 g
Fat	0.15 g	1.29 g
Crude Fiber	0.7 g	3.6 g
Ash	0.41 g	0.80 g
Calcium	13.8 mg	9.2 g
Phosphorus	17.1 mg	39.3 mg
Iron	0.80 mg	2.93 mg
Carotene	0.004 mg	0.019 mg
Thiamine		0.003 mg
Riboflavin	0.033 mg	0.120 mg
Niacin	0.378 mg	15.3 mg
Ascorbic Acid	14.3 mg	

*According to analyses made in El Salvador.

Toxicity

The leaves, skin and immature seeds contain a cyanogenic glycoside. The pulp contains passiflorine and, if indulged in excessively, causes lethargy and somnolence. The raw root is said to be emetic, narcotic and poisonous.

Medicinal Uses

The fruit is valued in the tropics as antiscorbutic and stomachic. In Brazil, the flesh is prescribed as a sedative to relieve nervous headache, asthma, diarrhea, dysentery, neurasthenia and insomnia. The seeds contain a cardiotonic principle, are sedative, and, in large doses, narcotic. The leaf decoction is a vermifuge and is used for bathing skin afflictions. Leaf poultices are applied in liver complaints. The root is employed as an emetic, diuretic and vermifuge. Powdered and mixed with oil, it is applied as a soothing poultice.

Morton, J. 1987. Sweet Granadilla. p. 330–331. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sweet Granadilla

Passiflora ligularis Juss.

Ranking close to *Passiflora edulis* in popular appeal and potential, the sweet granadilla, *P. ligularis* Juss., is also known as *granadilla* (Bolivia, Costa Rica, Ecuador, Mexico, Peru); *granadilla común* (Guatemala); *granadilla de China* or *parchita amarilla* (Venezuela); and *granaditta* (Jamaica).

Description

The vine is a vigorous, strong grower, woody at the base, climbing by tendrils, topping the highest trees, shading out and killing the understory. Its leaves are broadly heart-shaped, pointed at the apex, 3 3/16 to 8 in (8-20 cm) long, 2 3/8 to 6 in (6-15 cm) wide, conspicuously veined, medium-green on the upper surface, pale-green with a bloom on the underside. Spaced along the petiole, are 3 pairs of hairlike glands about 3/8 in (1 cm) long. At the leaf axils, there are paired, leaflike stipules, ovate-oblong and about 1 in (2.5 cm) long and a little over 1/2 in (1.25 cm) wide; more or less finely toothed.

The flowers, sweet and musky in odor, usually 2 to a node, may be 4 in (10 cm) across, on a 1 1/2 in (4 cm) peduncle bearing 3 leaflike, ovate-oblong, pointed bracts, 1 1/2 in (4 cm) long and 1 in (2.5 cm) wide, faintly toothed. The sepals are greenish-white, lanceolate; the petals pinkish white; the filaments, in 2 rows, white, horizontally striped with purple-blue.

Plate XLV: GIANT GRANDADILLA, *Passiflora quadrangularis*

The fruit is broad-elliptic, 2 3/8 to 3 in (6-7.5 cm) long, green with purple blush on sunny side and minutely dotted when unripe, orange-yellow with white specks when ripe. The rind is smooth, thin, hard and brittle externally, white and soft on the inside. The pulp (arils) is whitish-yellow or more or less orange, mucilaginous, very juicy, of sprightly, aromatic flavor, and encloses numerous black, flat, pitted, crisp but fairly tender seeds.

Origin and Distribution

The sweet granadilla is the common species of *Passiflora* ranging from central Mexico through Central America and western South America, through western Bolivia to south-central Peru. Throughout this region, it is popular and abundant in the markets.

It has been grown in Hawaii since late in the 19th Century. In 1916, the United States Department of Agriculture received seeds from Quito, Ecuador. The vine is not suited to California, has been grown in greenhouses in Florida but has never survived for long. Northern gardeners sometimes plant it as a summer ornamental. It is not reported in Guam; may be grown to some extent in New Guinea. Trial plantings in Israel were killed by cold weather. It is cultivated and naturalized in Jamaica and, in recent years, has been blooming and fruiting prolifically in mountainous Haiti.

Climate

The sweet granadilla is subtropical, not tropical. In its natural range, it is wild and cultivated at elevations of 3,000 to 8,850 ft (900-2,700 m). In Hawaii, it finds sufficiently cool temperatures at 3,000 ft (900 m). In Jamaica, the vine volunteers freely at altitudes between 3,500 and 4,000 ft (1,000-1,200 m). At 5,000 to 8,200 ft (1,500-2,500 m) in Colombia, the vine fruits well. At higher altitudes, it flourishes and blooms but will not fruit. An elevation of 6, 000 ft (1,828 m), where the clouds descend on peaks in the afternoon, has proven ideal in Haiti. The vine is intolerant of heat. It will do well over the winter in Florida but declines with the onset of hot weather.

Soil

Thin, volcanic soils do not discourage the sweet granadilla, providing they are moist. It is naturally adapted to high rainforests.

Propagation

The sweet granadilla can be grown from seeds or cuttings.

Season and Keeping Quality

There is but one crop per year. In Bolivia, the fruits ripen in May and June. The fruit, despite its hard shell, has poor keeping quality, deteriorating soon after the harvest.

Pests

In Haiti, the planted seeds are often devoured by rodents, though the seeds of *P. edulis* in the same situation have never been disturbed. Squirrels ravage the crop in the forests of Ecuador.

Food Uses

Usually, the fruit is cracked open and the pulp and seeds consumed out-of-hand. For the table, the fruit is cut in half and the contents are eaten with a spoon. The strained juice is much used for making cold drinks and sherbet (ice).

Food Value Per 100 g of Edible Portion*

	Pulp and Seeds Combined
Moisture	69.9-79.1 g
Protein	0.340-0.474 g
Fat	1.50-3.18 g
Crude Fiber	3.2-5.6 g
Ash	0.87-1.36 g
Calcium	5.6-13.7 mg
Phosphorus	44.0-78.0 mg
Iron	0.58-1.56 mg
Carotene	0.00-0.035 mg
Thiamine	0.00-0.002 mg
Riboflavin	0.063-0.125 mg
Niacin	1.42-1.813 mg
Ascorbic Acid	10.8-28.1 mg

*Analyses made in Ecuador, El Salvador, Costa Rica and Guatemala.

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Morton, J. 1987. Water Lemon. p. 331–332. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Water Lemon

Passiflora laurifolia L.

One of the best of the lesser-known passionfruit relatives, the water lemon, *Passiflora laurifolia* L., is also known as bell-apple, sweet cup, yellow granadilla, Jamaica honeysuckle, vinegar pear, golden apple, where English is spoken; as *pomme d'or, pomme liane,* or *pomme de liane, Marie-Tambour*, or *maritambou*, in the French West Indies; as *parcha, parcha de culebra*, or *pasionaria con hojas de laurel* in Spanish. In the Portuguese language, in Brazil, it is called *maracuja comum* or *maracuja laranja.* It is *paramarkoesa* in Surinam. In Malaya, it is *markusa leutih, buah susu, buah belebar*, or *buah selaseh;* in Thailand, *sa-wa-rot;* in Vietnam, *guoi tay.*

Description

The water lemon vine is a moderately vigorous climber, to 32 ft (10 m) or more, its twining, more or less woody or wiry stems longitudinally grooved and bearing slender, tough tendrils in the leaf axils flanked by 2 slim, green stipules. The alternate leaves are oblong-ovate or elliptical, rounded at the base, abruptly pointed at the apex; 6 to 8 in (15-20 cm) long, 1 1/3 to 3 1/8 in (3.4-8 cm) wide; thick and leathery. The fragrant, solitary, 5-petalled flowers, 3 to 4 in (7.4-10 cm) across, have a bell-shaped calyx, oblong, red or purple-red sepals and petals, and corona filaments 6-ranked, banded with red, blue, purple and white. The fruit is ellipsoidal or ovoid, 2 to 3 1/8 in (5-8 cm) long, 1 1/2 to 2 3/8 in (4-6 cm) wide; orange-yellow; clasped at the base by 3 large, green, leaflike bracts, toothed and edged with conspicuous glands. The rind is leathery, to 1/8 in (3 mm) thick, white and spongy within; becomes hard when dry. Pleasantly rose-scented, the translucent, nearly white pulp is juicy, mucilaginous and of agreeable, subacid flavor, and encloses numerous seeds, flat and minutely ribbed.

Origin and Distribution

The water lemon is native to tropical America and common, wild and cultivated from southern Venezuela, Surinam, Guyana and French Guiana down through the Amazon region of Brazil to Peru. In the dry season, the fruits are regularly sold in local markets. The vine is cultivated and naturalized from Trinidad and Barbados to Jamaica, Puerto Rico, Hispaniola and Cuba. In Bermuda, it is only occasionally grown. It was introduced into Malaya in the 18th Century; is commonly cultivated in the lowlands and naturalized in Singapore and Penang. According to Petelot, the water lemon is grown in Thailand and throughout the southern half of Vietnam. In India, Ceylon and Hawaii, the vine is grown as an ornamental but rarely fruits except in hot, dry situations where the pollen is dry enough to be naturally transmitted. There are only a few specimens in Florida.

Pollination

The water lemon flowers open only in the afternoon, and apparently are not self-pollinated, or only slightly so. Cross-pollination is required for good crops. If carpenter bees are not present at the right time, the pollen must be transferred by hand.

Climate

A warm, dry atmosphere is essential for early ripening of the stigmas. On Oahu, Hawaii, best yields have been obtained at sea-level, though the vine grows vigorously up to 1,500 ft (457 m).

Soil

The vine has grown and flowered well on sand and on limestone in Florida.

Propagation

The water lemon grows readily from seeds or cuttings.

Pests

Trials have shown that the vine is fairly resistant to rootknot nematodes in Florida.

Food Uses

Children and adults make a hole in one end of the fruit and suck out the pulp and seeds for refreshment. The juice of the strained pulp makes an excellent beverage.

Food Value

The pulp contains 1.55 mg of pantothenic acid per 100 g; the rind, 1.87 mg. This element belongs to the vitamin B complex group and is sometimes called vitamin B_5.

Toxicity

The rind, leaves and seeds contain a cyanogenic glycoside. On the other hand, the leaves possess 387 mg, per 100 g, ascorbic acid. The leaf decoction is taken as a vermifuge. The seeds have a sedative action on the nervous system and heart and, in strong doses, are hypnotic. The root acts as a very potent vermifuge.

Morton, J. 1987. Sweet Calabash. p. 334–335. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sweet Calabash

Passiflora maliformis L.

Of minor status among the cultivated species of *Passiflora*, the sweet calabash, *P. maliformis* L., has been called water lemon (Bermuda); *ceibey cimarron* (Cuba), *callebassie* (Haiti), *calabacito de Indio* (Dominican Republic); sweet cup, conch apple, conch nut (Jamaica); *parcha cimarrona* (Puerto Rico); *Pomme calabas, liane a agouti* (Guadeloupe); *pomme-liane de la Guadeloupe* (Martinique); *culupa, granadilla, curuba* or *kuruba* (Colombia); *granadilla de hueso* or *granadilla de mono* (Ecuador); *guerito* (Cuba).

Description

Fig. 93: The sweet calabash (*Passiflora maliformis*) is light-yellow with a very hard shell. Photographed at the experimental station, Palmira, Colombia, in 1969.

The vine is woody but slender, climbing to 33 ft (10 m) or more by means of tendrils in the leaf axils, and draping trees, walls and small buildings. The evergreen leaves are ovate-cordate, or ovate-oblong, with a short, recurved point at the apex; fairly thin, light-green; 2 3/8 to 6 in (6-15 cm) long, with 2 round, flat glands at about the middle of the petiole. The peduncle bears 3 thin, ovate, pointed bracts, to 2 in (5 cm) long which enclose the unopened bud and form an ivory-hued background for the opened flower, which is fragrant, 2 to 2 3/8 in (5-6 cm) wide, with keeled, green, maroon-dotted sepals and 5 small petals, greenish-white, dotted with red or purple. The corona is 3-ranked and variegated white, purple and blue.

The fruit is oblate to nearly round-oval, the specific name implying "apple-shaped", being derived from *Malus*, the apple genus. It is 1 3/4 to 2 in (4.5-5 cm) long, 1 3/8 to 1 1/2 in (3.5-4 cm) wide. The rind is yellow to brownish when fully ripe, thin; varies from rather flexible and leathery to hard and brittle. The pulp is grayish or pale orange-yellow, juicy, sweet or subacid and pleasingly aromatic, containing many black, flat, ovate, pitted seeds.

Origin and Distribution

This species is native and common in the wild in Cuba, Puerto Rico, the Dominican Republic, Jamaica, and from Saba to Barbados and Trinidad; also Venezuela, Colombia and northern Ecuador. It is cultivated in Jamaica, Brazil and Ecuador for its fruits, and in Hawaii as an ornamental in private gardens and in experimental stations for use in breeding work. The United States Department of Agriculture received seeds from Trinidad in 1909 (P.I. No. 26269); seeds of 4 varieties from Colombia in September 1914 (P.I. Nos. 39223-226); and more seeds from Colombia in November 1914 (P.I. No. 39383). However, the species has not been successful in Florida or California.

Climate

The vine grows and fruits at cool altitudes–up to 5,500 ft (1,700 m)–in South America; in Jamaica, between 500 and 1,200 ft (152-366 m). Lefroy saw it in Bermuda in 1871 but the climate apparently did not favor survival.

Season

The fruits ripen from September to December in Jamaica.

Pests and Diseases

This species is noted for its resistance to pests and diseases that affect its relatives.

Food Uses

The fruit, whether leathery or hard-shelled, is difficult to open but the seedy pulp is much enjoyed locally. In Jamaica, it is scooped from the shell and served with wine and sugar. The strained juice is excellent for making cold drinks.

Other Uses

Snuff boxes have been made of the shell of the hard type.

Morton, J. 1987. Papaya. p. 336–346. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Papaya

Carica papaya L.

The papaya, *Carica papaya* L., is a member of the small family Caricaceae allied to the

Passifloraceae. As a dual- or multi-purpose, early-bearing, space-conserving, herbaceous crop, it is widely acclaimed, despite its susceptibility to natural enemies.

In some parts of the world, especially Australia and some islands of the West Indies, it is known as papaw, or pawpaw, names which are better limited to the very different, mainly wild *Asimina triloba* Dunal, belonging to the Annonaceae. While the name papaya is widely recognized, it has been corrupted to *kapaya, kepaya, lapaya* or *tapaya* in southern Asia and the East Indies. In French, it is *papaye* (the fruit) and *papayer* (the plant), or sometimes *figuier des Iles*. Spanish-speaking people employ the names *melón zapote, lechosa, payaya* (fruit), *papayo* or *papayero* (the plant), *fruta bomba, mamón* or *mamona*, depending on the country. In Brazil, the usual name is *mamao*. When first encountered by Europeans it was quite naturally nicknamed "tree melon".

Description

Commonly and erroneously referred to as a "tree", the plant is properly a large herb growing at the rate of 6 to 10 ft (1.8-3 m) the first year and reaching 20 or even 30 ft (6-9 m) in height, with a hollow green or deep-purple stem becoming 12 to 16 in (30-40 cm) or more thick at the base and roughened by leaf scars. The leaves emerge directly from the upper part of the stem in a spiral on nearly horizontal petioles 1 to 3 1/2 ft (30-105 cm) long, hollow, succulent, green or more or less dark purple. The blade, deeply divided into 5 to 9 main segments, each irregularly subdivided, varies from 1 to 2 ft (30-60 cm) in width and has prominent yellowish ribs and veins. The life of a leaf is 4 to 6 months. Both the stem and leaves contain copious white milky latex.

Fig. 94: A healthy papaya (*Carica papaya*) in Homestead, Florida, in 1946, when virus diseases were not prevalent.

The 5-petalled flowers are fleshy, waxy and slightly fragrant. Some plants bear only short-stalked pistillate (female) flowers, waxy and ivory-white; or hermaprodite (perfect) flowers (having female and male organs), ivory-white with bright-yellow anthers and borne on short stalks; while others may bear only staminate (male) flowers, clustered on panicles to 5 or 6 ft (1.5-1.8 m) long. There may even be monoecious plants having both male and female flowers. Some plants at certain seasons produce short-stalked male flowers, at other times perfect flowers. This change of sex may occur temporarily during high temperatures in midsummer. Some "all-male" plants occasionally bear, at the tip of the spray, small flowers with perfect pistils and these produce abnormally slender fruits. Male or hermaphrodite plants may change completely to female plants after being beheaded.

Generally, the fruit is melon-like, oval to nearly round, somewhat pyriform, or elongated club-shaped, 6 to 20 in (15-50 cm) long and 4 to 8 in (10-20 cm) thick; weighing up to 20 lbs (9 kg). Semi-wild (naturalized) plants bear miniature fruits 1 to 6 in (2.5-15 cm) long. The skin is waxy and thin but fairly tough. When the fruit is green and hard it is rich in white latex. As it ripens, it becomes light- or deep-yellow externally and the thick wall of succulent flesh becomes aromatic, yellow, orange or various shades of salmon or red. It is then juicy, sweetish and somewhat like a cantaloupe in flavor; in some types quite musky. Attached lightly to the wall by soft, white, fibrous tissue, are usually numerous small, black, ovoid, corrugated, peppery seeds about 3/16 in (5 mm) long, each coated with a transparent, gelatinous aril.

Origin and Distribution

Though the exact area of origin is unknown, the papaya is believed native to tropical America, perhaps in southern Mexico and neighboring Central America. It is recorded that seeds were taken to Panama and then the Dominican Republic before 1525 and cultivation spread to warm elevations throughout South and Central America, southern Mexico, the West Indies and Bahamas, and to Bermuda in 1616. Spaniards carried seeds to the Philippines about 1550 and the papaya traveled from there to Malacca and India. Seeds were sent from India to Naples in 1626. Now the papaya is familiar in nearly all tropical regions of the Old World and the Pacific Islands and has become naturalized in many areas. Seeds were probably brought to Florida from the Bahamas. Up to about 1959, the papaya was commonly grown in southern and central Florida in home gardens and on a small commercial scale. Thereafter, natural enemies seriously reduced the plantings. There was a similar decline in Puerto Rico about 10 years prior to the setback of the industry in Florida. While isolated plants and a few commercial plots may be fruitful and long-lived, plants in some fields may reach 5 or 6 ft, yield one picking of undersized and misshapen fruits and then are so affected by virus and other diseases that they must be destroyed.

In the 1950's an Italian entrepreneur, Albert Santo, imported papayas into Miami by air from Santa Marta, Colombia, Puerto Rico and Cuba for sale locally as well as shipping fresh to New York, and he also processed quantities into juice or preserves in his own Miami factory.

Since there is no longer such importation, there is a severe shortage of papayas in Florida. The influx of Latin American residents has increased the demand and new growers are trying to fill it with relatively virus-resistant strains selected by the University of Florida Agricultural Research and Education Center in Homestead.

Successful commercial production today is primarily in Hawaii, tropical Africa, the Philippines, India, Ceylon, Malaya and Australia, apart from the widespread but smaller scale production in South Africa, and Latin America.

Annual papaya consumption in Hawaii is 15 lbs (6.8 kg) per capita, yet 26 million lbs (11,838,700 kg) of fresh fruits were shipped by air freight to mainland USA in 1974, mainly direct from Hilo or via Honolulu.

Puerto Rican production does not meet the local demand and fruits are imported from the

Dominican Republic for processing.

The papaya is one of the leading fruits of southern Mexico and 40% of that country's crop is produced in the state of Veracruz on 14,800 acres (6,000 ha) yielding 120,000 tons annually.

Fruits from bisexual plants are usually cylindrical or pyriform with small seed cavity and thick wall of firm flesh which stands handling and shipping well. In contrast, fruits from female flowers are nearly round or oval and thin-walled. In some areas, bisexual types are in greatest demand. In South Africa, round or oval papayas are preferred.

Varieties

Despite the great variability in size, quality and other characteristics of the papaya, there were few prominent, selected and named cultivars before the introduction into Hawaii of the dioecious, small-fruited papaya from Barbados in 1911. It was named **'Solo'** in 1919 and by 1936 was the only commercial papaya in the islands. 'Solo' produces no male plants; just female (with round, shallowly furrowed fruits) and bisexual (with pear-shaped fruits) in equal proportions. The fruits weigh 1.1 to 2.2 lbs (1/2-1 kg) and are of excellent quality. When the fruit is fully ripe the thin skin is orange-yellow and the flesh golden-orange and very sweet.

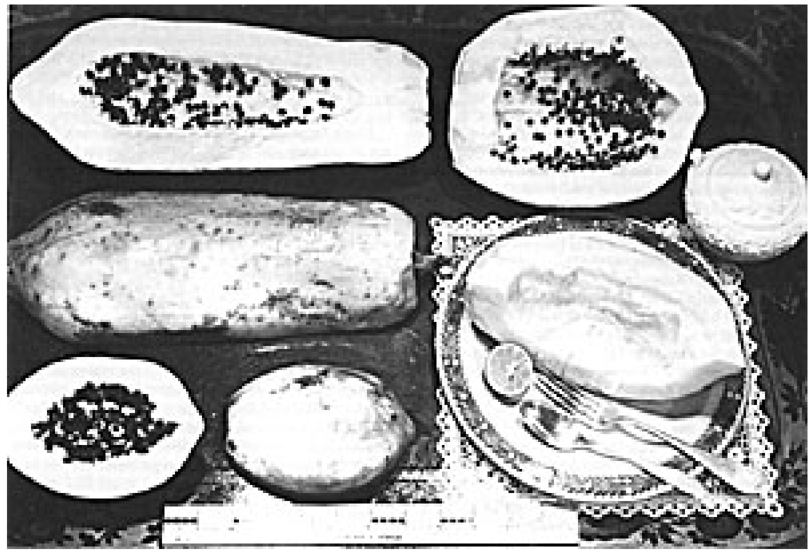

Fig. 95: Papaya fruits vary in form, size, thickness, color and flavor of flesh. Favored types have little, if any, muskiness of odor.

'Kapoho Solo' or 'Puna Solo' was discovered and became popular with growers on Kauai before 1950. In 1955 a **'Dwarf Solo'** (a back-cross of Florida's 'Betty' and 'Solo') was introduced to aid harvesting, and this became the leading commercial papaya on the island of Oahu. It was, up to 1974, the only export cultivar. It is pear-shaped, 14 to 28 oz (400-800 g) in weight in high rainfall areas, and has yellow skin and pale-orange flesh.

'Waimanalo' (formerly 'Solo' Line 77) was selected in 1960 and released by the Hawaii Agricultural Experiment Station in 1968 and soon superseded Line 8 'Solo' on Oahu for the fresh fruit market because of its firmness and quality, but there it is usually too large for export. It has long storage life and is recommended for sale fresh and for processing. Since 1974 this cultivar has been produced commercially on the low-rainfall island of Maui where it ripens at a greener color than on the island of Hawaii and is exported to cities in the northwestern and central USA. The growers raised only bisexual plants; they say that the fruits of female plants are too rough in appearance.

'Higgins' (formerly Line 17A), the result of crosses in 1960, was introduced to Hawaiian growers in 1974. It is of high quality, pear-shaped, with orange-yellow skin, deep-yellow flesh, and averages 1 lb (0.45 kg) when grown under irrigation. In and territory or seasons of low rainfall, the fruit is undersized.

'Wilder' (formerly Line 25) is a cultivar admired for its uniformity of size, firmness and small cavity and it is now popular for export.

'Hortus Gold', a South African cultivar, launched in the early 1950's, is dioecious, early-maturing, with round-oval, golden-yellow fruits, 2 to 3 lbs (0.9-1.36 kg) in weight. From 200 female 'Hortus Gold' seedlings planted at the University of Natal's Ukulinga Research Farm in 1960, selections were made of the plants showing the highest yield. Of these, one clone having the best sugar content and disease resistance was chosen and named **'Honey Gold'** in 1976. This cultivar has a slight beak at the apex, golden-yellow skin; is of sweet flavor and good texture but becomes mushy when overripe. It averages 2.2 lbs (1 kg) per fruit except for those at the end of the season which are much smaller. It does not reproduce true from seed and is therefore propagated by cuttings. It is late in season and late-maturing (10 months from fruit set to maturity) and therefore brings nearly double the price of other cultivars.

'Bettina' and **'Petersen'**, long-standing cultivars in Queensland, Australia, were inbred for several generations to obtain pure lines. 'Bettina', a hybrid of Florida's 'Betty' and a Queensland strain, is a low, shrubby, dioecious plant producing well-colored, round-oval fruits weighing 3 to 5 lbs (1.36-2.27 kg).

'Improved Petersen', of local origin, is dioecious, tall-growing, with fruits deficient in external color and indifferent as to keeping quality but noted for the fine color and flavor of the flesh. In 1947 'Bettina 100A' was crossed with 'Petersen 170' to produce the superior, semi-dwarf **'Hybrid No. 5'**, smooth, yellow, rounded-oval, 3 lbs (1.36 kg) in weight, thick-fleshed, of excellent flavor and prized for marketing fresh and for canning. It bore more heavily than either of its parents and remained a preferred cultivar for more than 20 years. 'Solo' and 'Hortus Gold' are often grown but most plantations are open-pollinated mixtures.

In Western Australia, after trials of 9 cultivars**–'Hybrid No. 5', 'Petersen', 'Yarwun Yellow', 'Gold Cross', 'Goldy', 'Hong Kong', 'Guinea Gold', 'Golden Surprise'** and **'Sunnybank'–**only 'Sunnybank' and 'Guinea Gold' were chosen as having sufficient yield and quality to be worth cultivating commercially. 'Sunnybank' fruits average 1.39 lbs (0.63 kg), and ripen over 11 months. 'Guinea Gold' averages 2.4 lbs (a little over 1 kg) and ripens over a period of 18 months.

The Universidad Agraria, La Molina, Peru, began to assemble papaya strains in 1964, collecting 40 from various parts of the country and introducing 3 from Brazil, 1 from Puerto Rico, 3 from Mexico and 2 lines of 'Solo' from Hawaii, and embarked on an evaluation and breeding program and the creation of a germplasm bank.

In Ghana, dioecious cultivars such as 'Solo', 'Golden Surprise', 'Hawaii', and 'No. 5595', were introduced and commonly cultivated by farmers but they hybridized with local types and lost their identities after several generations. A number of types were collected at the Agricultural Research Station at Kade from 1966 to 1970 and classified according to sex type, fruit form, weight, skin and flesh color, flesh thickness, texture and flavor, number of seeds, and various plant factors. It was determined that preference should be given female plants with short, stout stems, early maturing, and bearing heavily all year medium-size fruits of bright color, thick-flesh and with few seeds.

The Instituto Colombiano Agropecuario, at Palmira, Colombia, began a papaya breeding program in 1963 by bringing together Colombian-grown cultivars**–'Campo Grande', 'Tocaimera', 'Zapote', 'Solo',**–with some from Brazil**–'Betty', 'Bettina'** and **'43-A-3'**–South Africa–**'Hortus Gold'–**and Puerto Rico, and representatives of related species: *C. candamarcensis* Hook. F., *C. pentagona* Heilborn, *C. goudotiana* Tr. & Pl. (one type yellow with green peduncles and another red with purple peduncles), *C. cauliflora* Jacq. of Colombia and *C. monoica* Desf. and *Jacaratia dodecaphylla* A. DC. from Peru.

The first two of these species were not suited to conditions at Palmira.

The progeny of crosses with *C. caulfliora* were the only hybrids showing some virus resistance but they were unfruitful when attacked. There were no viable seeds and 30% of the fruits were seedless. *C. monoica* proved well adapted to Palmira, bore small, yellow fruits, but succumbed to virus. The introductions from Brazil were by far the most promising. **'Zapote'**, with rich, red flesh is much grown on the Atlantic coast of Colombia.

In India, papaya breeding and selection work has been carried on for over 30 years beginning with 100 introduced strains and 16 local variations. A well-known cultivar is **'Coorg Honey Dew',** a selection from 'Honey Dew' at Chethalli Station of the Indian Institute of Horticultural Research. There are no male plants; female and bisexual occur in equal proportions. The plant is low-bearing and prolific. The fruit is long to oval, weighs 4.4 to 7.7 lbs (2-3 1/2 kg); has yellow flesh with a large cavity, and keeps fairly well. **'Washington',** popular in Bombay, has dark-red petioles and yellow flowers. The fruits are of medium size with excellent, sweet flavor. **'Burliar Long'** is prolific, bearing as many as 103 fruits the first year, mostly in pairs densely packed along the stem down to 18 in (45 cm) from the ground. Seedlings are 70% females and bloom 3 months after transplanting.

'Co. 1' and **'Co. 2'** were developed at Tamil Nadu Agricultural University. Both are dioecious and dwarf, the first fruits being borne 3 ft (1 m) from the ground. 'Co. 1' is valued for eating fresh; 'Co. 2' is grown for table use and for papain extraction. The fruits are of medium size–3.3 to 5.5 lbs (1 1/2-2 1/2 kg), with yellow, sweet flesh.

The Regional Research Station at Pusa has introduced some promising selections:

'Pusa Delkious' ('Pusa 1-15')–medium size; flesh deep-orange, of excellent flavor; female and hermaphrodite plants; high-yielding.

'Pusa Majesty' ('Pusa 22-3')–round, of medium size; flesh yellowish, solid; keeps well and ships well; vinis resistant; hermaphrodite plants higher-yielding than the female.

'Pusa Giant' ('Pusa 1-45V')–large fruits suitable for marketing ripe, or green for use as a vegetable, also for canning. Plant dioecious, fast-growing; tall; trunk thick, wind-resistant.

'Pusa Dwarf' ('Pusa 1-45')–fruit oval, of medium size. Plant is dwarf; begins bearing fruit at 10 to 12 in (25-30 cm) above the ground. In much demand for home and commercial culture; suitable for high-density plantings.

In 1965, a program of papaya improvement was undertaken in Trinidad and Tobago utilizing promising selections from local types, including **'Santa Cruz Grant',** a vigorous plant mainly bisexual (having both male and female flowers), very large fruits weighing 10 to 15 lbs (4.5-6.8

kg), with firm, yellow flesh of agreeable flavor. The fruit is too large for marketing fresh but is processed both green and ripe. 'Cedro' is dioecious, rarely bisexual, a heavy bearer and highly resistant to anthracnose. The fruits weigh from 3 to 8 lbs (1.37-3.6 kg) but average 6 lbs (2.7 kg); have firm, yellow, melon-like flesh and are suitable for sale fresh or for processing.

In **'Singapore Pink',** the plants are mainly bisexual, producing cylindrical fruit. The minority are female with round fruit. Average weight of fruit is 5 lbs (2.27 kg) though there is variation from 2 to 7 lbs (1-3 kg). The flesh is pink. The fruit surface is prone to anthracnose in rainy periods, so, at such times, the fruits must be picked and sold in the green state. Two smaller-fruited types, 2 to 3 lbs (1-1.37 kg) in weight, with bright-yellow skin and thick, firm flesh, were selected for marketing fresh.

The **'Solo'** of Hawaii has performed unsatisfactorily in Florida, producing low yields of small fruits. Scott Stambaugh, a papaya specialist, began his papaya breeding with a strain designated USDA Bureau of Plant Industry #28533 obtained from the then Plant Introduction Station in Miami. From offspring of this he made a selection which he named **'Norton'.** When he acquired seed of a type called **'Purplestem';** later **'Bluestem',** he crossed it with 'Norton' and the hybrid yielded fruits 10 lbs (4.5 kg) in weight and was named **'Big Bluestem'.** The latter was crossed with 'Solo' and the hybrid was called **'Bluestem Solo'** or **'Blue Solo'.** The 'Blue Solo' has been well regarded in Florida for its low growth, dependable yields of good quality fruits, 2 to 4 lbs (1-2 kg) in weight, orange-fleshed and rich in flavor.

'Cariflora' is a new cultivar developed at the recently renamed Tropical Research and Education Center of the University of Florida at Homestead. It is nearly round, about the size of a cantaloupe, with thick, dark-yellow to light-orange flesh; tolerant of papaya ringspot virus, but not resistant to papaya mosaic virus or papaya apical necrosis virus. Yield is good in southern Florida and warm lowlands of tropical America but not at elevations above 2625 ft (800 m).

'Sunrise Solo' (formerly HAES 63-22) was introduced from Hawaii into Puerto Rico. The fruit has pink flesh with high total solid content. In Puerto Rican trials, seeds were planted in mid-November, seedlings were transplanted to the field 2 months later, flowering occurred in April and mature fruits were harvested from early August to January. Recent selections from Puerto Rican breeding programs are 'P.R. 6-65' (early), 'P.R. 7-65' (late), and 'P.R. 8-65'.

Venezuelan papayas are usually long and large, ranging in weight from 2 to 13 lbs (1-6 kg) and mostly for domestic consumption or shipment by boat to nearby islands.

Pollination

If a papaya plant is inadequately pollinated, it will bear a light crop of fruits lacking uniformity in size and shape. Therefore, hand-pollination is advisable in commercial plantations that are not entirely bisexual.

Bags are tied over bisexual blossoms for several days to assure that they are self-pollinated. The progeny of self-pollinated bisexual flowers are 67% bisexual, the rest being female.

To cross-pollinate, one or 2 stamens from a bisexual flower are placed on the pistil of a female flower about to open and a bag is tied over the flower for a few days. Most of such cross-pollinated blooms should set fruit. Resulting seeds will produce 1/2 female and 1/2 bisexual plants.

By another method, all but the apical female flower bud are removed from a stalk and the apical bud is bagged 1-2 days before opening. At full opening, the stigma is dusted with pollen from a selected male bloom and the bag quickly resealed and it remains so for 7 days.

Plants from female flowers crossed with male flowers are 50-50 male and female. Bisexual flowers pollinated by males give rise to 1/3 female, 1/3 bisexual and 1/3 male plants.

South African growers have long been urged to practice hand-pollination in order to maintain a selected strain and, in breeding, to incorporate factors such as purple stem, yellow flowers and reddish flesh so that the improved selection will be distinguishable from ordinary strains with non-purple stems, white flowers and yellow flesh.

Climate

The papaya is a tropical and near-tropical species, very sensitive to frost and limited to the region between 32º north and 32º south of the Equator. It needs plentiful rainfall or irrigation but must have good drainage. Flooding for 48 hours is fatal. Brief exposure to 32º F (-0.56º C) is damaging; prolonged cold without overhead sprinkling will kill the plants.

Soil

While doing best in light, porous soils rich in organic matter, the plant will grow in scarified limestone, marl, or various other soils if it is given adequate care. Optimum pH ranges from 5.5 to 6.7. Overly acid soils are corrected by working in lime at the rate of 1-2 tons/acre (2.4-4.8 tons/ha). On rich organic soils the papaya makes lush growth and bears heavily but the fruits are of low quality.

Propagation

Papayas are generally grown from seed. Germination may take 3 to 5 weeks. It is expedited to 2 to 3 weeks and percentage of germination increased by washing off the aril. Then the seeds need to be dried and dusted with fungicide to avoid damping-off, a common cause of loss of seedlings. Well-prepared seeds can be stored for as long as 3 years but the percentage of germination declines with age. Dipping for 15 seconds in hot water at 158º F (70º C) and then soaking for 24 hrs in distilled water after removal from storage will improve the germination rate. If germination is slow at some seasons, treatment with gibberellic acid may be needed to get quicker results.

To reproduce the characteristics of a preferred strain, air-layering has been successfully practiced on a small scale. All offshoots except the lowest one are girdled and layered after the parent plant has produced the first crop of fruit. Later, when the parent has grown too tall for convenient harvesting the top is cut off and new buds in the crown are pricked off until offshoots from the trunk appear and develop over a period of 4 to 6 weeks. These are layered and removed and the trunk cut off above the originally retained lowest sprout which is then allowed to grow as the main stem. Thereafter the layering of offshoots may be continued until the plant is exhausted.

Rooting of cuttings has been practiced in South Africa, especially to eliminate variability in certain clones so that their performance can be more accurately compared in evaluation studies. Softwood cuttings made in midsummer rooted quickly and fruited well the following summer. Cuttings taken in fall and spring were slow to root and deficient in root formation. The commercial cultivar

'Honey Gold' is grown entirely from cuttings. Once rooted, the cuttings are planted in plastic bags and kept under mist for 10 days, and then put in a shade house for hardening before setting in the field.

Hawaiian workers have found that large branches 2-3 ft (60-90 cm) long rooted more readily than small cuttings. Planted 1 ft (30 cm) deep in the rainy season, they began fruiting in a few months very close to the ground.

In budding experiments both Forkert and chip methods have proved satisfactory in Trinidad. However, it is reported that a vegetatively propagated selected strain deteriorates steadily and is worthless after 3 or 4 generations.

In Hawaii, 'Solo' grafted onto 'Dwarf Solo' was reduced in vigor and productivity, but 'Dwarf Solo' grafted onto 'Solo' showed improved performance.

In recent years, the potential of rapid propagation of papaya selections by tissue culture is being explored and promises to be feasible even for the establishment of commercial plantations of superior strains.

Efforts have been made to determine the sex of seedlings in the nursery, Indian scientists making colorimetric tests of leaf extracts have had 87% success in identifying seedlings as female; 67% in classifying males/bisexuals grouped together.

Variable Season

Planting may be done at any time of year and local conditions determine when it is best for the crop to come in. Papayas mature in 6 to 9 months from seed in the hotter areas of South Africa; in 9 to 11 months where it is cooler, providing an opportunity to supply markets in the off-season when prices are high. Seeds planted in early summer or midsummer will produce the first crop in the second winter. Thereafter, the same plants will mature fruit from spring to early summer. Spring fruits are apt to be sunburned because of winter leaf loss; are also subject to fruit spot and have a low sugar content. Sunburn can be avoided by advance whitewashing of sides exposed to the afternoon sun. Some growers manipulate the harvest season by stripping off 6 of the newly set fruits, thus forcing the plant to bloom again and produce fruits 6 to 8 weeks later than they normally would.

In southern Florida, plants set out in March or April will ripen their fruits in November and December and have the advantage of a "tourist" market. July plantings will be slowed down by winter and will not fruit for 10 months or more. Some growers advocate planting in September and October so that the crop will be ready for harvest before the onset of the main hurricane season. Further north in the state, papayas must be set out in March or April in order to have the required growing season before frost.

Spacing

Puerto Rican trials have shown that papaya plants set in the field on 6 ft (1.8 m) centers made stronger, stouter growth and were more fruitful than those at closer spacings. Some growers insist on an 8 x 8 ft (2.4 x 2.4 m) area per plant. In India, 'Co. 1' and 'Co. 2' and 'Solo' are set on 6 ft (1.8 m) centers; 'Coorg Honey Dew' and 'Washington' on 8 ft (2.4 m) centers. Princess Orchards on

Maui, Hawaii, plant in double rows with an alley between each pair providing room for cultural and harvesting operations. In Queensland, plants may be set only 3 ft (1 m) apart on level ground and then thinned out by removal of unwanted plants after flowering.

Culture

Seeds may be planted directly in the field, or seedlings raised in beds or pots may be transplanted when 6 weeks old or even up to 6 months of age, though there must be great care in handling and the longer the delay the greater the risk of dehydrated or twisted roots; also, transplanting often results in trunk-curvature in windy locations.

Experiments in Hawaii indicate that direct seeding results in deeper tap-roots, erect and more vigorous growth, earlier flowering and larger yields.

In Puerto Rico, it is customary to set 2 plants per hole. In El Salvador planters place 5 to 6 seeds, separated from each other, in each hole at a depth of 3/8 in (1 cm). When the plants bloom, 90% of the males are removed, preferably by cutting off at ground level. Pulling up disturbs the roots of the remaining plants. If the plantation is isolated and there is no chance of cross-pollination by males, all the seed will become female or hermaphrodite plants. Fruits should mature 5 to 8 months later.

In India, seeds are usually treated with fungicide and planted in beds 6 in (15 cm) above ground level that have been organically enriched and fumigated. The seeds are sown 2 in (5 cm) apart and 3/4 to 1 1/8 in (2-3 cm) deep in rows 6 in (15 cm) apart. They are watered daily and transplanted in 2 1/2 months when 6 to 8 in (15-20 cm) high. Transplanting is more successful if polyethylene bags of enriched soil are used instead of raised beds. Two seeds are planted in each bag but only the stronger seedling is maintained. Transplanting is best done in the evening or on cloudy, damp days. On hot, dry days, each plant must be protected with a leafy branch or palm leaf stuck in the soil. Except for 'Coorg Honey Dew' and 'Solo', the plants are set out in 3's, 6 in (15 cm) apart in enriched pits. After flowering, one female or hermaphrodite plant is retained, the other two removed. But one male is kept for every 10 females. 'Coorg Honey Dew' and 'Solo' are planted one to a pit and no males are necessary. Watering is done every day until the plants are well established, but overwatering is detrimental to young plants. Double rows of *Sesbania aegyptiaca* are planted as a windbreak.

The installation of constant drip irrigation (12 gals per day) has made possible papaya cultivation on mountain slopes on the relatively dry island of Maui which averages 10 in (25 cm) of rain annually.

Papaya plants require frequent fertilization for satisfactory production. In India, best results have been obtained by giving 9 oz (250 g) of nitrogen, 9 oz (250 g) of phosphorus, and 18 oz (500 g) potash to each plant each year, divided into 6 applications.

Because of the need to expedite growth and production before the onslaught of diseases, Puerto Rican agronomists recommend treating the predominantly clay soil with a nematicide before planting, giving each plant 4 oz (113 g) of 15-15-15 fertilizer at the end of the first week, and each month thereafter increasing the dose by 1 oz (28 g) until the beginning of flowering, then applying .227 g per plant as a final treatment. In trials, this program has permitted 6 harvests of green fruits for processing, each over 1 lb (1/2 kg) in weight, spanning a period of 13 months. The roots usually extend out beyond the leaves and it is advisable to spread fertilizer over the entire root area.

In late fertilizer applications of a crop destined for canning, nitrogen should be omitted because it renders the fruit undesirable for processing. High nitrate content in canned papaya (as with several common vegetables) removes the tin from the can. To avoid nitrogen deficiency at the beginning of flowering for the next crop, 1 or 2% urea sprays can be applied.

In southern Florida, on oolitic limestone, experts have prescribed liquid fertilizer weekly for the first 10 weeks and then 1 lb (1/2 kg) of 4-8-6 dry fertilizer mixture (with added minor elements) per plant weekly until flowering. Here a heavy organic mulch is desirable to conserve moisture, control weeds, keep the soil cool, and help repel nematodes.

Mechanical cultivation between rows is apt to disturb the shallow roots. judicious use of herbicides is preferable.

Overcrowded fruits should be thinned out when young to provide room for good form development and avoid pressure injury. Cold weather may interfere with pollination and cause shedding of unfertilized female flowers. Spraying the inflorescence with growth regulators stops flower drop and significantly enhances fruit set. After the first crop, the terminal growth may be nipped off to induce branching which tends to dwarf the plant and facilitates harvesting. However, unless the plants are strong growers, fruiting branches may need to be propped to avoid collapse.

Harvesting

Studies in Hawaii have shown that papaya flavor is at its peak when the skin is 80% colored. For the local market, in winter months, papayas may be allowed to color fairly well before picking, but for local market in summer and for shipment, only the first indication of yellow is permissible. The fruits must be handled with great care to avoid scratching and leaking of latex which stains the fruit skin. Home growers may twist the fruit to break the stem, but in commercial operations it is preferable to use a sharp knife to cut the stem and then trim it level with the base of the fruit. However, to expedite harvesting of high fruits, most Hawaiian growers furnish their pickers with a bamboo pole with a rubber suction cup (from the well-known "plumber's helper") at the tip. With the cup held against the lower end of the fruit, the pole is thrust upward to snap the stem and the falling fruit is caught by hand. One man can thus gather 800-1,000 lbs (363-454 kg) daily.

In Hawaii, it has been calculated that manual picking and field sorting constitute 40% of the labor cost of the crop (1,702 man-hours per acre to pick and pack). Therefore, in 1970, an experimental mechanical aid was tested and results indicated that a machine with one operator and 2 pickers could harvest 1,000 lbs (454 kg) of fruit per hour, the equivalent of 8 men hand-picking. Many factors, such as investment, operation and repair costs, useful life, and so forth must be considered before such a machine could be determined to be feasible. On the island of Maui, harvesting is aided by hydraulic lifts, each operated by a single worker. Picking starts when the plants are 11 months of age and continues for 48 months when the trees are 25 ft (7.5 m) high, too tall for further usefulness.

The fruits are best packed in single layers and padded to avoid bruising. The latex oozing from the stem may irritate the skin and workers should be required to wear gloves and protective clothing.

Yield

In the usual papaya plantation, each plant may ripen 2 to 4 fruits per week over the fruiting season. Healthy plants, if well cared for, may average 75 lbs (34 kg) of fruit per plant per year, though individual plants have borne as much as 300 lbs (136 kg). In South Africa, branched 'Honey Gold' plants set 20 ft (6 m) apart in rows 10 ft (3 m) apart have produced 45 lbs (100 kg) of fruit each in their 4th year. A field of 1,000 plants occupying 2 1/2 acres (1 ha) gave 30 tons of fruit. In the Hilo area of the island of Hawaii, production averages 15 tons per acre (37 tons/ha). From 250 acres (100 ha), Princess Orchards on Maui harvests 150,000 lbs (68,180 kg) weekly during the season.

In the Kapoho region of the island of Hawaii, yields average 38,000 lbs/acre (roughly 38,000 kg/ha) the first year, 25,000 lbs (11,339 kg) the second year. Papaya plants bear well for 2 years and then productivity declines and commercial plantings are generally replaced after 3-4 years. By that time they have attained heights which make harvesting difficult.

Renovation of Plantings

In Trinidad and Tobago, plants that have become too tall are cut to the ground and side shoots are allowed to grow and bear. In El Salvador, after the 3rd year of bearing, the main stem is cut off about 3 ft (1 m) from the ground at the beginning of winter and is covered with a plastic bag to protect it from rain and subsequent rotting. Several side shoots will emerge within a few days. When these reach 8 in to 1 ft (20-30 cm) in height, all are cut off except the most vigorous one which replaces the original top.

Postharvest Treatment

Fruits can be held at 85º F (29.64º C) and high atmospheric humidity for 48 hours to enhance coloring before packing. Standard decay control has been a 20-minute submersion in water at 120º F (49º C) followed by a cool rinse. In India, dipping in 1,000 ppm of aureofungin has been shown to be effective in controlling postharvest rots. In Philippine trials, thiabendazole reduced fruit rot by 50%. In 1979, Hawaiian workers demonstrated that spreading an aqueous solution of carnauba wax and thiabendazole over harvested fruits gives good protection from postharvest diseases and can eliminate the hot-water bath.

In Puerto Rico, fruits of 'P.R. 8-65', picked green, were ripened successfully by 6-7 days treatment with ethylene gas in airtight chambers at 77º F (25º C) and 85 to 95% humidity, following the hot-water bath.

Hawaiian papayas must be sanitized before shipment to the mainland USA to avoid introduction of fruit flies. Fruits picked 1/4 ripe are prewarmed in water at 110º F (43.33º C) for about 40 min, then quickly immersed for 20 min at 119º (48.33º C). This double-dipping maybe replaced by irradiation. One little-used method is a vapor-heat treatment following dry heat at 110º F (43.33º C) and 40% relative humidity.

Fruits that have had hot water treatment and EDB fumigation and then have been stored in 1.5% oxygen at 55º F (13º C) for 12 days will have a shelf life of about 3 1/2 days at room temperature. Fruits that have had hot water treatment when 1/4 colored, followed by irradiation at 75-100 krad, and storage at 2-4% oxygen and 60º F (16º C) for 6 days will have a market life of 8 days. Those held for 12 days will be saleable thereafter for 5 days.

In Puerto Rico, gamma irradiation (25-50 krads) delayed ripening up to 7 days. Treatment at 100 krads slightly accelerated ripening in storage. Even at the lowest level irradiation inhibited fungal growth. Carotenoid content was unaffected but ascorbic acid was slightly reduced at all exposures.

Partly ripe papayas stored below 50º F (10º C) will never fully ripen. This is the lowest temperature at which ripe papayas can be held without chilling injury.

'Solo 62/3' fruits harvested in Trinidad at the first sign of yellow, treated with fungicide, placed in perforated polyethylene bags and packed in individual compartments in cartons, have been shipped to England by air (2 days' flight), ripened at 68º F (20º C), and found to be of excellent quality and flavor.

The same cultivar, similarly handled, withstood transport in the refrigerated hold of a ship for 21 days. Immediately ripened on arrival, the fruits were well accepted on the London market. Sea shipment proved to be the more economical.

Hypobaric (low pressure) containers have made possible satisfactory sea shipment (18-21 days) of hot-water treated and fungicidal-waxed papayas from Hilo, Hawaii, to Los Angeles and New York.

Pests

A major hazard to papayas in Florida and Venezuela is the wasp-like papaya fruit fly, *Toxotrypana curvicauda.* The female deposits eggs in the fruit which will later be found infested with the larvae. Only thick-fleshed fruits are safe from this enemy. Control on a commercial scale is very difficult. Home gardeners often protect the fruit from attack by covering with paper bags, but this must be done early, soon after the flower parts have fallen, and the bags must be replaced every 10 days or 2 weeks as the fruits develop. Rolled newspaper may be utilized instead of bags and is more economical. India has no fruit fly with ovipositor long enough to lay eggs inside papayas.

An important and widespread pest is the papaya web-worm, or fruit cluster worm, *Homolapalpia dalera,* harbored between the main stem and the fruit and also between the fruits. It eats into the fruit and the stem and makes way for the entrance of anthracnose. Damage can be prevented if spraying is begun at the beginning of fruit set, or at least at the first sign of webs.

The tiny papaya whitefly, *Trialeuroides variabilis, is* a sucking insect and it coats the leaves with honeydew which forms the basis for sooty mold development. Shaking young leaves will often reveal the presence of whiteflies. Spraying or dusting should begin when many adults are noticed. Hornworms (immature state of the sphinx moth–*Erinnyis obscura* in Jamaica, *E. ello* in Venezuela, *E. alope* in Florida) feed on the leaves, as do the small, light-green leafhoppers.

Mention is made later on of the aphids that transmit virus diseases and other infections.

Other pests requiring control measures in Australia include the red spider, or red spider mite, *Tetranychus seximaculatus,* which sucks the juice from the leaves. In India and on the island of Maui, plant and fruit infestation by red spider has been a major problem. This pest and the cucumber fly and fruit-spotting bugs feed on the very young fruits and cause them to drop. In Hawaii, the red-and-black-flat mite feeds on the stem and leaves and scars the fruit. The broad mite damages young plants especially during cool weather.

In the Virgin Islands scale has been most troublesome, apart from rats and fruit-bats that attack ripe fruits. In Australia, 5 species of scale insects have been found on papayas, the most serious being oriental scale, *Aonidiella orientalis*, which occurs on both the fruit and the stem. So far, it is confined to limited areas. In Florida, the scale insects *Aspidiotus destructor* and *Coccus hesperidium* may infest bagged fruit more than unbagged fruit. Another scale, *Philaphedra* sp., has recently been reported here.

Indian scientists have observed that immature earthworms, *Megascolex insignis*, are attracted by and feed on rotting tissue of papaya plants. They hasten the demise of plants afflicted with stem rot from *Pythium aphanidermatum* and may act as vectors for this fungus.

Root-knot nematodes, *Meloidogyne incognita acrita*, and reniforin nematodes, *Rotylenchulus reniformis*, are detrimental to the growth and productivity of papaya plants and should be combatted by pre-planting soil fumigation if the nematode population is high.

Diseases

Hawaii, partly because of its distance from other papaya-growing areas, is less afflicted with disease problems than Florida and Puerto Rico, but still has to combat a number of major and minor maladies. Most serious of all is the mosaic virus, on plant and fruit, which is common in Florida, Cuba, Puerto Rico, Trinidad, and first seen in Hawaii in 1959. It is transmitted mechanically or by the green peach aphid, *Myzus Persicae*, and other aphids including the green citrus aphid, *Aphis spiraecola*, in Puerto Rico. Two forms of mosaic virus are reported in Puerto Rico: the long-known "southern coast papaya mosaic virus", the symptoms of which include extreme leaf deformation, and the relatively recent "Isabela mosaic virus" on the northern coast which is similar but without leaf distortion. Both forms occur in some northcoast plantations. There is no remedy, but measures to avoid spread include the destruction of affected plants, control of aphids by pesticides, and elimination of all members of the Cucurbitaceae from the vicinity. Mosaic is sporadic and scattered and not of great concern in Queensland.

Papaya ringspot virus, prevalent in Florida, the Dominican Republic and Venezuela, is occasionally serious in the Waianae area on the dry leeward side of Oahu. It is transmitted by the same vectors. Mosaic and ringspot viruses are the main limiting factors in papaya production in the Cauca Valley of Colombia.

In Florida, virus diseases were recognized as the greatest threat to the papaya industry in the early 1950's. The first signs are irregular mottling of young leaves, then yellowing with transparent areas, leaf distortion, and rings on the fruit. If affected plants are not removed, the condition spreads throughout the plantation. Fruits borne 2 or 3 months after the first symptoms will have a disagreeable, bitter flavor.

At the Agricultural Research and Education Center of the University of Florida in Homestead, the late Dr. Robert Conover established a test plot of papayas grown from seed of 95 accessions from a number of countries and 94 collections in Florida in the hope of finding some virus-free strains. Most of the introductions were highly susceptible to papaya ringspot virus; local strains showed some resistance. Highest tolerance was shown by a dioecious, round-fruited, yellow-fleshed strain brought from Colombia by Dr. S.E. Malo several years ago. The fruits weigh 3-5 lbs (1.36-2.27 kg).

It is thought that at least 3 virus diseases are involved in papaya decline in East Africa and it has been suggested that the diseases are spread in part by the tapping of green fruits for their latex (the source of papain).

Bunchy top is a common, controllable mycoplasma disease transmitted by a leafhopper, *Empoasca papayae* in Puerto Rico, the Dominican Republic, Haiti, and Jamaica; by that species and *E. dilitara* in Cuba; and by *E. stevensi* in Trinidad. Bunchy top can be distinguished from boron deficiency by the fact that the tops of affected plants do not ooze latex when pricked.

In the subtropical part of Queensland, but not in the tropical, wet climate of northern Queensland, papaya plants are subject to die-back, a malady of unknown origin, which begins with shortening of the petioles and bunching of inner crown leaves. Then the larger crown leaves quickly turn yellow. Affected plants can be cut back at the first sign of the disease and if the cut stem is covered to avoid rotting, the top will be replaced by healthy side branches. The problem occurs mainly in the hot, dry spring after a season of heavy rains.

Anthracnose, which usually attacks the ripe fruits and is caused by the fungus *Colletotrichum gloeosporioides*, was formerly the most important papaya disease in Hawaii, Mexico and India, but it is controllable by spraying every 10 days, or every week in hot, humid seasons, and hotwater treatment of harvested fruits. A strain of this fungus produces "chocolate spot" (small, angular, superficial lesions). A disease resembling anthracnose but which attacks papayas just beginning to ripen, was reported from the Philippines in 1974 and the causal agent was identified as *Fusarium solani*.

A major disease in wet weather is phytophthora blight. *Phytophthora parasitica* attacks and rots the stem and roots of the plant and infects and spoils the fruit surface and the stem-end, inducing fruit fall and mummification. Fungicidal sprays and removal of diseased plants and fruits will reduce the incidence. *P. Palmivora* has been identified as the chief cause of root-rot in Hawaii and Costa Rica. In Hawaii, the strains, 'Waimanalo-23' and -24, 'Line 8' and 'Line 40', are resistant to this fungus. 'Kapoho Solo' and '45-T_{22}' are moderately resistant, and 'Higgins' is susceptible.

Root-rot by *Pythium* sp. is very damaging to papayas in Africa and India. *P. ultimum* causes trunk rot in Queensland. Collar rot in 8- to 10-month old seedlings, evidenced by stunting, leaf-yellowing and shedding, and total loss of roots, was first observed in Hawaii in 1970, and was attributed to attack by *Calonectria* sp. Collar rot is sometimes so severe in India as to cause growers to abandon their plantations.

Powdery mildew, caused by *Oidium caricae* (the imperfect state of *Erysiphe cruciferarum* the source of mildew in the Cruciferae) often affects papaya plants in Hawaii and both plants and fruits elsewhere. Sulfur, judiciously applied, is an effective control. Powdery mildew is caused by *Sphaerotheca humili* in Queensland and by *Ovulariopsis papayae* in East Africa. Angular leaf spot, a form of powdery mildew, is linked in Queensland to the fungus *Oidiopsis taurica*.

Corynespora leaf spot, or brown leaf spot, greasy spot or "papaya decline" (spotting of leaves and petioles and defoliation) in St. Croix, Puerto Rico, Florida and Queensland, is caused by *Corynespora cassiicola*, which is controllable with fungicides.

A new papaya disease, yellow strap leaf, similar to YSL of chrysanthemums, appeared in Florida during the summer in 1978 and 1979.

Black spot, resulting from infection by *Cercospora papayae*, has plagued Hawaiian growers since the winter of 1952-53. It causes defoliation, reduces yield, blemishes the fruit, and is unaffected by the hot-water dip. It can be prevented by field use of fungicides.

Rhizopus oryzae is most commonly linked with rotting fruits on Pakistan markets. *R. nigricans* is the usual source of fruit rot in Queensland. Injured fruits are prone to fungal rotting caused by *R. stolonifer* and *Phytophthora palmivora*. Stem-end rot occurs when fruits are pulled, not cut, from the plant and the fungus, *Ascochyta caricae*, is permitted entrance. This fungus attacks very young and older fruits in Queensland and also causes trunk rot. In South Africa, it affects cv 'Honey Gold' which is also subject to spotting by *Asperisporium caricae* on the fruits and leaves. Both of these diseases are controllable by fungicidal sprays.

Infection at the apex by *Cladospoiium* sp. is manifested by internal blight. A pre-harvest fruit rot caused by *Phomopsis caricae papayae* is troublesome in Queensland and was announced from India in 1971. A new disease, papaya apical necrosis, caused by a rhabdovirus, was reported in Florida in 1981.

Papayas are frequently blemished by a condition called "freckles", of unknown origin; and mysterious hard lumps of varying size and form may be found in ripe fruits. Star spot (grayish-white, star-shaped superficial markings) appears on immature fruits in Queensland after exposure to cold winter winds. In Uttar Pradesh, an alga, *Cephaleuros mycoidea*, often disfigures the fruit surface.

In Brazil, Hawaii and other areas, a fungus, *Botryodiplodia theobromae*, causes severe stem rot and fruit rot. Trichothecium rot (*T. roseum) is* evidenced by sunken spots soon covered by pink mold on fruits in India. Charcoal rot, *Macrophomina phaseoli, is* reported in Pakistan.

Young papaya seedlings are highly susceptible to damping-off, a disease caused by soil-borne fungi–*Pythium aphanidermatum, P*. ultimum, *Phytophthorap palmivora*, and *Rhizoctonia* sp.,–especially in warm, humid weather. Pre-planting treatment of the soil is the only means of prevention.

Papayas generally do poorly on land previously planted with papayas and this is usually the result of soil infestation by *Pythium aphanidernwtum* and *Phytophthora palmivora*. Plant refuse from previous plantings should never be incorporated into the soil. Soil fumigation is necessary before replanting papayas in the same field.

Food Uses

Ripe papayas are most commonly eaten fresh, merely peeled, seeded, cut in wedges and served with a half or quarter of lime or lemon. Sometimes a few seeds are left attached for those who enjoy their peppery flavor but not many should be eaten. The flesh is often cubed or shaped into balls and served in fruit salad or fruit cup. Firm-ripe papaya may be seasoned and baked for consumption as a vegetable. Ripe flesh is commonly made into sauce for shortcake or ice cream sundaes, or is added to ice cream just before freezing; or is cooked in pie, pickled, or preserved as marmalade or jam. Papaya and pineapple cubes, covered with sugar sirup, may be quick-frozen for later serving as dessert. Half-ripe fruits are sliced and crystallized as a sweetmeat.

Plate XLVII: PAPAYA, *Carica papaya*

Papaya juice and nectar may be prepared from peeled or unpeeled fruit and are sold fresh in bottles or canned. In Hawaii, papayas are reduced to puree with sucrose added to retard gelling and the puree is frozen for later use locally or in mainland USA in fruit juice blending or for making jam.

Unripe papaya is never eaten raw because of its latex content. Even for use in salads, it must first be peeled, seeded, and boiled until tender, then chilled. Green papaya is frequently boiled and served as a vegetable. Cubed green papaya is cooked in mixed vegetable soup. Green papaya is commonly canned in sugar sirup in Puerto Rico for local consumption and for export. Green papayas for canning in Queensland must be checked for nitrate levels. High nitrate content causes detinning of ordinary cans, and all papayas with over 30 ppm nitrate must be packed in cans lacquered on the inside. Australian growers are hopeful that the papaya can be bred for low nitrate uptake.

A lye process for batch peeling of green papayas has proven feasible in Puerto Rico. The fruits may be immersed in boiling 10% lye solution for 6 minutes, in a 15% solution for 4 minutes, or a 20% solution for 3 minutes. They are then rapidly cooled by a cold water bath and then sprayed with water to remove all softened tissue. Best proportions are 1 lb (.45 kg) of fruit for every gallon (3.8 liters) of solution.

Young leaves are cooked and eaten like spinach in the East Indies. Mature leaves are bitter and must be boiled with a change of water to eliminate much of the bitterness. Papaya leaves contain the bitter alkaloids, carpaine and pseudocarpaine, which act on the heart and respiration like digitalis, but are destroyed by heat. In addition, two previously undiscovered major Δ^{1}-piperideine alkaloids, dehydrocarpaine I and II, more potent than carpaine, were reported from the University of Hawaii in 1979. Sprays of male flowers are sold in Asian and Indonesian markets and in New Guinea for boiling with several changes of water to remove bitterness and then eating as a vegetable. In Indonesia, the flowers are sometimes candied. Young stems are cooked and served in Africa. Older stems, after peeling, are grated, the bitter juice squeezed out, and the mash mixed with sugar and salt.

In India, **papaya seeds** are sometimes found as an adulterant of whole black pepper. Collaborating chemists in Italy and Somalia identified 18 amino acids in papaya seeds, principally, in descending order of abundance, glutamic acid, arginine, proline, and aspartic acid in the endosperm; and proline, tyrosine, lysine, aspartic acid, and glutamic acid in the sarcotesta. A yellow to brown, faintly scented oil was extracted from the sundried, powdered seeds of unripe papayas at the

Central Food Technological Research Institute, Mysore, India. White seeds yielded 16.1% and black seeds 26.8% and it was suggested that the oil might have edible and industrial uses.

Food Value

The papaya is regarded as a fair source of iron and calcium; a good source of vitamins A, B and G and an excellent source of vitamin C (ascorbic acid). The following figures represent the minimum and maximum levels of constituents as reported from Central America and Cuba.

Food Value Per 100 g of Edible Portion

	Fruit	*Leaves**
Calories	23.1-25.8	
Moisture	85.9-92.6 g	83.3%
Protein	.081-.34 g	5.6%
Fat	.05-.96 g	0.4%
Carbohydrates	6.17-6.75 g	8.3%
Crude Fiber	0.5-1.3 g	1.0%
Ash	.31-.66 g	1.4%
Calcium	12.9-40.8 mg	0.406% (CO)
Phosphorus	5.3-22.0 mg	
Iron	0.25-0.78 mg	0.00636%
Carotene	.0045-.676 mg	28,900 I.U.
Thiamine	.021-.036 mg	
Riboflavin	.024-058 mg	
Niacin	.227-555 mg	
Ascorbic Acid	35.5-71.3 mg	38.6%
Tryptophan	4-5 mg	
Methionine	1 mg	
Lysine	15-16 mg	
Magnesium		0.035%
Phosphoric Acid		0.225%

*Analyses made in Malaya.

Carotenoid content of papaya (13.8 mg/100 g dry pulp) is low compared to mango, carrot and tomato. The major carotenoid is cryptoxanthin.

Papain

The latex of the papaya plant and its green fruits contains two proteolytic enzymes, papain and chymopapain. The latter is most abundant but papain is twice as potent. In 1933, Ceylon (Sri

Lanka) was the leading commercial source of papain but it has been surpassed by East Africa where large-scale production began in 1937.

The latex is obtained by making incisions on the surface of the green fruits early in the morning and repeating every 4 or 5 days until the latex ceases to flow. The tool is of bone, glass, sharp-edged bamboo or stainless steel (knife or raxor blade). Ordinary steel stains the latex. Tappers hold a coconut shell, clay cup, or glass, porcelain or enamel pan beneath the fruit to catch the latex, or a container like an "inverted umbrella" is clamped around the stem. The latex coagulates quickly and, for best results, is spread on fabric and oven-dried at a low temperature, then ground to powder and packed in tins. Sun-drying tends to discolor the product. One must tap 1,500 average-size fruits to gain 1 1/2 lbs (.68 kg) of papain.

The lanced fruits may be allowed to ripen and can be eaten locally, or they can be employed for making dried papaya "leather" or powdered papaya, or may be utilized as a source of pectin.

Because of its papain content, a piece of green papaya can be rubbed on a portion of tough meat to tenderize it. Sometimes a chunk of green papaya is cooked with meat for the same purpose.

One of the best known uses of papain is in commercial products marketed as meat tenderizers, especially for home use. A modern development is the injection of papain into beef cattle a half-hour before slaughtering to tenderize more of the meat than would normally be tender. Papain-treated meat should never be eaten "rare" but should be cooked sufficiently to inactivate the enzyme. The tongue, liver and kidneys of injected animals must be consumed quickly after cooking or utilized immediately in food or feed products, as they are highly perishable.

Papain has many other practical applications. It is used to clarify beer, also to treat wool and silk before dyeing, to de-hair hides before tanning, and it serves as an adjunct in rubber manufacturing. It is applied on tuna liver before extraction of the oil which is thereby made richer in vitamins A and D, It enters into toothpastes, cosmetics and detergents, as well as pharmaceutical preparations to aid digestion.

Papain has been employed to treat ulcers, dissolve membranes in diphtheria, and reduce swelling, fever and adhesions after surgery. With considerable risk, it has been applied on meat impacted in the gullet. Chemopapain is sometimes injected in cases of slipped spinal discs or pinched nerves. Precautions should be taken because some individuals are allergic to papain in any form and even to meat tenderized with papain.

Folk Uses

In tropical folk medicine, the fresh latex is smeared on boils, warts and freckles and given as a vermifuge. In India, it is applied on the uterus as an irritant to cause abortion. The unripe fruit is sometimes hazardously ingested to achieve abortion. Seeds, too, may bring on abortion. They are often taken as an emmenagogue and given as a vermifuge. The root is ground to a paste with salt, diluted with water and given as an enema to induce abortion. A root decoction is claimed to expel roundworms. Roots are also used to make salt.

Crushed leaves wrapped around tough meat will tenderize it overnight. The leaf also functions as a vermifuge and as a primitive soap substitute in laundering. Dried leaves have been smoked to relieve asthma or as a tobacco substitute. Packages of dried, pulverized leaves are sold by "health food" stores for making tea, despite the fact that the leaf decoction is administered as a purgative for horses in Ghana and in the Ivory Coast it is a treatment for genito-urinary ailments. The dried leaf infusion is taken for stomach troubles in Ghana and they say it is purgative and may cause abortion.

Antibiotic Activity

Studies at the University of Nigeria have revealed that extracts of ripe and unripe papaya fruits and of the seeds are active against gram-positive bacteria. Strong doses are effective against gram-negative bacteria. The substance has protein-like properties. The fresh crushed seeds yield the aglycone of glucotropaeolin benzyl isothiocyanate (BITC) which is bacteriostatic, bactericidal and fungicidal. A single effective does is 4-5 g seeds (25-30 mg BITC).

In a London hospital in 1977, a post-operative infection in a kidney-transplant patient was cured by strips of papaya which were laid on the wound and left for 48 hours, after all modern medications had failed.

Papaya Allergy

Mention has already been made of skin irritation in papaya harvesters because of the action of fresh papaya latex, and of the possible hazard of consuming undercooked meat tenderized with papain. It must be added that the pollen of papaya flowers has induced severe respiratory reactions in sensitive individuals. Thereafter, such people react to contact with any part of the plant and to eating ripe papaya or any food containing papaya, or meat tenderized with papain.

Related Species

The mountain papaya (*C. candamarcencis* Hook. f.), is native to Andean regions from Venezuela to Chile at altitudes between 6,000 and 10,000 ft (1,800-3,000 m). The plant is stout and tall but bears a small, yellow, conical, 5-angled fruit of sweet flavor. It is cultivated in climates too cold for the papaya, including northern Chile where it thrives mainly in and around the towns of Coquimbo and La Serena at near-sea-level. The fruit (borne all year) is too rich in papain for eating raw but is popular cooked, and is canned for domestic consumption and for export. The plant grows on mountains in Ceylon and South India; does well at 1800 ft (549 m) in Puerto Rico. Its high resistance to papaya viruses is of great interest to plant breeders there and elsewhere.

The babaco, or *chamburo (C. pentagona* Heilborn), is commonly cultivated in mountain valleys of Ecuador. The plant is slender and no more than 10 ft (3 m) high, but the 5-angled fruits reach a foot (30 cm) in length. Usually seedless, or with only a few seeds at most, the fruits are locally eaten only after cooking. The plant is not known in the wild and botanists have suggested that it may be a hybrid. It is propagated by cuttings and is grown on a small scale in Australia and New Zealand primarily for export.

Morton, J. 1987. Strawberry Pear. p. 347–348. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Strawberry Pear

Hylocereus undatus Britt. & Rose

Cereus undatus Haw.

This is one of the most beautiful and widespread members of the family Cactaceae, with one common name for its fruit, strawberry pear, and another for the plant, night-blooming cereus. *Hylocereus undatus* Britt. & Rose (syn. *Cereus undatus* Haw.), has been often misnamed *H. triangularis,* a binomial restricted today to a very similar cactus, *H. triangularis* Britt. & Rose (syns. *Cereus triangularis* Haw.; *Cactus triangularis* L.), endemic in Jamaica.

The Spanish terms *pitaya, pitajaya, pitahaya,* are applied to the strawberry pear in Latin America, in common with the edible fruits of several other species of cacti; but *pitahqya roja* and *pitahaya blanca* are applied specifically to *H. undatus* in Mexico; *pitahaya de cardón* in Guatemala.

Description

This cactus may be terrestrial or epiphytic. Its heavy, 3-sided, green, fleshy, much-branched stems with flat, wavy wings having horny margins, may reach 20 ft (6 m) in length. They arch over rocks or bushes, climb and form dense masses in trees, and cling to walls, by means of numerous, strong aerial roots. There are 2 to 5 short, sharp spines at each areole. The magnificent, night-blooming, very fragrant, bell-shaped, white flowers, up to 14 in (35 cm) long and 9 in (22.5 cm) wide, have a thick tube bearing several linear, green scales 1 1/2 to 3 in (4-7.5 cm) long, above which is a circle of recurved, greenish-yellow, linear segments 4 3/8 in (11 cm) long and 3/8 to 5/8 in (1-1.6 cm) wide, and an inner circle of about 20 white, oblong-lanceolate segments 4 in (10 cm) long and 1

1/4 to l 1/2 in (3.2-4 cm) wide. Very numerous, cream-colored stamens form a showy fringe in the center and at the apex of the thick perianth tube. The non-spiny fruit is oblong-oval, to 4 in (10 cm) long, 2 1/2 in (6.25 cm) thick, coated with the bright-red, fleshy or yellow, ovate bases of scales. Within is white, juicy, sweet pulp containing innumerable tiny black, partly hollow seeds.

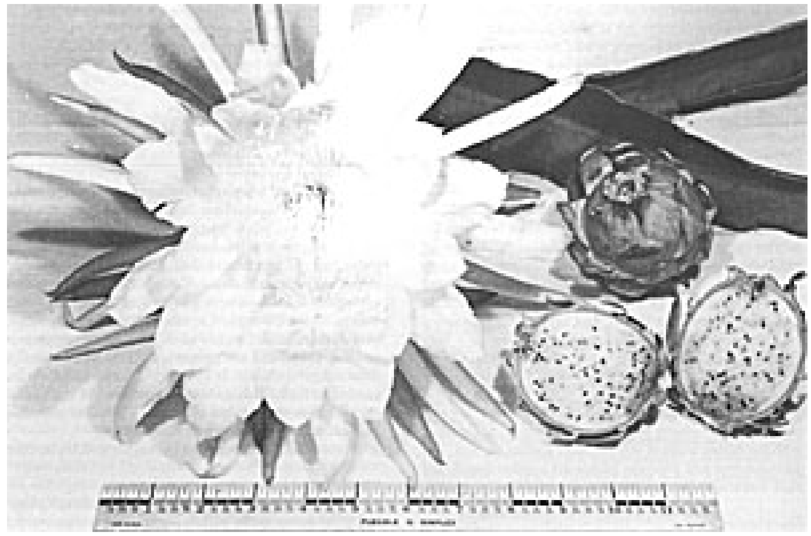

Fig. 96: The strawberry pear is the fruit of the much-admired climbing cactus (*Hylocereus undatus),* one of several species called "night-blooming cereus".

Origin and Distribution

The strawberry pear is believed native to southern Mexico, the Pacific side of Guatemala and Costa Rica, and El Salvador. It is commonly cultivated and naturalized throughout tropical American lowlands, the West Indies, the Bahamas, Bermuda, southern Florida and the tropics of the Old World.

Degener tells how this species reached Hawaii in 1830 in a shipment of plants loaded at a Mexican port aboard a ship en route from Boston to Canton, China. He says most of the plants died and were being discarded during a stopover in Hawaii, but the Captain noticed that the strawberry pear was still partly alive. Cuttings were planted and flourished and the cactus became a common ornamental in the islands. It blooms there spectacularly but rarely sets fruit. This species is often used as a rootstock on which to graft various ornamental cacti including *Zygocactus, Epiphyllum* and *Rhipsalis.*

It blooms and fruits mainly in August and September.

Varieties

It is not clear whether the *pitahaya amarilla* of Colombia is the same as the yellow form of *H. undatus* which occurs in Mexico. Perez-Arbelaez describes it under *Cereus triangularis* Haw. but expresses doubt as to its true identity. The attractive and delicious fruit is served whole or halved as dessert in hotels in Bogotá. (see Plate XLVIII).

Food Uses

The ripe strawberry pear is much appreciated, especially if chilled and cut in half so that the flesh can be eaten with a spoon. The juice is enjoyed as a cool drink. A sirup made of the whole fruit is used to color pastries and candy. The unopened flowerbud can be cooked and eaten as a vegetable.

Food Value

We have only Aguilar Giron's assay of the pulp: water, 92.20; protein, 0.48-0.50; carbohydrates, 4.33-4.98; fat, 0.17-0.18; fiber, 1.12; ash, 1.10%.

Analyses made in Guatemala were published under the heading *"Hylocereus undatus"*. However, the pulp is described in accompanying notes as being "a bright, clear cerise", and the fruits analyzed were accordingly those of *H. guatemalensis* Britt. & Rose which is very much like *H. undatus*, but has smaller, red-fleshed fruits instead of white-fleshed. A large vine of the Guatemalan species has festooned a tree at the Agricultural Research and Education Center, Homestead, Florida, for many years. The composition of this species, analyzed by Munsell, *et al.* (1950), is tabulated here in lieu of comparable data on *H. undatus.*

Food Value Per 100 g of Edible Portion*	
Moisture	82.5-83.0 g
Protein	0.159-0.229 g
Fat	0.21-0.61 g
Crude Fiber	0.7-0.9 g
Ash	0.54-0.68 g
Calcium	6.3-8.8 mg
Phosphorus	30.2-36.1 mg
Iron	0.55-0.65 mg
Carotene	0.005-0.012 mg
Thiamine	0.28-0.043 mg
Riboflavin	0.043-0.045 mg
Niacin	0.297-0.430 mg
Ascorbic Acid	8.0-9.0 mg

*Analyses of *H. guatemalensis.*

Medicinal Uses

The sap of the stems of *H. undatus* has been utilized as a vermifuge but it is said to be caustic and hazardous. The air-dried, powdered stems contain *B*-sitosterol.

Related Species

H. ocamponis Britt. & Rose (syn. *Cereus ocamponis* Salm-Dyck) is a similar cactus cultivated in Guatemala, Colombia, Bolivia and Puerto Rico. It has more deeply undulate wings bordered with brown, and longer spines. The fruit is wine-red outside and inside and the pulp is sweet.

The so-called apple cactus is *Cereus Peruvianus* Mill., a striking, large, erect, multiple-stemmed, ribbed, spiny columnar species from South America, much grown as an ornamental in southern Florida and Hawaii. The fruit is oval, to 4 in (10 cm) long, deep-pink externally and white internally, sweet, juicy and desirable.

Morton, J. 1987. Pomegranate. p. 352–355. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Pomegranate

Punica granatum L.

Steeped in history and romance and almost in a class by itself, the pomegranate, *Punica granatum* L., belongs to the family Punicaceae which includes only one genus and two species, the other one, little-known, being *P. protopunica* Balf. peculiar to the island of Socotra.

Despite its ancient background, the pomegranate has acquired only a relatively few commonly recognized vernacular names apart from its many regional epithets in India, most of which are variations on the Sanskrit *dadima* or *dalim*, and the Persian *dulim* or *dulima*. By the French it is called *grenade;* by the Spanish, *granada* (the fruit), *granado* (the plant); by the Dutch, *granaatappel*, and Germans, *granatapfel;* by the Italians, *melogranato*, *melograno granato*, *pomo granato*, or *pomo punico*. In Indonesia, it is *gangsalan;* in Thailand, *tab tim;* and in Malaya, *delima*. Brazilians know it as *roma*, *romeira* or *romazeira*. The Quecchi Indian name in Guatemala is *granad*. The Samoan name is *limoni*. The generic term, *Punica,* was the Roman name for

Carthage from whence the best pomegranates came to Italy.

Description

Plate XLIX: POMEGRANATE, *Punica granatum*

An attractive shrub or small tree, to 20 or 30 ft (6 or 10 m) high, the pomegranate is much-branched, more or less spiny, and extremely long-lived, some specimens at Versailles known to have survived two centuries. It has a strong tendency to sucker from the base. The leaves are evergreen or deciduous, opposite or in whorls of 5 or 6, short-stemmed, oblong-lanceolate, 3/8 to 4 in (1-10 cm) long, leathery. Showy flowers are home on the branch tips singly or as many as 5 in a cluster. They are 1 1/4 in (3 cm) wide and characterized by the thick, tubular, red calyx having 5 to 8 fleshy, pointed sepals forming a vase from which emerge the 3 to 7 crinkled, red, white or variegated petals enclosing the numerous stamens. Nearly round, but crowned at the base by the prominent calyx, the fruit, 2 1/2 to 5 in (6.25-12.5 cm) wide, has a tough, leathery skin or rind, basically yellow more or less overlaid with light or deep pink or rich red. The interior is separated by membranous walls and white spongy tissue (rag) into compartments packed with transparent sacs filled with tart, flavorful, fleshy, juicy, red, pink or whitish pulp (technically the aril). In each sac, there is one white or red, angular, soft or hard seed. The seeds represent about 52% of the weight of the whole fruit.

Origin and Distribution

The pomegranate tree is native from Iran to the Himalayas in northern India and has been cultivated since ancient times throughout the Mediterranean region of Asia, Africa and Europe. The fruit was used in many ways as it is today and was featured in Egyptian mythology and art, praised in the Old Testament of the Bible and in the Babylonian Talmud, and it was carried by desert caravans for the sake of its thirst-quenching juice. It traveled to central and southern India from Iran about the first century A.D. and was reported growing in Indonesia in 1416. It has been widely cultivated throughout India and drier parts of southeast Asia, Malaya, the East Indies and tropical Africa. The most important growing regions are Egypt, China, Afghanistan, Pakistan, Bangladesh, Iran, Iraq, India, Burma and Saudi Arabia. There are some commercial orchards in Israel on the coastal plain and in the Jordan Valley.

It is rather commonly planted and has become naturalized in Bermuda where it was first recorded in 1621, but only occasionally seen in the Bahamas, West Indies and warm areas of South and Central America. Many people grow it at cool altitudes in the interior of Honduras. In Mexico it is frequently planted, and it is sometimes found in gardens in Hawaii. The tree was introduced in California by Spanish settlers in 1769. It is grown for its fruit mostly in the dry zones of that state and Arizona. In California, commercial pomegranate cultivation is concentrated in Tulare, Fresno and Kern counties, with small plantings in Imperial and Riverside counties. There were 2,000 acres (810 ha) of hearing trees in these areas in the 1920's. Production declined from lack of demand in the 1930's but new plantings were made when demand increased in the 1960's.

Cultivars

There is little information available on the types grown in the Near East, except that the cultivars **'Ahmar', 'Aswad', 'Halwa'** are important in Iraq, and **'Mangulati'** in Saudi Arabia. **'Wonderful'** and **'Red Loufani'** are often grown in the Jewish sector of Israel, while the sweeter, less tangy **'Malissi'** and **'Ras el Baghl',** are favored in the Arab sector.

In India there are several named cultivars. Preference is usually given those with fleshy, juicy pulp around the seeds. Types with relatively soft seeds are often classed as "seedless". Among the best are **'Bedana'** and **'Kandhari'.** 'Bedana' is medium to large, with brownish or whitish rind, pulp pinkish-white, sweet, seeds soft. 'Kandhari' is large, deep-red, with deep-pink or blood-red, subacid pulp and hard seeds. Others include:

'Alandi' ('Vadki')–medium-sized, with fleshy red or pink, subacid pulp, very hard seeds.

'Dholka'–large, yellow-red, with patches of dark-pink and purple at base, or all-over greenish-white; thick rind, fleshy, purplish-white or white, sweet, pulp; hard seeds. The plant is evergreen, non-suckering, desirable for commercial purposes in Delhi.

'Kabul'–large, with dark-red and pale-yellow rind; fleshy, dark-red, sweet, slightly bitter pulp.

'Muscat Red'–small to medium, with thin or fairly thick rind, fleshy, juicy, medium-sweet pulp, soft or medium-hard seeds. The plant is a moderately prolific bearer.

'Paper Shell'–round, medium to large, pale-yellow blushed with pink; with very thin rind, fleshy, reddish or pink, sweet, very juicy pulp and soft seeds. Bears heavily.

'Poona'–large, with dark-red, gray or grayish-green rind, sometimes spotted, and orange-red or pink-and-red pulp.

'Spanish Ruby'–round, small to medium or large; bright-red, with thin rind, fleshy, rose-colored, sweet, aromatic pulp, and small to medium, fairly soft seeds. Considered medium in quality.

'Vellodu'–medium to large, with medium-thick rind, fleshy, juicy pulp and medium-hard seeds.

'Muscat White'–large, creamy-white tinged with pink; thin rind; fleshy, cream-colored, sweet pulp; seeds medium-hard. Bears well. Desirable for commercial planting in Delhi.

'Wonderful'–originated as a cutting in Florida and propagated in California in 1896. The fruit is oblate, very large, dark purple-red, with medium-thick rind; deep-red, juicy, winey pulp; medium-hard seeds. Plant is vigorous and productive.

In California, 'Spanish Ruby' and 'Sweet Fruited' were the leading cultivars in the past century, but were superseded by 'Wonderful'. In recent years 'Wonderful' is losing ground to the more colorful 'Grenada'.

Mexicans take especial pride in the pomegranates of Tehuacan, Puebla. Many cultivars are grown, including **'Granada de China'** and **'Granada Agria'.**

The Japanese dwarf pomegranate, *P. granatum* var. *nana, is* especially hardy and widely grown as an ornamental in pots. The flowers are scarlet, the fruit only 2 in (5 cm) wide but borne abundantly. Among other ornamental cultivars are **'Multiplex'** with double, creamy white blooms; **'Chico',** double, orange-red; **'Pleniflora',** double, red; **'Rubra Plena',** double, red; **'Mme. Legrelle'** and **'Variegata',** double, scarlet bordered and streaked with yellowish-white.

Pollination

The pomegranate is both self-pollinated and cross-pollinated by insects. There is very little wind dispersal of pollen. Self-pollination of bagged flowers has resulted in 45% fruit set. Cross-pollination has increased yield to 68%. In hermaphrodite flowers, 6 to 20% of the pollen may be infertile; in male, 14 to 28%. The size and fertility of the pollen vary with the cultivar and season.

Climate

The species is primarily mild-temperate to subtropical and naturally adapted to regions with cool winters and hot summers, but certain types are grown in home dooryards in tropical areas, such as various islands of the Bahamas and West Indies. In southern Florida, fruit development is enhanced after a cold winter. Elsewhere in the United States, the pomegranate can be grown outdoors as far north as Washington County, Utah, and Washington, D.C., though it doesn't fruit in the latter locations. It can be severely injured by temperatures below 12º F (-11.11º C). The plant favors a semi-arid climate and is extremely drought -tolerant.

Soil

The pomegranate thrives on calcareous, alkaline soil and on deep, acidic loam and a wide range of soils in between these extremes. In northern India, it is spontaneous on rockstrewn gravel.

Propagation

Pomegranate seeds germinate readily even when merely thrown onto the surface of loose soil and the seedlings spring up with vigor. However, to avoid seedling variation, selected cultivars are usually reproduced by means of hardwood cuttings 10 to 20 in (25-50 cm) long. Treatment with 50 ppm. indole-butyric acid and planting at a moisture level of 15.95% greatly enhances root development and survival. The cuttings are set in beds with 1 or 2 buds above the soil for 1 year, and then transplanted to the field. Grafting has never been successful but branches may be air-layered and suckers from a parent plant can be taken up and transplanted.

Culture

Rooted cuttings or seedlings are set out in pre-fertilized pits 2 ft (60 cm) deep and wide and are spaced 12 to 18 ft (3.5-5.5 m) apart, depending on the fertility of the soil. Initially, the plants are cut back to 24 to 30 in (60-75 cm) in height and after they branch out the lower branches are pruned to provide a clear main stem. Inasmuch as fruits are borne only at the tips of new growth, it is recommended that, for the first 3 years, the branches be judiciously shortened annually to encourage the maximum number of new shoots on all sides, prevent straggly development, and achieve a strong, well-framed plant. After the 3rd year, only suckers and dead branches are removed.

For good fruit production, the plant must be irrigated. In Israel, brackish water is utilized with no adverse effect. In California, irrigation water is supplied by overhead sprinklers which also provide frost protection during cold spells. The pomegranate may begin to bear in 1 year after planting out, but 2 1/2 to 3 years is more common.

Harvesting and Yield

The fruits ripen 6 to 7 months after flowering. In Israel, cultivar 'Wonderful' is deemed ready for harvest when the soluble solids (SSC) reach 15%. In California, maturity has been equated with 1.8% titratable acidity (TA) and SSC of 17% or more. The fruit cannot be ripened off the tree even with ethylene treatment. Growers generally consider the fruit ready for harvest if it makes a metallic sound when tapped. The fruit must be picked before over maturity when it tends to crack open if rained upon or under certain conditions of atmospheric humidity, dehydration by winds, or insufficient irrigation. Of course, one might assume that ultimate splitting is the natural means of seed release and dispersal.

The fruits should not be pulled off but clipped close to the base so as to leave no stem to cause damage in handling and shipping. Appearance is important, especially in the United States where pomegranates may be purchased primarily to enhance table arrangements and other fall (harvest-time) decorations. Too much sun exposure causes sunscald–brown, russeted blemishes and roughening of the rind.

The fruit ships well, cushioned with paper or straw, in wooden crates or, for nearby markets, in baskets. Commercial California growers grade the fruits into 8 sizes, pack in layers, unwrapped but topped with shredded plastic, in covered wood boxes, precool rapidly, and ship in refrigerated trucks.

Keeping Quality and Storage

The pomegranate is equal to the apple in having a long storage life. It is best maintained at a temperature of 32º to 41º F (0º-5º C). The fruits improve in storage, become juicier and more flavorful; may be kept for a period of 7 months within this temperature range and at 80 to 85% relative humidity, without shrinking or spoiling. At 95% relative humidity, the fruit can be kept only 2 months at 41º F (5º C); for longer periods at 50º F (10º C). After prolonged storage, internal breakdown is evidenced by faded, streaky pulp of flat flavor. 'Wonderful' pomegranates, stored in Israel for Christmas shipment to Europe, are subject to superficial browning ("husk scald"). Control has been achieved by delaying harvest and storing in 2% O_2 at 35.6º F (2º C). Subsequent transfer to 68º F (20º C) dispels off-flavor from ethanol accumulation.

Pests and Diseases

The pomegranate butterfly, *Virachola isocrates*, lays eggs on flower-buds and the calyx of developing fruits; in a few days the caterpillars enter the fruit by way of the calyx. These fruit borers may cause loss of an entire crop unless the flowers are sprayed 2 times 30 days apart. A stem borer sometimes makes holes right through the branches. Twig dieback may be caused by either *Pleuroplaconema* or *Ceuthospora Phyllosticta*. Discoloration of fruits and seeds results from infestation by *Aspergillus castaneus.* The fruits may be sometimes disfigured by *Sphaceloma punicae.* Dry rot from *Phomopsis* sp. or *Zythia versoniana* may destroy as much as 80% of the crop unless these organisms are controlled by appropriate spraying measures. Excessive rain during the ripening season may induce soft rot. A post-harvest rot caused by *Alternaria solani* was observed in India in 1974. It is particularly prevalent in cracked fruits.

Minor problems are leaf and fruit spot caused by *Cercospora, Gloeosporium* and *Pestalotia* sp.; also foliar damage by whitefly, thrips, mealybugs and scale insects; and defoliation by *Euproctis* spp. and *Archyophora dentula.* Termites may infest the trunk. In India, paper or plastic bags or other covers may be put over the fruits to protect them from borers, birds, bats and squirrels.

Food Uses

For enjoying out-of-hand or at the table, the **fruit** is deeply scored several times vertically and then broken apart; then the clusters of juice sacs can be lifted out of the rind and eaten. Italians and other pomegranate fanciers consider this not a laborious handicap but a social, family or group activity, prolonging the pleasure of dining.

In some countries, such as Iran, the **juice** is a very popular beverage. Most simply, the juice sacs are removed from the fruit and put through a basket press. Otherwise, the fruits are quartered and crushed, or the whole fruits may be pressed and the juice strained out. In Iran, the cut-open fruits may be stomped by a person wearing special shoes in a clay tub and the juice runs through outlets into clay troughs. Hydraulic extraction of juice should be at a pressure of less than 100 psi to avoid undue yield of tannin. The juice from crushed whole fruits contains excess tannin from the rind (as much as .175%) and this is precipitated out by a gelatin process. After filtering, the juice may be preserved by adding sodium benzoate or it may be pasteurized for 30 minutes, allowed to settle for 2 days, then strained and bottled. For beverage purposes, it is usually sweetened. Housewives in South Carolina make pomegranate jelly by adding 7 1/2 cups of sugar and 1 bottle of liquid pectin for every 4 cups of juice. In Saudi Arabia, the juice sacs may be frozen intact or the extracted juice may be concentrated and frozen, for future use. Pomegranate juice is widely made into grenadine for use in mixed drinks. In the Asiatic countries it may be made into a thick sirup for use as a sauce. It is also often converted into wine.

In the home kitchen, the juice can be easily extracted by reaming the halved fruits on an ordinary orange-juice squeezer.

In northern India, a major use of the wild fruits is for the preparation of "anardana"–the juice sacs being dried in the sun for 10 to 15 days and then sold as a spice.

Food Value Per 100 g of Edible Portion*	
Calories	63-78
Moisture	72.6-86.4 g
Protein	0.05-1.6 g
Fat	Trace only to 0.9 g
Carbohydrates	15.4-19.6 g
Fiber	3.4-5.0 g

Ash	0.36-0.73 g
Calcium	3-12 mg
Phosphorus	8-37 mg
Iron	0.3-1.2 mg
Sodium	3 mg
Potassium	259 mg
Carotene	None to Trace
Thiamine	0.003 mg
Riboflavin	0.012-0.03 mg
Niacin	0.180-0.3 mg
Ascorbic Acid	4-4.2 mg
Citric Acid	0.46-3.6 mg
Boric Acid	0.005 mg

*Analyses of fresh juice sacs made by various investigators.

Toxicity

A tannin content of no more than 0.25% in the edible portion is the desideratum. Many studies have shown that tannin is carcinogenic and excessive ingestion of tannin from one or more sources, over a prolonged period, is detrimental to health. (See also "Medicinal Uses" regarding overdoses of bark.)

Other Uses

All parts of the tree have been utilized as sources of tannin for curing leather. The **trunk bark** contains 10 to 25% tannin and was formerly important in the production of Morocco leather. The **root bark** has a 28% tannin content, the leaves, 11%, and the fruit rind as much as 26%. The latter is a by-product of the "anardana" industry. Both the **rind** and the **flowers** yield dyes for textiles. Ink can be made by steeping the **leaves** in vinegar. In Japan, an insecticide is derived from the bark. The pale-yellow **wood** is very hard and, while available only in small dimensions, is used for walking-sticks and in woodcrafts.

Medicinal Uses: The juice of wild pomegranates yields citric acid and sodium citrate for pharmaceutical purposes. Pomegranate juice enters into preparations for treating dyspepsia and is considered beneficial in leprosy.

The bark of the stem and root contains several alkaloids including *iso*pelletierine which is active against tapeworms. Either a decoction of the bark, which is very bitter, or the safer, insoluble Pelletierine Tannate may be employed. Overdoses are emetic and purgative, produce dilation of pupila, dimness of sight, muscular weakness and paralysis.

Because of their tannin content, extracts of the bark, leaves, immature fruit and fruit rind have been given as astringents to halt diarrhea, dysentery and hemorrhages. Dried, pulverized flower buds are employed as a remedy for bronchitis. In Mexico, a decoction of the flowers is gargled to relieve oral and throat inflammation. Leaves, seeds, roots and bark have displayed hypotensive, antispasmodic and anthelmintic activity in bioassay.

Morton, J. 1987. Guava. p. 356–363. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Guava

Psidium guajava L.

One of the most gregarious of fruit trees, the guava, *Psidium guajava* L., of the myrtle family (Myrtaceae), is almost universally known by its common English name or its equivalent in other languages. In Spanish, the tree is *guayabo*, or *guayavo*, the fruit *guayaba* or *guyava*. The French call it *goyave* or *goyavier*; the Dutch, *guyaba*, *goeajaaba*; the Surinamese, *guave* or *goejaba;* and the Portuguese, *goiaba* or *goaibeira*. Hawaiians call it guava or *kuawa*. In Guam it is *abas*. In Malaya, it is generally known either as guava or *jambu batu*, but has also numerous dialectal names as it does in India, tropical Africa and the Philippines where the corruption, *bayabas*, is often applied. Various tribal names–*pichi, posh, enandi, etc*.–are employed among the Indians of Mexico and Central and South America.

Description

A small tree to 33 ft (10 in) high, with spreading branches, the guava is easy to recognize because of its smooth, thin, copper-colored bark that flakes off, showing the greenish layer beneath; and also because of the attractive, "bony" aspect of its trunk which may in time attain a diameter of 10 in (25 cm). Young twigs are quadrangular and downy. The leaves, aromatic when crushed, are evergreen, opposite, short-petioled, oval or oblong-elliptic, somewhat irregular in outline; 2 3/4 to 6 in (7-15 cm) long, I 'A to 2 in (3-5 cm) wide, leathery, with conspicuous parallel veins, and more or less downy on the underside. Faintly fragrant, the white flowers, borne singly or in small clusters in the leaf axils, are 1 in (2.5 cm) wide, with 4 or 5 white petals which are quickly shed, and a prominent tuft of perhaps 250 white stamens tipped with pale-yellow anthers.

Plate L: GUAVA, *Psidium guajava*

The fruit, exuding a strong, sweet, musky odor when ripe, may be round, ovoid, or pear-shaped, 2 to 4 in (5-10 cm) long, with 4 or 5 protruding floral remnants (sepals) at the apex; and thin, light-yellow skin, frequently blushed with pink. Next to the skin is a layer of somewhat granular flesh, 1/8 to 1/2 in (3-12.5 mm) thick, white, yellowish, light- or dark-pink, or near-red, juicy, acid, subacid, or sweet and flavorful. The central pulp, concolorous or slightly darker in tone, is juicy and normally filled with very hard, yellowish seeds, 1/8 in (3 min) long, though some rare types have soft, chewable seeds. Actual seed counts have ranged from 112 to 535 but some guavas are seedless or nearly so.

When immature and until a very short time before ripening, the fruit is green, hard, gummy within and very astringent.

Origin and Distribution

The guava has been cultivated and distributed by man, by birds, and sundry 4-footed animals for so long that its place of origin is uncertain, but it is believed to be an area extending from southern Mexico into or through Central America. It is common throughout all warm areas of tropical America and in the West Indies (since 1526), the Bahamas, Bermuda and southern Florida where it was reportedly introduced in 1847 and was common over more than half the State by 1886. Early Spanish and Portuguese colonizers were quick to carry it from the New World to the East Indies and Guam. It was soon adopted as a crop in Asia and in warm parts of Africa. Egyptians have grown it for a long time and it may have traveled from Egypt to Palestine. It is occasionally seen in Algeria and on the Mediterranean coast of France. In India, guava cultivation has been estimated at 125,327 acres (50,720 ha) yielding 27,319 tons annually.

Apparently it did not arrive in Hawaii until the early 1800's. Now it occurs throughout the Pacific islands. Generally, it is a home fruit tree or planted in small groves, except in India where it is a major commercial resource. A guava research and improvement program was launched by the government of Colombia in 1961. In 1968, it was estimated that there were about 10 million wild trees (around Santander, Boyacá, Antioquia, Palmira, Buga, Cali and Cartago) bearing, 88 lbs (40 kg) each per year and that only 10% of the fruit was being utilized in processing. Bogotà absorbs 40% of the production and preserved products are exported to markets in Venezuela and Panama.

Brazil's modern guava industry is based on seeds of an Australian selection grown in the botanical garden of the Sao Paulo Railway Company at Tatu. Plantations were developed by Japanese farmers at Itaquera and this has become the leading guava-producing area in Brazil. The guava is one of the leading fruits of Mexico where the annual crop from 36,447 acres (14,750 ha) of seedling trees totals 192,850 tons (175,500 MT). Only in recent years has there been a research program designed to evaluate and select superior types for vegetative propagation and large-scale cultivation.

In Florida, the first commercial guava planting was established around 1912 in Palma Sola. Others appeared at Punta Gorda and Opalocka. A 40-acre (16 ha) guava grove was planted by Miami Fruit Industries at Indian-town in 1946. There have been more than two dozen guava jelly manufacturers throughout the state. A Sarasota concern was processing 250 bushels of guavas per day and a Pinellas County processor was operating a 150-bushel capacity plant in 1946. There has always been a steady market for guava products in Florida and the demand has increased in recent years with the influx of Caribbean and Latin American people.

The guava succumbs to frost in California except in a few favorable locations. Even if summers are too cool–a mean of 60º F (15.56º C)–in the coastal southern part of the state, the tree will die back and it cannot stand the intense daytime heat of interior valleys.

In many parts of the world, the guava runs wild and forms extensive thickets–called "guayabales" in Spanish–and it overruns pastures, fields and roadsides so vigorously in Hawaii, Malaysia, New Caledonia, Fiji, the U.S. Virgin Islands, Puerto Rico, Cuba and southern Florida that it is classed as a noxious weed subject to eradication. Nevertheless, wild guavas have constituted the bulk of the commercial supply. In 1972, Hawaii processed, for domestic use and export, more than 2,500 tons (2,274 MT) of guavas, over 90% from wild trees. During the period of high demand in World War II, the wild guava crop in Cuba was said to be 10,000 tons (9,000 MT), and over 6,500 tons (6,000 MT) of guava products were exported.

Cultivars

Formerly, round and pear-shaped guavas were considered separate species–*P. pomiferum* L. and *P. pyriferum* L.–but they are now recognized as mere variations. Small, sour guavas predominate in the wild and are valued for processing.

'Redland', the first named cultivar in Florida, was developed at the University of Florida Agricultural Research and Education Center, Homestead, and described in 1941. Very large, with little odor, white-fleshed and with relatively few seeds, it was at first considered promising but because of its excessively mild flavor, low ascorbic acid content, and susceptibility to algal spotting, it was abandoned in favor of better selections.

'Supreme' came next, of faint odor, thick, white flesh, relatively few, small seeds, high ascorbic acid content and ability to produce heavy crops over a period of 8 months from late fall to early spring.

'Red Indian', of strong odor, medium to large size, round but slightly flattened at the base and apex, yellow skin often with pink blush; with medium thick, red flesh of sweet flavor; numerous but small seeds; agreeable for eating fresh; fairly productive in fall and early winter.

'Ruby', with pungent odor, medium to large size; ovate; with thick, red flesh, sweet flavor, relatively few seeds. An excellent guava for eating fresh and for canning; fairly productive, mainly in fall and early winter.

'Blitch' (a seedling which originated in West Palm Beach and was planted at Homestead)–of strong odor, medium size, oval, with light-pink flesh, numerous, small seeds; tart, pleasant flavor; good for jelly.

'Patillo' (a seedling selection at DeLand propagated by a root sucker and from that by air-layer and planted at Homestead)–of very mild odor, medium size, ovate to obovate, with pink flesh, moderate number of small seeds; subacid, agreeable flavor; good for general cooking. (As grown in Hawaii it is highly acid and best used for processing).

'Miami Red' and **'Miami White',** large, nearly odorless and thick-fleshed, were released by the University of Miami's Experimental Farm in 1954.

In early 1952, Dr. J.J. Ochse imported into Florida air-layers of a seedless guava from Java. All died. In September 1953, the writer received air-layers from Saharanpur, India. One survived and was turned over to the Agricultural Research and Education Center, Homestead. Four more were ordered from Coimbatore but arrived dead. Willim Whitman brought in a grafted plant from Java in 1954 which grew well, fruited and was the source of propagating material. In 1955, Whitman obtained a plant of a seedless guava from Cuba and it bore its first fruit in 1957. Seedless guavas are the result of low fertility of pollen grains and self-incompatibility. The fruits tend to be malformed and the trees are scant bearers. Applications of gibberellic acid increase fruit size, weight and ascorbic acid content but induce prominent ridges on the surface.

Among early California cultivars were:

'Webber' (formerly 'Riverside'), of medium-large size, pale-yellowish flesh, good flavor and 9.5% sugar.

'Rolfs', of medium size with pink flesh; of good quality and containing 9% sugar.

'Hart', fairly large, with pale-yellow flesh, and 8% sugar content.

Currently, some rare fruit fanciers grow the Florida-developed **'Red Indian'** and **'White Indian';** also **'Detwiler' and 'Turnbull'.**

In 1975, a guava trial project was undertaken at the Maroochy Horticultural Research Station in southeastern Queensland, beginning with 5 strains from Hawaii. By 1981, 4 selections (GA9-39R1T2', 'GA11-56T7', GA11-56R5T2' and 'GA11-564T1') seemed to hold promise for processing and 2 selections ('GA11-56T3' and 'GA11-56R1T1') for marketing fresh. They were all vegetatively propagated and tested as to performance. The green-skinned, acid, 'GA11-56' and another Hawaiian selection, '1050', yellow-skinned and mild in flavor and odor, are being grown commercially for processing in New South Wales.

In India much attention is given the characteristics of local and introduced guava cultivars and their suitability for various purposes. Among common white-fleshed cultivars are:

'Apple Colour'–of medium size, slightly oblate; deep-pink skin, creamy-white flesh, moderate amount of seeds, very sweet flavor (0.34-2.12% acid, 9 to 11.36% sugar); heavy bearer; good keeping quality; good for canning.

'Behat Coconut'–large, with thick white flesh, few seeds; poor for canning.

'Chittidar'–medium to large, round-ovate, white-fleshed, mild acid-sweet flavor; bears moderately well; keeps well; good for canning.

'Habshi'–of medium size with thick, white flesh, few seeds; halves good for canning.

'Lucknow 42'–of medium size, roundish, with creamy-white, soft flesh; sweet, pleasant flavor; very few seeds; good quality; bears heavily; keeps fairly well; not suitable for canning.

'Lucknow 49'–medium-large with cream-white, thick flesh, few seeds; acid-sweet; good quality; heavy bearer; high in pectin and good for jelly; halves good for canning.

'Safeda'–of medium size, with very thin skin, thick, white flesh, few seeds. Outstanding quality for canning. A famous guava, widely planted, but susceptible to wilt and branches are brittle and break readily.

'Smooth Green'–of medium size, with thick white flesh, few, small, hard seeds. Halves are firm, good for canning.

'Allahabad'–large, white-fleshed, with few, medium-sized, fairly hard seeds.

'Karela'–medium-large, pear-shaped, furrowed, rough-skinned, with soft, granular, white flesh; sweet, rich, pleasant flavor. Poor bearer. Not popular.

'Nagpur Seedless'–small to medium, often irregular in shape; white-fleshed.

'Seedless' (from Allahabad)–medium to large, pear-shaped to ovoid; with thick white flesh, firm to soft, sweet. Light bearer; poor keeper.

A seedless type at Poona, India, was found to be a triploid with 33 chromosomes in place of the usual 22.

Other white-fleshed guavas with poor canning qualities are: **'Dharwar', 'Mirzapuri', 'Nasik', 'Sindh',** and **'White Supreme X Ruby'.**

Among red-fleshed cultivars in India there are:

'Anakapalle'–small, with thin, red flesh, many seeds; not suitable for canning.

'Florida Seedling'–small, with thin, red, acid flesh; many seeds; not suitable for canning.

'Hapi'–medium to large, with red flesh.

'Hybrid Red Supreme'–large, with thin, red, acid flesh; moderate amount of seeds; not suitable for canning.

'Kothrud'–of medium size with medium thick, red flesh; moderate amount of seeds; not suitable for canning.

'Red-fleshed'–of medium size with many (about 567) fairly soft seeds; high in pectin and good for jelly; not suitable for canning.

Among other Indian cultivars are: **'Banaras', 'Dholka', 'Hasijka', 'Kaffree',** and **'Wickramasekara'.** The latter is a small fruit and poor bearer.

Indian breeders have crossed the guava with its dwarf, small-fruited relative, *P. guineense* Sw., with a view to reducing tree size and enhancing hardiness and yield.

In Egypt, a cultivar named **'Bassateen El Sabahia'** has long been the standard commercial guava. Efforts have been made to improve quality and yield and to this end selections were made from 300 seedlings. The most promising selection was tested and introduced into cultivation in 1975 under the name **'Bassateen Edfina'.** It is pear-shaped, of medium size, sometimes pink-blushed, with thick, white flesh, few seeds, good flavor and higher ascorbic acid content than the parent. It bears well over a long season.

In Puerto Rico, over 100 promising selections were under observation in 1963.

Numerous cultivated clones identified only by number have been evaluated for processing characters. Others have been tested and rated for resistance to *Glomerella* disease. Among the few named cultivars are **'Corozal Mixta', 'Corriente',** and **'Seedling 57-6-79'.**

In Trinidad, a large, white-fleshed type is known as **'Cayenne'**.

In 1967, French horticulturists made a detailed evaluation of 11 guava cultivars grown at the Neufchateau Station in Guadeloupe:

'Elisabeth'–large, round, pink-fleshed, very acid; good for processing.

'Red' X 'Supreme' X 'Ruby'–large, ovoid, with deep-pink flesh; agreeable for eating fresh.

'Large White'–large, round, white-fleshed; low sugar content, astringent; can be useful as filler in preserves.

'Acid Speer'–large, round, with pale-yellow flesh; acid; recommended only as source of pectin.

'Red' X 'Supreme' X 'Ruby' X 'White'–large to very large, pear-shaped, with creamy-white flesh; good for eating fresh and for juice and nectar.

'Pink Indian'–of medium size, red-fleshed; agreeably acid; good for eating fresh and for processing.

'Red Hybrid'–medium, sub-ovoid, red-fleshed; medium quality.

'Supreme' X 'Ruby'–medium, sub-ovoid, white-fleshed; unremarkable except for high productivity.

'Stone'–small, ovoid, with deep-pink flesh; attractive and of agreeable flavor for eating fresh.

'Supreme'–small, ovoid, with pale-yellow, pink-tinged flesh; sweet; good for sherbet and paste; very productive.

'Patricia'–very small, ovoid, salmon-fleshed; attractive; good to eat fresh but quickly loses its distinct strawberry flavor; good for sirup; very productive.

Between 1948 and 1969, 21 guava cultivars from 7 countries were introduced into Hawaii. Some have been test planted and evaluated at the Waimanalo Experimental Farm. Four sweet, white-fleshed, thick-walled cultivars were rated as commercially desirable: **'Indonesian White', 'Indonesian Seedless', 'Lucknow 49',** and **'No. 6363'** (a 'Ruby' X 'Supreme' hybrid from Florida). Lower ratings were given four others of this group: **'Apple'** (too musky and seedy); **'Allahabad Safeda'** (too bumpy of surface); **'Burma'** (too seedy) and **'Hong Kong White'** (too seedy). Of the sweet, pink-fleshed, thick-walled cultivars examined, **'Hong Kong Pink'** was preferred. Second choice was **'No. 6362'** (a seedling of a 'Ruby' X' Supreme' cross in Florida). **'No. 7199'**, a seedling of a 'Stone Acid' X 'Ruby' cross in Florida, was considered too musky. Among acid, non-musky, thick-walled guavas, **'Beaumont'**, a Hawaiian selection, is large and pink-fleshed. **'Pink Acid'** (#7198), from a Florida cross of 'Speer' and 'Stone Acid', has dark-pink flesh and few seeds. These cultivars are employed in breeding programs in Hawaii. In 1978, a new cultivar, **'Ka Hua Kula',** selected from 1,200 seedlings of 'Beaumont', was released and recommended for commercial guava puree. The fruit is large, with thick, deep-pink flesh, and fewer seeds than 'Beaumont', and is less acid. It is also a heavier bearer.

In Colombia, the cultivars **'Puerto Rico', 'Rojo Africano',** and **'Agrio',** all yield over 2,200 fruits annually. Other high-yielding cultivars being evaluated are **'White', 'Red', 'D-13', 'D-14',** and **'Trujillo 2'.**

Collecting guava cultivars is a hobby of Mr. Arthur Stockdale, Finca Catalina, Zitacuaro, Mexico. He is said to have some very superior selections in his grove.

Pollination

The chief pollinator of guavas is the honeybee (*Apis mellifera).* The amount of cross-pollination ranges from 25.7 to 41.3%.

Climate

The guava thrives in both humid and dry climates. In India, it flourishes up to an altitude of 3,280 ft (1,000 m); in Jamaica, up to 3,906 ft (1,200 m); in Costa Rica, to 4,590 ft (1,400 m); in Ecuador, to 7,540 ft (2,300 m). It can survive only a few degrees of frost. Young trees have been damaged or killed in cold spells at Allahabad, India, in California and in Florida. Older trees, killed to the ground, have sent up new shoots which fruited 2 years later. The guava requires an annual rainfall between 40 and 80 in (1,000-2,000 mm); is said to bear more heavily in areas with a distinct winter season than in the deep Tropics.

Soil

The guava seems indiscriminate as to soil, doing equally well on heavy clay, marl, light sand, gravel bars near streams, or on limestone; and tolerating a pH range from 4.5 to 9.4. It is somewhat salt-resistant. Good drainage is recommended but guavas are seen growing spontaneously on land with a high water table–too wet for most other fruit trees.

Propagation

Guava seeds remain viable for many months. They often germinate in 2 to 3 weeks but may take as long as 8 weeks. Pretreatment with sulfuric acid, or boiling for 5 minutes, or soaking for 2 weeks, will hasten germination. Seedlings are transplanted when 2 to 30 in (5-75 cm) high and set out in the field when 1 or 2 years old. Inasmuch as guava trees cannot be depended upon to come true from seed, vegetative propagation is widely practiced.

In Hawaii, India and elsewhere, the tree has been grown from root cuttings. Pieces of any roots except the smallest and the very large, cut into 5 to 10 in (12.5-20 cm) lengths, are placed flat in a prepared bed and covered with 2 to 4 in (5-10 cm) of soil which must be kept moist. Or one can merely cut through roots in the ground 2 to 3 ft (0.6-0.9 m) away from the tree trunk; the cut ends will sprout and can be dug up and transplanted.

By another method, air-layers of selected clones are allowed to grow 3 to 5 years and are then sawn off close to the ground. Then a ring of bark is removed from each new shoot; root-inducing chemical is applied. Ten days later, the shoots are banked with soil to a height 4 to 5 in (10-12.5 cm) above the ring. After 2 months, the shoots are separated and planted out.

Pruned branches may serve as propagating material. Cuttings of half-ripened wood, 1/4 to 1/2 in (6-12.5 mm) thick will root with bottom heat or rooting-hormone treatment. Using both, 87% success has been achieved. Treated softwood cuttings will also root well in intermittent mist. In Trinidad, softwood, treated cuttings have been rooted in 18 days in coconut fiber dust or sand in shaded bins sprayed 2 or 3 times daily to keep humidity above 90%. Over 100,000 plants were produced by this method over a 2-year period. Under tropical conditions (high heat and high humidity), mature wood 3/4 to 1 in (2-2.5 cm) thick and 1 1/2 to 2 ft (45-60 cm) long, stuck into 1-ft (30-cm) high black plastic bags filled with soil, readily roots without chemical treatment.

In India, air-layering and inarching have been practiced for many years. However, trees grown from cuttings or air-layers have no taproot and are apt to be blown down in the first 2 or 3 years. For this reason, budding and grafting are preferred.

Approach grafting yields 85 to 95% success. Trials have been made of the shield, patch and Forkert methods of budding. The latter always gives the best results (88 to 100%). Vigorous seedlings 1/2 to 1 in (1.25-2.5 cm) thick are used as rootstocks. The bark should slip easily to facilitate insertion of the bud, which is then tightly bound in place with a plastic strip and the rootstock is beheaded, leaving only 6 to 8 leaves above the bud. About a month later, an incision is made halfway through 2 or 3 in (5-7.5 cm) above the bud and the plant is bent over to force the bud to grow. When the bud has put up several inches of growth, the top of the rootstock is cut off immediately above the bud. Sprouting of the bud is expedited in the rainy season.

At the Horticultural Experiment and Training Center, Basti, India, a system of patch budding has been demonstrated as commercially feasible. A swollen but unsprouted, dormant bud is taken as a 3/4 x 3/8 in (2 x l cm) patch from a leaf axil of previous season's growth and taped onto a space of the same size cut 6 to 8 in (15-20 cm) above the ground on a 1-year-old, pencil-thick seedling during the period April-June. After the bud has "taken", 1/3 is cut from the top of the seedling; 2-3 weeks later, the rest of the top is cut off leaving only 3/4 to 1 1/4 in (2-3.2 cm) of stem above the bud. This method gives 80 to 90% success. If done in July, only 70%. In Hawaii, old seedling orchards have been topworked to superior selections by patch budding on stump shoots.

Culture

Guava trees are frequently planted too close. Optimum distance between the trees should be at least 33 ft (10 m). Planting 16 1/2 ft (5 m) apart is possible if the trees are "hedged". The yield per tree will be less but the total yield per land area will be higher than at the wider spacing. Some recommend setting the trees 8 ft (2.4 m) apart in rows 24 ft (7.3 m) apart and removing every other tree as soon as there is overcrowding. Where mass production is not desired and space is limited, guava trees can be grown as cordons on a wire fence. Rows should always run north and south so that each tree receives the maximum sunlight. Exudates from the roots of guava trees tend to inhibit the growth of weeds over the root system.

Light pruning is always recommended to develop a strong framework, and suckers should also be eliminated around the base. Experimental heading-back has increased yield in some cultivars in Puerto Rico. In Palestine, the trees are cut back to 6 1/2 ft (2 m) every other spring to facilitate harvesting without ladders. Fruits are borne by new shoots from mature wood. If trees bear too heavily, the branches may break. Therefore, thinning is recommended and results in larger fruits.

Guava trees grow rapidly and fruit in 2 to 4 years from seed. They live 30 to 40 years but productivity declines after the 15th year. Orchards may be rejuvenated by drastic pruning.

The tree is drought-tolerant but in dry regions lack of irrigation during the period of fruit development will cause the fruits to be deficient in size. In areas receiving only 15 to 20 in (38-50 cm) rainfall annually, the guava will benefit from an additional 2,460 cm (2 acre feet) applied by means of 8 to 10 irrigations, one every 15-20 days in summer and one each month in winter.

Guava trees respond to a complete fertilizer mix applied once a month during the first year and every other month the second year (except from mid-November to mid-January) at the rate of 8 oz (227 g) per tree initially with a gradual increase to 24 oz (680 g) by the end of the second year. Nutritional sprays providing copper and zinc are recommended thrice annually for the first 2 years and once a year thereafter. In India, flavor and quality of guavas has been somewhat improved by spraying the foliage with an aqueous solution of potassium sulfate weekly for 7 weeks after fruit set.

Control of Wild Trees

Large trees that have overrun pastures are killed in Fiji with 2,4-D dicamba or 2,4,5-T in diesel fuel or old engine oil. Extensive wild stands of young trees are best burned. Cutting results in regrowth with multiple stems.

Cropping and Yield

The fruit matures 90 to 150 days after flowering. Generally, there are 2 crops per year in southern Puerto Rico; the heaviest, with small fruits, in late summer and early fall; another, with larger fruits, in late winter and early spring. In northern India, the main crop ripens in mid-winter and the fruits are of the best quality. A second crop is home in the rainy season but the fruits are less abundant and watery. Growers usually withhold irrigation after December or January or root-prune the trees in order to avoid a second crop. The trees will shed many leaves and any fruits set will drop. An average winter crop in northern India is about 450 fruits per tree. Trees may bear only 100-300 fruits in the rainy season but the price is higher because of relative scarcity despite the lower quality. Of course, yields vary with the cultivar and cultural treatment. Experiments have shown that spraying young guava trees with 25% urea plus a wetting agent will bring them into production early and shorten the harvest period from the usual 15 weeks to 4 weeks.

Handling and Keeping Quality

Ripe guavas bruise easily and are highly perishable. Fruits for processing may be harvested by mechanical tree-shakers and plastic nets. For fresh marketing and shipping, the fruits must be clipped when full grown but underripe, and handled with great care. After grading for size, the fruits should be wrapped individually in tissue and packed in 1 to 4 padded layers with extra padding on top before the cover is put on. They have been successully shipped from Miami to wholesalers in major northern cities in refrigerated trucks at temperatures of 45º to 55º F (7.22º-12.78º C). It is commonly said that guavas must be tree-ripened to attain prime quality, but the cost of protecting the crop from birds makes early picking necessary. It has been demonstrated that fruits picked when yellow-green and artificially ripened for 6 days in straw at room temperature developed superior color and sugar content.

Guavas kept at room temperature in India are normally overripe and mealy by the 6th day, but if wrapped in pliofilm will keep in good condition for 9 days. In cold storage, pliofilm-wrapped fruits remain unchanged for more than 12 days. Wrapping checks weight loss and preserves glossiness. Unwrapped 'Safeda' guavas, just turned yellow, have kept well for 4 weeks in cold storage at 47º to 50º F (8.33º-10º C) and relative humidity of 85-95%, and were in good condition for 3 days thereafter at room temperature of 76º to 87º F (24º-44º C).

Fruits coated with a 3% wax emulsion will keep well for 8 days at 72º to 86º F (22.2º-30º C) and 40 to 60% relative humidity, and for 21 days at 47º to 50º F (8.3º-10º C) and relative humidity of 85-90%. Storage life of mature green guavas is prolonged at 68º F (20º C), relative humidity of 85%, less than 10% carbon dioxide, and complete removal of ethylene.

Researchers at Kurukshetra University, India, have shown that treatment of harvested guavas with 100 ppm morphactin (chlorflurenol methyl ester 74050) increases the storage life of guavas by controlling fungal decay, and reducing loss of color, weight, sugars, ascorbic acid and non-volatile organic acids. Combined fungicidal and double-wax coating has increased marketability by 30 days.

Australian workers report prolonged life and reduced rotting in storage after a hot water dip, but better results were achieved by dipping in an aqueous benomyl suspension at 122º F (50º C). Higher temperatures cause some skin injury, as does a guazatine dip which is also a less effective fungicide.

Fruits sprayed on the tree with gibberellic acid 20-35 days before normal ripening, were retarded nearly a week as compared with the untreated fruits. Also, mature guavas soaked in gibberellic acid off the tree showed a prolonged storage life.

Trials at Haryana Agricultural University, Hissar, India, showed that weekly spraying with 1.0% potassium sulfate–1.6 gals (6 liters) per tree–beginning 7 days after fruit set and ending just before harvesting at the pale-green stage, delays yellowing, retains firmness and flavor beyond normal storage life.

Food technologists in India found that bottled guava juice (strained from sliced guavas boiled 35 minutes), preserved with 700 ppm SO_2, lost much ascorbic acid but little pectin when stored for 3 months without refrigeration, and it made perfectly set jelly.

Pests and Diseases

Guava trees are seriously damaged by the citrus flat mite, *Brevipa1pus californicus* in Egypt. In India, the tree is attacked by 80 insect species, including 3 bark-eating caterpillars *(Indarbella* spp.) and the guava scale, but this and other scale insects are generally kept under control by their natural enemies. The green shield scale, *Pulvinaria psidii,* requires chemical measures in Florida, as does the guava white fly, *Trialeurodes floridensis,* and a weevil, *Anthonomus irroratus,* which bores holes in the newly forming fruits.

The red-banded thrips feed on leaves and the fruit surface. In India, cockchafer beetles feed on the leaves at the end of the rainy season and their grubs, hatched in the soil, attack the roots. The larvae of the guava shoot borer penetrates the tender twigs, killing the shoots. Sometimes aphids are prevalent, sucking the sap from the underside of the leaves of new shoots and excreting honeydew on which sooty mold develops.

The guava fruit worm, *Argyresthia eugeniella,* invisibly infiltrates hard green fruits, and the citron plant bug, *Theognis gonagia,* the yellow beetle, *Costalimaita ferruginea*, and the fruit-sucking bug, *Helopeltis antonii,* feed on ripe fruits. A false spider mite, *Brevipalpus phoenicis,* causes surface russeting beginning when the fruits are half-grown. Fruit russeting and defoliation result also from infestations of red-banded thrips, *Selenothrips rubrocinctus.* The coconut mealybug, *Pseudococcus nipae,* has been a serious problem in Puerto Rico but has been effectively combatted by the introduction of its parasitic enemy, *Pseudaphycus utilis.*

Soil-inhabiting white grubs require plowing-in of an approved and effective pesticide during field preparation in Puerto Rico. There are other minor pests, but the great problems wherever the guava is grown are fruit flies.

The guava is a prime host of the Mediterranean, Oriental, Mexican, and Caribbean fruit flies, and the melon fly–*Ceratitis capitata, Dacus dorsalis, Anastrepha ludens, A. suspensa,* and *Dacus cucurbitae.* Ripe fruits will be found infested with the larvae and totally unusable except as feed for cattle and swine. To avoid fruit fly damage, fruits must be picked before full maturity and this requires harvesting at least 3 times a week. In Brazil, choice, undamaged guavas are produced by covering the fruits with paper sacks when young (the size of an olive). Infested fruits should be burned or otherwise destroyed. In recent years, the Cooperative Extension Service in Dade County, Florida, has distributed wasps that attack the larvae and pupae of the Caribbean fruit fly and have somewhat reduced the menace.

In Puerto Rico, up to 50% of the guava crop (mainly from wild trees) may be ruined by the uncontrollable fungus, *Glomerella cingulata,* which mummifies and blackens immature fruits and rots mature fruits. *Diplodia natalensis* may similarly affect 40% of the crop on some trees in South India.

Fruits punctured by insects are subject to mucor rot (caused by the fungus, *Mucor hiemalis)* in Hawaii. On some trees, 80% of the mature green fruits may be ruined.

Algal spotting of leaves and fruits (caused by *Cephaleuros virescens)* occurs in some cultivars in humid southern Florida but can be controlled with copper fungicides. During the rainy season in India, and the Province of Sancti Spiritus, Cuba, the fungus, *Phytophthora parasitica, is* responsible for much infectious fruit rot. *Botryodiplodia* sp. and *Dothiorella* sp. cause stem-end rot in fruits damaged during harvesting. *Macrophomina* sp. has been linked to fruit rot in Venezuela and *Gliocladium roseum* has been identified on rotting fruits on the market in India.

In Bahia, Brazil, severe deficiency symptoms of guava trees was attributed to nematodes and nematicide treatment of the soil in a circle 3 ft (0.9 in) out from the base restored the trees to normal in 5 months. Zinc deficiency may be conspicuous when the guava is grown on light soils. It is corrected by two summer sprayings 60 days apart with zinc sulphate.

Wilt, associated with the fungi *Fusarium solani* and *Macrophomina phaseoli*, brings about gradual decline and death of undernourished 1-to 5-year-old guava trees in West Bengal. A wilt disease brought about by the wound parasite, *Myxosporium psidii*, causes the death of many guava trees, especially in summer, throughout Taiwan. Wilt is also caused by *Fusarium oxysporum* f. *psidii* which invades the trunk and roots through tunnels bored by the larvae of *Coelosterna* beetles. Anthracnose (*Colletotrichum gloeosporioides*) may attack the fruits in the rainy season. *Pestalotia psidii* sometimes causes canker on green guavas in India and rots fruits in storage.

Severe losses are occasioned in India by birds and bats and some efforts are made to protect the crop by nets or noisemakers.

Food Uses

Raw guavas are eaten out-of-hand, but are preferred seeded and served sliced as dessert or in salads. More commonly, the fruit is cooked and cooking eliminates the strong odor. A standard dessert throughout Latin America and the Spanish-speaking islands of the West Indies is stewed guava shells (*cascos de guayaba*), that is, guava halves with the central seed pulp removed, strained and added to the shells while cooking to enrich the sirup. The canned product is widely sold and the shells can also be quick-frozen. They are often served with cream cheese. Sometimes guavas are canned whole or cut in half without seed removal.

Bars of thick, rich guava paste and guava cheese are staple sweets, and guava jelly is almost universally marketed. Guava juice, made by boiling sliced, unseeded guavas and straining, is much used in Hawaii in punch and ice cream sodas. A clear guava juice with all the ascorbic acid and other properties undamaged by excessive heat, is made in South Africa by trimming and mincing guavas, mixing with a natural fungal enzyme (now available under various trade names), letting stand for 18 hours at 120º to 130º F (49º-54º C) and filtering. It is made into sirup for use on waffles, ice cream, puddings and in milkshakes. Guava juice and nectar are among the numerous popular canned or bottled fruit beverages of the Caribbean area. After washing and trimming of the floral remnants, whole guavas in sirup or merely sprinkled with sugar can be put into plastic bags and quick-frozen.

There are innumerable recipes for utilizing guavas in pies, cakes, puddings, sauce, ice cream, jam, butter, marmalade, chutney, relish, catsup, and other products. In India, discoloration in canned guavas has been overcome by adding 0.06% citric acid and 0.125% ascorbic acid to the sirup. For pink sherbet, French researchers recommend 2 parts of the cultivar 'Acid Speer' and 6 parts 'Stone'. For white or pale-yellow sherbet, 2 parts 'Supreme' and 4 parts 'Large White'. In South Africa, a baby-food manufacturer markets a guava-tapioca product, and a guava extract prepared from small and overripe fruits is used as an ascorbic-acid enrichment for soft drinks and various foods.

Dehydrated guavas may be reduced to a powder which can be used to flavor ice cream, confections and fruit juices, or boiled with sugar to make jelly, or utilized as pectin to make jelly of low-pectin fruits. India finds it practical to dehydrate guavas during the seasonal glut for jelly-manufacture in the off-season. In 1947, Hawaii began sea shipment of frozen guava juice and puree in 5-gallon cans to processors on the mainland of the United States. Since 1975, Brazil has been exporting large quantities of guava paste, concentrated guava pulp, and guava shells not only to the United States but to Europe, the Middle East, Africa and Japan.

Canned, frozen guava nectar is an important product in Hawaii and Puerto Rico but may be excessively gritty unless stone cells from the outer flesh and skin are reduced by use of a stone mill or removed by centrifuging.

In South Africa, guavas are mixed with cornmeal and other ingredients to make breakfast-food flakes.

Green mature guavas can be utilized as a source of pectin, yielding somewhat more and higher quality pectin than ripe fruits.

Food Value Per 100 g of Edible Portion*	
Calories	36-50
Moisture	77-86 g
Crude Fiber	2.8-5.5 g
Protein	0.9-1.0 g
Fat	0.1-0.5 g
Ash	0.43-0.7 g
Carbohydrates	9.5-10 g
Calcium	9.1-17 mg
Phosphorus	17.8-30 mg
Iron	0.30-0.70 mg
Carotene (Vitamin A)	200-400 I.U.
Thiamine	0.046 mg
Riboflavin	0.03-0.04 mg
Niacin	0.6-1.068 mg
Vitamin B3	40 I.U.
Vitamin G4	35 I.U.

*Analyses of whole ripe guavas.

Ascorbic acid–mainly in the skin, secondly in the firm flesh, and little in the central pulp–varies from 56 to 600 mg. It may range up to 350-450 mg in nearly ripe fruit. When specimens of the same lot of fruits are fully ripe and soft, it may decline to 50-100 mg. Canning or other heat processing destroys about 50% of the ascorbic acid. Guava powder containing 2,500-3,000 mg ascorbic acid was commonly added to military rations in World War II. Guava seeds contain 14% of an aromatic oil, 15% protein and 13% starch. The strong odor of the fruit is attributed to carbonyl compounds.

Other Uses

Wood: The wood is yellow to reddish, fine-grained, compact, moderately strong, weighs 650-750 kg per cubic meter; is durable indoors; used in carpentry and turnery. Though it may warp on seasoning, it is much in demand in Malaya for handles; in India, it is valued for engravings. Guatemalans use guava wood to make spinning tops, and in El Salvador it is fashioned into hair combs which are perishable when wet. It is good fuelwood. and also a source of charcoal.

Leaves and bark: The leaves and bark are rich in tannin (10% in the leaves on a dry weight basis, 11-30% in the bark). The bark is used in Central America for tanning hides. Malayans use the leaves with other plant materials to make a black dye for silk. In southeast Asia, the leaves are employed to give a black color to cotton; and in Indonesia, they serve to dye matting.

Wood flowers: In Mexico, the tree may be parasitized by the mistletoe, *Psittacanthus calyculatus* Don, producing the rosette-like malformations called "wood flowers" which are sold as ornamental curiosities.

Medicinal Uses: The roots, bark, leaves and immature fruits, because of their astringency, are commonly employed to halt gastroenteritis, diarrhea and dysentery, throughout the tropics. Crushed leaves are applied on wounds, ulcers and rheumatic places, and leaves are chewed to relieve toothache. The leaf decoction is taken as a remedy for coughs, throat and chest ailments, gargled to relieve oral ulcers and inflamed gums; and also taken as an emmenagogue and vermifuge, and treatment for leucorrhea. It has been effective in halting vomiting and diarrhea in cholera patients. It is also applied on skin diseases. A decoction of the new shoots is taken as a febrifuge. The leaf infusion is prescribed in India in cerebral ailments, nephritis and cachexia. An extract is given in epilepsy and chorea and a tincture is rubbed on the spine of children in convulsions. A combined decoction of leaves and bark is given to expel the placenta after childbirth.

The leaves, in addition to tannin, possess essential oil containing the sesquiterpene hydrocarbons caryophyllene, β-bisabolene, aromadendrene, β-selinene, nerolidiol, caryophyllene oxide and sel-11-en-4x -ol, also some triterpenoids and β-sitosterol. The bark contains tannin, crystals of calcium oxalate, ellagic acid and starch. The young fruits are rich in tannin.

Morton, J. 1987. Cattley Guava. p. 363–364. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Cattley Guava

Psidium cattleianum Sabine

Psidium littorale Raddi

Psidium chinense Hort.

Much more attractive in foliage and fruit than the common guava, the cattley guava, *Psidium cattleianum* Sabine (syns. *P. littorale* Raddi; *P. chinense* Hort.), is also known as the strawberry or purple guava, Chinese guava, Calcutta guava, *araca da praia* (Brazil), *araza* (Uruguay), *cas dulce* (Costa Rica), *guayaba japonesa* (Guatemala), and *guayaba peruana* (Venezuela). In Hawaii, the yellow-fruited is called *waiawi*, and the red-fruited *waiawi ulaula.*

Description

A fairly slow-growing shrub or small tree, the cattley guava generally ranges from 6.5 to 14 ft (2-4 m) tall but the yellow-fruited may attain 40 ft (12 m). Both have slender, smooth, brown-barked stems and branches, and alternate, evergreen, obovate, dark, smooth, glossy, somewhat leathery leaves 1 1/3 to 4 3/4 in (3.4-12 cm) long and 5/8 to 2 1/3 in (1.6-6 cm) wide. The fragrant flowers, 5/8 to 2 1/3 in(1.5-6 cm) wide are white with prominent stamens about 3/4 in (2 cm) long, and are borne singly or in 3's in the leaf axils. The fruit is round or obovoid, 1 to 1 1/2 in (2.5-4 cm) long, tipped with the protruding 4- to 5-parted calyx; thin-skinned, dark-red or purple-red or, in variety *lucidum*, lemon-yellow. Red-skinned fruits have white flesh more or less reddish near the skin. Yellow-skinned fruits have faintly yellowish flesh. In both types, the flesh is aromatic, about 1/8 in (3 mm) thick, surrounding the central juicy, somewhat translucent pulp filled with hard, flattened-triangular seeds 3/32 in (2.5 mm) long. Free of the muskiness of the common guava, the flavor is somewhat strawberry-like, spicy, subacid.

Fig. 99: Red Cattley guava (*Psidium cattleianum*) (left) and the yellow (var. *lucidum*) are flavorful but seedy. The trees are very ornamental.

Origin and Distribution

The cattley guava is believed native to the lowlands of eastern Brazil, especially near the coast. It is cultivated to a limited extent in other areas of South America and Central America and in the West Indies, Bermuda, the Bahamas, southern and central Florida and southern California. A commercial planting of about 3,000 trees was established at La Mesa, California, around 1884 and the trees were still producing heavily a half century later. Today there is much more use of the cattley guava as an ornamental hedge than as a fruit tree. It is grown occasionally in subtropical Africa, and in highlands of the Philippines at elevations up to 5,000 ft (1,500 m), India, Ceylon and Malaya. It was introduced into Singapore in 1877 and at various times thereafter but failed to survive at low altitudes. In Hawaii, it has become naturalized in moist areas, forming dense, solid stands, and is subject to eradication in range lands. It is one of the major "weed trees" of Norfolk Island; has escaped into pastures and woods at elevations between 1,500 and 3,000 ft (457-914 m) in Jamaica.

Cultivars

No named cultivars are reported but there is considerable variation, apart from the distinct botanical variety *lucidum.* Types with pubescent foliage are seen in cultivation in tropical America.

Climate

The red cattley guava is hardier than the common guava and can survive temperatures as low as 22º F (-5.56º C). It can succeed wherever the orange is grown without artificial heating. The yellow is tenderer and its climatic requirements are similar to those of the lemon. Both kinds flourish in full sun.

Soil

The cattley guava does well in limestone and poor soils that would barely support other fruit trees.

It is shallow-rooted but the red type is fairly drought tolerant. The yellow is able to endure flooding for short periods.

Propagation

The tree is not easily multiplied by budding or grafting because of its thin bark. It can be propagated by layering or rooting of soft tip cuttings or root cuttings, but is usually grown from seed even though seedlings of the red type vary in habit of growth, fruit size and seediness, also bearing season. The yellow comes fairly true from seed.

Culture

Cultural information is scant except that irrigation is necessary to obtain full-size fruits on poor soil, and the tree benefits from mulching when grown in limestone. Seedlings are set out 10 ft (3 m) apart in rows 10 ft (3 m) apart.

Cropping and Yield

On good soil and under irrigation, the cattley guava has yielded 30 tons from 5 acres (2 ha). In India, it bears two crops a year, one in July and August and another in January and February. Near the coast in California, fruits ripen continuously from August to March; inland the season is shorter, October to December.

Keeping Quality

The fresh fruit is very perishable when fully ripe and can be kept only 3 to 4 days at room temperature. For shipping, the fruit must be picked slightly unripe, handled carefully and refrigerated during transit. Generally it is sent to local processors instead of to fresh fruit markets. Hawaiian-grown fruits, slightly underripe, were stored at 32º to 36º F (0º-2.22º C) for a month and were found shriveled and decomposed. Accordingly, much higher temperatures are recommended.

Pests and Diseases

The cattley guava is usually reported as disease- and pest-free. In California, there are occasional infestations of the greenhouse thrips *(Heliothrips haemorrhoidalis).* The Caribbean fruit fly attacks the fruits in southern Florida and wherever this pest abounds. In India, birds compete with humans for the ripe fruits.

Food Uses

Cattley guavas are eaten out-of-hand without preparation except the removal of the calyx. A delicious puree or tart-filling can be made by trimming and cooking 6 cups of red cattleys with 1 cup water and 2 cups granulated sugar and pressing through a sieve. The resulting 3 cups of puree will be subacid, spicy and a dull, old-rose in color. Commercial growers ship to, factories which convert the fruits into jelly, jam, butter, paste and sherbet. In Hawaii, either half-ripe or full-ripe cattleys are cut in half, boiled, and the juice strained to make ade or punch.

Food Value

Analyses of ripe fruits in the Philippines, Hawaii and Florida have shown the following constituents:

Red: seeds, 6%; water, 81.73-84.9%; ash, 0.74-1.50%; crude fiber, 6.14%; protein, 0.75-1-03%; fat, 0.55%; total sugar, 4.42-4.46%.

Yellow: seeds, 10.3%; water, 84.2%; ash, 0.63-0.75%; crude fiber, 3.87%; protein, 0.80%; fat, 0.42%; total sugar, 4.32-10.01%.

Red or *Yellow:* ascorbic acid, 22-50 mg/100 g. Calories per 2.2 lbs (1 kg), 268.

Morton, J. 1987. Costa Rican Guava. p. 365. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Costa Rican Guava

Psidium friedrichsthalianum Ndz.

Perhaps the most noteworthy of the lesser species of *Psidium is P. friedrichsthalianum* Ndz., known variously in Latin America as *cas* or *cas ácida* (Costa Rica), *guayaba ácida* (Guatemala), *guayaba agria* (Colombia), *guayaba de danto* (Honduras), *guayaba de agua* (Panama), *guayaba del Choco* (Ecuador), *guayaba montes* (Mexico), *guayaba* (Nicaragua), and *arrayan* (El Salvador).

Description

An attractive, shapely tree, 20 to 35 ft (6-10 m) high, it has wiry, quadrangular, or 4-winged, branchlets which are dark reddish and minutely hairy. The trunk bark is red-brown with grayish patches. The evergreen leaves are 2 to 4 3/4 in (5-12 cm) long, 1 to 2 in (2.5-5 cm) wide, elliptic or oval, pointed, gland-dotted, thin; dark and smooth above, pale beneath. Flowers, usually borne singly, are fragrant, white, 1 in (2.5 cm) wide, with 5 waxy petals and about 300 stamens up to 1/2 in (1.25 cm) long. The fruit is round or oval, 1 1/4 to 2 1/2 in (3-6 cm) long, with yellow skin and soft, white, very acid flesh, and a few flattened seeds 3/16 in (5 mm) long. There is no musky odor.

Distribution

This tree grows naturally in Colombia (especially in the Cauca and Magdalena valleys), throughout Central America and around Oaxaca in southern Mexico, usually bordering streams and in swampy woods along the coast and inland. It is commonly cultivated in home gardens in temperate highlands of Costa Rica, occasionally in El Salvador, Guatemala and northern Ecuador. It thrives in the Philippines at medium and low elevations. Introductions into California and Florida have not been very successful, the tree bearing poorly and eventually succumbing to cold spells.

Food Uses

Because of its acidity, the fruit is mostly used for ade, jelly and jam. It makes fine filling for pies. Early Spaniards complained that eating the raw fruits "set the teeth on edge".

Food Value

Analyses in Guatemala show: moisture, 83.15%; protein, 0.78-0.88%; carbohydrates, 5.75-6.75%; fat, 0.39-0.52%; fiber, 7.90%; ash, 0.80%. The fruit is rich in pectin even when fully ripe.

Other Uses

The wood is fine-grained and durable, with specific gravity of 0.650-0.700. Weight per cubic meter is 650-700 kg.

Morton, J. 1987. Feijoa. p. 367–370. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Feijoa

Feijoa sellowiana Berg.

Few fruit bearers have received as much initial high-level attention and yet have amounted to so little as this member of the Myrtaceae, *Feijoa sellowiana* Berg. It is the best known of only 3 species in the genus which the German botanist, Ernst Berger, named after Don da Silva Feijoa, a botanist of San Sebastian, Spain. The specific name honors F. Sellow, a German who collected specimens in the province of Rio Grande do Sul in southern Brazil. The paucity of vernacular names is indicative of its lack of popularity. In Uruguay, it is called, in Spanish, *guayabo del pais*. It has been nicknamed "pineapple guava", "Brazilian guava" and "fig guava". The term "guavasteen" has been adopted in Hawaii. The most unlikely term, "New Zealand banana", has shown up in agricultural literature from that country.

Description

The plant is a bushy shrub 3 to 20 ft (0.9-6 m) or more in height with pale gray bark; the spreading branches swollen at the nodes and white-hairy when young. The evergreen, opposite, short-petioled, bluntly elliptical leaves are thick, leathery, 1 1/8 to 2 1/2 in (2.8-6.25 cm) long, 5/8 to 1 1/8 in (1.6-2.8 cm) wide; smooth and glossy on the upper surface, finely veiny and silvery-hairy beneath. Conspicuous, bisexual flowers, 1 1/2 in (4 cm) wide, borne singly or in

Fig. 100: The feijoa, or pineapple guava (*Feijoa sellowiana*) which thrives best in areas too cool for the common guava, is not fully ripe until it falls to the ground.

clusters, have 4 fleshy, oval, concave petals, white outside, purplish-red inside; 5/8 to 3/4 in (1.6-2 cm) long, and a cluster of numerous, erect, purple stamens with round, golden-yellow anthers. The fruit is oblong or ovoid or slightly pear-shaped, 1-1 1/2 to 2 1/2 in (4-6 cm) long and 1 1/8 to 2 in (2.8-5 cm) wide, with the persistent calyx segments adhering to the apex. The thin skin is coated with a "bloom" of fine whitish hairs until maturity, when it remains dull-green or yellow-green, sometimes with a red or orange blush. The fruit emits a strong long-lasting perfume, even before it is fully ripe. The thick, white, granular, watery flesh and the translucent central pulp enclosing the seeds are sweet or subacid, suggesting a combination of pineapple and guava or pineapple and strawberry in flavor. There are usually 20 to 40, occasionally as many as 100, very small, oblong seeds hardly noticeable when the fruit is eaten.

Origin and Distribution

The feijoa is native to extreme southern Brazil, northern Argentina, western Paraguay and Uruguay where it is common wild in the mountains. It is believed that the plant was first grown in Europe by M. de Wette in Switzerland and, a little later, about 1887, it was known to be in the Botanic Garden at Basle. In 1890, the renowned French botanist and horticulturist, Dr. Edouard Andre, brought an air-layered plant from La Plata, Brazil and planted it in his garden on the Riviera. It fruited in 1897. Dr. Andre published a description with color plates of the leaves, flowers and fruit, in the *Revue Horticole* in 1898, praising the fruit and recommending cultivation in southern France and all around the Mediterranean area.

A nurseryman in Lyons distributed air-layers from the Andre plant in 1899 and many were planted on the Riviera, some in Italy and Spain and some in greenhouses further north. That same year, the prominent nurserymen, Besson Freres, obtained seeds from Montevideo and raised thousands of plants which were widely sold and proved to be of a different type than Dr. Andre's plant. Seeds were imported by one or two other French nurserymen, and then, in 1901, seedlings from Dr. Andre's plant were obtained by Dr. F. Franceschi of Santa Barbara, California, from M. Naudin of Antibes. These were planted at several different California locations. In 1903, Dr. Franceschi acquired, through F. Morel of Lyons, several air layers from Dr. Andre's plant. He planted 1 or 2 at Santa Barbara and most of the rest were sent to Florida. The plant did not succeed in southern Florida but became quite popular in northern Florida, primarily as an ornamental and particularly as a clipped hedge. Dr. Henry Nehrling had two plants growing well in a shed in half-shade at Gotha in central Florida, in 1911. They flowered and fruited but the fruit dropped before maturity and rotted quickly. In recent years, the cultivar **'Coolidge',** vegetatively propagated, has borne well in Florida. In California, the feijoa is grown in a limited way for its fruit, especially in cool coastal locations, mainly around San Francisco. At the Experimental Station in Honolulu a plant flourished for 15 years without bearing fruit. Later plantings have succeeded at higher elevations.

The feijoa is sometimes cultivated in the highlands of Chile and other South American countries and in the Caribbean area. Jamaica received a few plants from California in 1912 and planted them at various altitudes. I have seen occasional plants on roadsides and in private gardens in the Bahamas, but they do not fruit and often fail to flower. In southern India, the feijoa is grown for its fruit in home gardens at temperate elevations–about 3,500 ft (1,067 m).

Nowhere has the feijoa received more attention than in New Zealand. An Auckland nurseryman introduced 3 cultivars from Australia**–'Coolidge', 'Choiceana',** and **'Superba'–**about 1908. They remained little known until 1930 when the feijoa was advertised as an ornamental plant. Later, after improvement by selection and naming of types with large, superior fruits and their vegetative propagation, small commercial plantings were made in citrus-growing areas of the North Island. The New Zealand Feijoa Growers' Association was formed in 1983 and some fruit is being exported to the United States, United Kingdom, Germany, Netherlands, France and Japan. New Zealanders also plant the feijoa as a windbreak around wind-sensitive crops. It is planted as an ornamental and for its fruit in southern Africa. Following WW II, feijoa plantations were established in North Africa, the Caucasian region of southern Russia, as well as in Sicily, Portugal and Italy.

In England, the feijoa is much appreciated as a wall shrub, though it flowers profusely only in sunny locations. Planting of feijoas has been officially discouraged in New South Wales and Victoria, Australia, because the fruit is a prime host of the fruit fly.

Varieties

As stated, right at the outset seedlings from different sources showed distinct characteristics. It is reported that a man named H. Hehre of Los Angeles got seeds from Argentina and among the seedlings he raised there was one that seemed superior to the others and was earlier bearing. It became known as the **'Hehre'** variety. The fruit is large, slender-pyriform, sometimes curved; yellow-green, with thin skin, finely granular flesh, abundant, very juicy pulp, fairly numerous and larger than ordinary seeds, sweet but not aromatic flavor; seedlings erect, compact, vigorous, with lush foliage but only moderately fruitful.

'Andre' (the original air-layer from Brazil), has a medium to large, oblong to round fruit, rough-surfaced, light-green, thick-fleshed, few-seeded; richly flavored and very aromatic. Seedlings are upright, spreading to intermediate. Self-fertile; bears heavily.

Besson' (seeds from Uruguay in 1899) has small to medium, oval, smooth fruits with red or maroon cheek; thin-skinned, with medium-thick, fine-grained flesh, very juicy pulp, numerous seeds, and rich, aromatic flavor. Seedlings are upright or spreading. This is the type grown in southern India. Both 'Andre' and 'Besson' have long been prominent in France.

'Coolidge', most commonly grown in California, has fruit varying from pyriform to oblong or elongated, of medium size, with somewhat crinkled skin. It is of indifferent flavor but is a dependable bearer being 100% self-fertile. The plant is upright and strong growing.

'Choiceana', next in favor, has round to oval, fairly smooth, medium sized to small fruit, 2 to 3 1/2 in (5-9 cm) long, of good flavor; almost always or no less than 42% self-fertile; the plant of spreading habit and medium vigor.

'Superba' has round to slightly oval, medium smooth, medium to small fruits of good flavor; it is partially (33%) self-incompatible. The plant is spreading, straggly in habit and of medium vigor.

The two leading New Zealand cultivars are selections made there from 'Choiceana' seedlings: **'Triumph'** has oval, short, plump fruits, not as pointed as those of 'Coolidge'; medium to large; smooth. The plant is upright, of medium vigor.

'Mammoth' has oval fruits resembling those of 'Coolidge'; large, to 8 1/2 oz (240 g); somewhat wrinkled. The plant is of upright habit, and strong-growing. In 1979, 'Mammoth', 'Coolidge', and 'Triumph' grown from cuttings were being advertised in the New Zealand journal of Agriculture as suitable for export.

Two new New Zealand cultivars, of which 20,000 plants had been sold in 1983, are **'Apollo',** with thin skin subject to bruising and purpling; and **'Gemini',** having very small fruits with thin skin. The Association recommends that growers plant the tried and true 'Triumph'.

Among Australian selections are 'Large Oval' and 'Chapman'.

'David' has round or oval fruits with skin of sweet and agreeable flavor; matures in November in Europe.

'Roundjon' has oval or rounded fruits, somewhat rough-skinned and red-blushed; of agreeable flavor; matures in November in Europe.

'Magnifica' is a selected seedling with very large fruits of inferior quality.

'Robert' has oval fruits with grainy flesh, and undesirable brownish leaves.

'Hirschvogel' is highly self-incompatible. 'Bliss' is partially self-incompatible.

The botanical variety *variegata* has variegated foliage.

Pollination

It has been said that feijoa pollen is transferred by birds that are attracted to and eat the flowers, but bees are the chief pollinators. Most flowers pollinated with compatible pollen show 60 to 90% fruit-set. Hand-pollination is nearly 100% effective. One should plant 2 or more bushes together for cross-pollination unless the cultivar is known to be self-compatible. Poor bearing is usually the result of inadequate pollination.

Climate

The feijoa needs a subtropical climate with low humidity. The optimum annual rainfall is 30 to 40 in (762-1,016 mm). The plant thrives where the weather is cool part of the year and it can withstand temperatures as low as 12º to 15º F (-11.11º-9.44º C). The flavor of the fruit is much better in cool than in warm regions.

Soil

While the shrub is often said to be adapted to a wide range of soil types and in England does well even where there is a high chalk content, it actually prefers rich organic soil and is not very thrifty on light or sandy terrain. Some believe that an acid soil is best but the feijoa has done well on soil with a pH of 6.2. It is drought-resistant but needs adequate water for fruit production. The site must be well-drained. The feijoa can tolerate partial shade and slight exposure to salt spray.

Propagation

The feijoa is generally grown from seed and reproduces fairly, but not absolutely, true to type. Seeds are separated by squeezing the seedy pulp into a container, covering with water, and letting the liquid stand for 4 days to ferment. Seeds are then strained out and dried before sowing. The seeds will retain viability for a year or more if kept dry. Germination takes place in 3 weeks. Soil in nursery flats must be sterile, otherwise there will be much loss of seedlings from damping-off. The young plants are transplanted to pots when they have produced their second leaves and later transferred to the field without difficulty. The plant fruits in 3 to 5 years from seed. To reproduce a special selection, vegetative propagation is, of course, necessary. In France and New Zealand-ground-layering is practiced and rooting occurs in 6 months. Air-layering is usually successful and the layers will fruit the second year.

Whip-, tongue-, and veneer-grafting on own rootstock the thickness of a pencil (about 2 years old) gives a low percentage of "takes" but grafted plants will bear in 2 years. Feijoa cuttings are said to be hard to root, but in England and Auckland cuttings are preferred. Young wood from branch tips will root in 1 to 2 months with bottom heat. If placed in sand in a glass-covered box in full sun and kept well watered, they will root in 10 days. In New Zealand, growers are advised to take 4 to 6 in (10-15 cm) cuttings of side shoots in late summer, cutting close to the firm base or pulling off with a heel of older wood which is then trimmed off; and a hormone rooting agent is applied.

Culture

A 20-year-old plant on the Riviera was reported to be 15 ft (4.5 m) high and 18 ft (5.5 m) in diameter with a trunk 8 in (20 cm.) thick at the base. Because of the spreading habit of such types, 15 to 18 ft (4.5-5.5 m) should be allowed between plants for good fruit production. As the fruit is borne on young wood, pruning reduces the crop, but all shoots below 12 in (30 cm) from the ground should be removed. Some seedlings have a more erect habit and these should be chosen where space is limited. The shrubs may be set 5 ft (1.5 m) apart to form a barrier hedge; 3 ft (1 m) apart in a compact foundation planting. A 15 x 15 ft (4.5 x 4.5 m) spacing requires 190 plants per acre (468 per hectare).

The feijoa requires little care beyond good soil preparation before planting. Subsequent cultivation is inadvisable because of the plant's shallow, fibrous root system which should be left undisturbed. If planted for its fruit, fertilizer should be low in nitrogen to avoid excessive vegetative growth. It should be watered liberally during hot, dry spells.

Season and Yield

Flowering occurs in November in Uruguay, in late April in northern Florida, May in southern California, early June in the San Francisco Bay area and July in England. In southern California the fruits ripen 4 1/2 to 6 months after flowers appear, in the San Francisco Bay area, 5 1/2 to 7 months. In New Zealand fruits are borne from early February to May. The fruits fall when mature and are collected daily from the ground and kept cool until slightly soft to the touch. Straw mulch beneath the plants helps avoid bruising. If picked from the tree before they are ready to fall or if eaten before they are fully ripe, the fruits will not have their full richness of flavor.

The 20-year-old Riviera plant referred to above is said to have borne a crop of 2,000 fruits. The yield is poor in India where the maximum crop per season is 100 fruits per plant, probably due to inadequate pollination or flower damage by birds.

New Zealand test plantings have given the following yields: 3rd year, 13.2 lbs (6 kg) per plant; 4,000 lbs/ acre, (4,000 kg/ha); 4th year, 26.5 lbs (12 kg) per plant; 8,000 lbs/acre, (8,000 kg/ha); 5th year, 39.7 lbs (18 kg) per plant; 12,000 lbs/acre (12,000 kg/ha). The growers now foresee 66 lbs (30 kg) per plant–25 tons per hectare. In 1978, New Zealand produced 333 tons of feijoas–149 tons to be sold fresh, and 184 tons to be processed.

In New Zealand, flat tomato boxes are employed for shipping feijoas. A case 4 1/2 in (11.25 cm) deep and 12 in (30 cm) to 16 in (40 cm) long and wide holds about 20 lbs (9.07 kg).

Keeping Quality

If the atmosphere is too warm, the interior of the fruit turns brown and decays in 3 to 4 days even though the fruit may appear intact on the surface. In cool storage, undamaged fruits will remain in good condition for one month or longer. In France, fruits harvested in November and December have been kept till spring at a cool temperature and with sufficient humidity. In the early days of its introduction, feijoa shipments were successfully made from France to California despite being 30 days at sea. Today, air transport is essential for New Zealand feijoas en route to Europe. They can be held 1 mo at 32º F (0º C) and then have only a week's life on the market.

Pests and Diseases

The shrub is remarkably pest-resistant. Occasionally it may be attacked by hard wax scale *(Ceroplastes sinensis)* and associated sooty mold in New Zealand and Florida, also greedy scale in New Zealand, by black scale *(Saissetia oleae)* in California and southern Europe. In New Zealand, the larvae of a leaf-rolling caterpillar *(Tortrix spp.*) and of a bagworm moth may eat holes in the leaves but they are effectively controlled with suitable sprays. Fruit flies attack the ripe fruits. A leaf-spotting fungus *(Sphaceloma* sp.) occasionally requires control measures. In Florida, leaf spot is caused by the fungi *Cercospora* sp., *Cylindrocladium scoparium,* and *Phyllosticta* sp.; algal leaf spot by *Cephaleuros virescens.* Thread blight (*Corticium stevensii* Burt. and *Rhizoctonia ramicola),* and mushroom root rot *(Clytocybe tabescens).*

Food Uses

When preparing feijoas for eating or preserving, peeling should be immediately followed by dipping into a weak salt solution or into water containing fresh lemon juice. Both of these methods will prevent the flesh from oxidizing (turning brown). The flesh and pulp (with seeds) are eaten raw as dessert or in salads, or are cooked in puddings, pastry fillings, fritters, dumplings, fruit-sponge-cake, pies or tarts, or employed as flavoring for ice cream or soft drinks. Surplus fruits may be peeled, halved and preserved in sirup in glass jars, or sliced and crystallized, or made into chutney, jam, jelly, conserve, relish, sauce or sparkling wine.

The thick petals are spicy and are eaten fresh by children and sometimes by adults. The petals may be plucked without interfering with fruit set.

Food Value Per 100 g of Edible Portion*

Moisture	84%
Protein	0.9%
Fat	0.2%
Carbohydrates*	10%
Ash	0.5%
Minerals:	
Potassium	166 mg
Sodium	5 mg
Calcium	4 mg
Magnesium	8 mg
Phosphorus	10 mg
Iron	0.05 mg
Ascorbic Acid	28-35 mg

*Analyses reported in the literature.

**Sugar 6% compared to 13% in the orange.

The fruit is rich in water-soluble iodine compounds. The percentage varies with locality and from year to year but the usual range is 1.65 to 3.90 mg/kg of fresh fruit. Most types are high in pectin, so that 3 lbs (1.4 kg) of jelly can be made from 1 lb (.45 kg) of fruit.

Morton, J. 1987. Jaboticabas. p. 371–374. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Jaboticabas

Myrciaria cauliflora Berg.

Eugenia cauliflora DC.

Little known outside their natural range, these members of the myrtle family, Myrtaceae, are perhaps the most popular native fruit-bearers of Brazil. Generally identified as *Myrciaria cauliflora* Berg. (syn. *Eugenia cauliflora* DC.), the names *jaboticaba, jabuticaba* or *yabuticaba* (for the fruit; *jaboticabeira for* the tree) actually embrace 4 species of very similar trees and fruits: *M. cauliflora, sabará jaboticaba,* also known as *jabuticaba sabará, jabuticaba de Campinas, guapuru, guaperu, hivapuru,* or *ybapuru; M. jaboticaba Berg.*, great jaboticaba, also known as *jaboticaba de Sao Paulo, jaboticaba do mato, jaboticaba batuba, jaboticaba grauda; M. tenella* Berg., *Jaboticaba macia, also* known as *guayabo colorado, cambui preto, murta do campo, camboinzinho; M. trunciflora* Berg., long-stemmed jaboticaba, also called *jaboticaba de Cabinho,* or *jaboticaba do Pará.*

The word "jaboticaba" is said to have been derived from the Tupi term, *jabotim*, for turtle, and means "like turtle fat", presumably referring to the fruit pulp.

Description

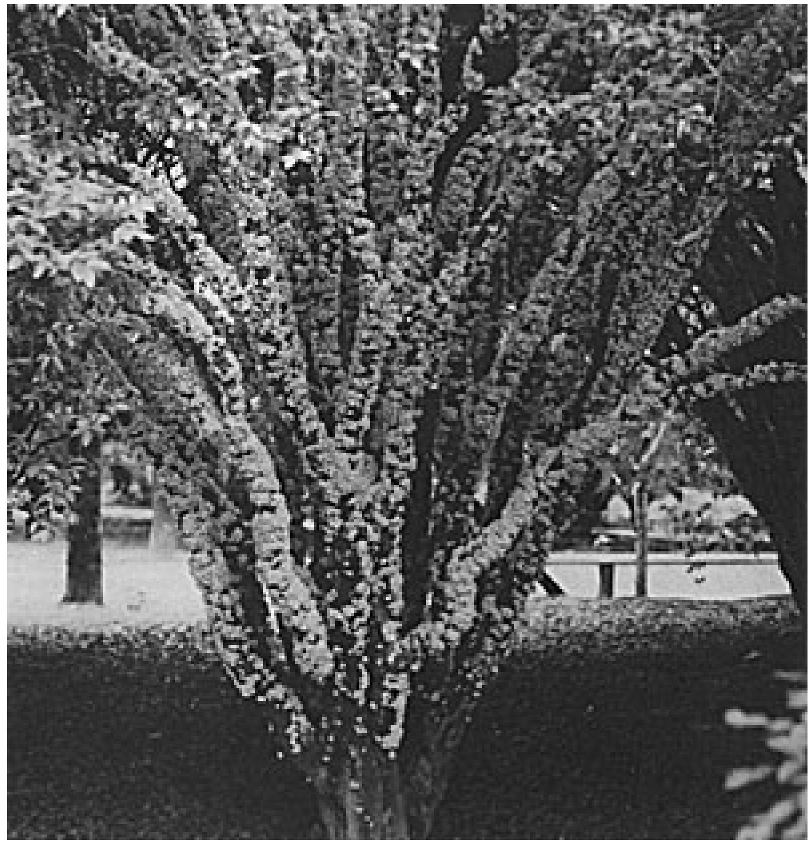

Fig. 101: A jaboticaba tree in full bloom in Brazil is a striking example of cauliflory (flowers arising from axillary buds on main trunks or older branches).

Jaboticaba trees are slow-growing, in *M. tenella*, shrubby, 3 1/2 to 4 1/2 ft (1-1.35 m) high; in *M. trunciflora,* 13 to 23 or rarely 40 ft (4-7 or 12 m); in the other species usually reaching 35 to 40 ft (10.5-12 m). They are profusely branched, beginning close to the ground and slanting upward and outward so that the dense, rounded crown may attain an ultimate spread of 45 ft (13.7 m). The thin outer bark, like that of the guava, flakes off, leaving light patches. Young foliage and branchlets are hairy.

The evergreen, opposite leaves, on very short, downy petioles, are lanceolate or elliptic, rounded at the base, sharply or bluntly pointed at the apex; 1 to 4 in (2.5-10 cm) long, 1/2 to 3/4 in (1.25-2 cm) in width; leathery, dark-green, and glossy. Spectacularly emerging from the multiple trunks and branches in groups of 4, on very short, thick pedicels, the flowers have 4 hairy, white petals and about 60 stamens to 1/6 in (4 mm) long. The fruit, borne in abundance, singly or in clusters, on short stalks, is largely hidden by the foliage and the shade of the canopy, but conspicuous on the lower portions of the trunks. Round, slightly oblate, broad-pyriform, or ellipsoid, with a small disk and vestiges of the 4 sepals at the apex, the fruits vary in size with the species and variety, ranging from 1/4 in (6 mm) in *M. tenella* and from 5/8 to 1 1/2 in (1.6-4 cm) in diameter in the other species. The smooth, tough skin is very glossy, bright-green, red-purple, maroon-purple, or so dark a purple as to appear nearly black, slightly acid and faintly spicy in taste; encloses a gelatinous, juicy, translucent, all-white or rose-tinted pulp that clings firmly to the seeds. The fruit has an overall subacid to sweet, grapelike flavor, mildly to disagreeably resinous, and is sometimes quite astringent. There may be 1 to 5 oval to nearly round but flattened, hard to tender, light-brown seeds, 1/4 to 1/2 in (6-12.5 mm) long, but often some are abortive. The fruit has been well likened to a muscadine grape except for the larger seeds.

Origin and Distribution

M. cauliflora is native to the hilly region around Rio de Janeiro and Minas Gerais, Brazil, also around Santa Cruz, Bolivia, Asunción, Paraguay, and northeastern Argentina. *M. jaboticaba* grows wild in the forest around Sao Paulo and Rio de Janeiro; *M. tenella* occurs in the and zone of Bahia and the mountains of Minas Gerais; in the states of Sao Paulo, Pernambuco and Rio Grande do

Sul; also around Yaguarón, Uruguay, and San Martin, Peru. *M. trunciflora* is indigenous to the vicinity of Minas Gerais.

Jaboticabas are cultivated from the southern city of Rio Grande to Bahia, and from the seacoast to Goyaz and Matto Grosso in the west, not only for the fruits but also as ornamental trees. They are most common in parks and gardens throughout Rio de Janeiro and in small orchards all around Minas Gerais. Many cultivated forms are believed to be interspecific hybrids.

An early "hearsay" account of the jaboticabas of Brazil was published in Amsterdam in 1658. The jaboticaba was introduced into California (at Santa Barbara) about 1904. A few of the trees were still living in 1912 but all were gone by 1939. In 1908, Brazil's National Society of Agriculture sent to the United States Department of Agriculture plants of 3 varieties, **'Coroa', 'Murta',** and **'Paulista'.** The first 2 died soon but 'Paulista' lived until 1917. A Dr. W. Hentz bought 6 small inarched plants in Rio Janeiro in 1911 and planted them in City Point, Brevard County, Florida. Only one, variety 'Murta', survived and he moved it to Winter Haven in 1918. It began fruiting in 1932 and continued to bear in great abundance. Another introduction was made by the U.S. Department of Agriculture in 1913 in the form of seeds collected by the plant explorers, P.H. Dorsett, A.D. Shamel, and W. Popenoe from marketed fruits in Rio de Janeiro, the best of which was described as 1 1/2 in (3.8 cm) thick. In 1914, the U.S. Department of Agriculture received seeds from 40 lbs (28 kg) of fruit purchased in the public market in Rio de Janeiro, which appeared different from previous introductions being purple-maroon, round or slightly oblate, and, at most, not quite 1 in (2.5 cm) in diameter. Plants grown from these seeds, believed to represent more than one species, were distributed to Florida, California and Cuba. A seedling of *M. trunciflora* from this lot was, up until 1928, grown at the Charles Deering estate, Buena Vista, Florida, and then transferred to the then U.S.D.A. Plant Introduction Station (now the Subtropical Horticulture Research Unit) on Old Cutler Road. It made poor growth in the limestone, but survived.

In 1918, seeds were presented to the U.S. Department of Agriculture by the Director of the Escola Agricola de Lavras in Minas Gerais, and most of the resulting trees were growing at the Brickell Avenue Garden until 1926 when they were killed by the 3 ft (1 m) of salt water pushed over the garden by the disastrous hurricane of that year. Dr. David Fairchild rejoiced that, in 1923, he had set out two of the seedlings at his home, "The Kampong", in Coconut Grove and these lived; one fruiting for the first time in 1935. Seedlings of the same lot were successfully grown and fruited heavily at the Atkins Garden of Harvard University at Soledad, near Cienfuegos, Cuba.

In 1920, Dr. Fairchild and P.H. Dorsett took several young trees to Panama and planted them at Juan Mina at sea-level where they grew well and fruited for many years. Later, jaboticabas were set out in the new Summit Botanic Garden. Between 1930 and 1940, plants presumably from the Summit Garden, were installed at the Estacion Agrícola de Palmira, in southern Colombia.

Seeds were sent from Washington to the Philippines in 1924. Plants were sent to Puerto Arturo, Honduras, and transferred to the Lancetilla Experimental Garden, at Tela, in 1926 and again in 1929. Other plants were transferred from the Summit Garden in 1928. The trees flourished and fruited well in Honduras. Dr. Hamilton P. Traub, of the Orlando, Florida, branch of the U.S. Department of Agriculture, was establishing a 2 1/2 acre (nearly 1 ha) experimental block of jaboticabas in 1940 for testing and study. At that time there were only a few bearing trees in the state. Soon, nurseries began selling grafted trees and they began appearing in home gardens.

Varieties

M. cauliflora differs mainly from the other species in the large size of the tree and of the fruits. The well-known variety 'Coroa' is believed to belong to this species, also 'Murta' which has smaller leaves and larger fruits. The latter was among those sent to California in 1904.

Among commercial sorts in Brazil are:

'Sabará, a form of *M. cauliflora*, is the most prized and most often planted. The fruit is small, thin-skinned and sweet. The tree is of medium size, precocious, and very productive. Early in season; bears 4 crops a year. Susceptible to rust on flowers and fruits.

'Paulista'–fruit is very large, with thick, leathery skin. The tree is a strong grower and highly productive though it bears a single crop. Later in season than 'Sabará' Fruits are resistant to rust. Was introduced into California in 1904.

'Rajada'–fruit very large, skin green-bronze, thinner than that of 'Paulista'. Flavor is sweet and very good. The tree is much like that of 'Paulista'. Midseason.

'Branca'–fruit is large, not white, but bright-green; delicious. Tree is of medium size and prolific; recommended for home gardens.

'Ponhema'–fruit is turnip-shaped with pointed apex; large; with somewhat leathery skin. Must be fully ripe for eating raw; is most used for jelly and other preserves. Tree is very large and extremely productive.

'Rujada'–fruit is striped white and purple.

'Roxa'–an old type mentioned by Popenoe as being more reddish than purple, as the name (meaning "red") implies.

'Sao Paulo' (probably *M. jaboticaba*)–tree is large-leaved.

'Mineira'–was introduced into California in 1904.

Pollination

It has been reported from Brazil that solitary jaboticaba trees bear poorly compared with those planted in groups, which indicates that cross-pollination enhances productivity.

Climate

In Brazil, jaboticabas grow from sea-level to elevations of more than 3,000 ft (910 m). At Minas Gerais, the temperature rarely falls below 33º F (0.56º C). Trees in central Florida have lived through freezing weather. In 1917, one very young jaboticaba tree at Brooksville survived a drop in temperature to 18º F (-7.78º C), only the foliage and branches being killed back. In southern Florida, jaboticabas have not been damaged by brief periods of 26º F (-3.33º C).

Soil

Jaboticaba trees grow best on deep, rich, well-drained soil, but have grown and borne well on sand in central Florida and have been fairly satisfactory in the southern part of the state on oolitic limestone.

Propagation

Jaboticabas are usually grown from seeds in South America. These are nearly always polyembryonic, producing 4 to 6 plants per seed. They germinate in 20 to 40 days.

Selected strains can be reproduced by inarching (approach-grafting) or air-layering. Budding is not easily accomplished because of the thinness of the bark and hardness of the wood. Side-veneer grafting is fairly successful. And experimental work has shown that propagation by tissue culture may be feasible.

At the Agricultural Research and Education Center in Homestead, Florida, 6 related genera, including 10 species, were tried as rootstocks in grafting experiments but none was successful. However, *M. cauliflora* scions were satisfactorily joined to rootstock of the same species 1/8 to 1/4 in (3-6 mm) thick, bound with parafilm and grown in plastic bags under mist.

Culture

Jaboticaba trees in plantations should be spaced at least 30 ft (9 m) apart each way. Dr. Wilson Popenoe wrote that in Brazil they were nearly always planted too close–about 15 ft (4.5 m) apart, greatly restricting normal development.

Growth is so slow that a seedling may take 3 years to reach 18 in (45 cm) in height. However, a seedling tree in sand at Orlando, Florida, was 15 ft (4.5 m) high when 10 years old. Others on limestone at the United States Department of Agriculture's Subtropical Horticulture Research Unit were shrubby and only 5 to 6 ft (1.5-1.8 m) high when 10 and 11 years old. Seedlings may not bear fruit until 8 to 15 years of age, though one seedling selection flowered in 4 to 5 years. Grafted trees have fruited in 7 years. One planted near Bradenton, Florida, in bagasse-enriched soil started bearing the 6th year. The fruit develops quickly, in 1 to 3 months, after flowering.

Traditionally, jaboticabas have not been given fertilizer in Brazil, the belief prevailing that it might be prejudicial rather than beneficial because of the sensitivity of the root system. Some agronomists have advocated digging a series of pits around the base of the tree and filling them with organic matter enriched with 1 part ammonium sulfate, 2 parts superphosphate, and 1 part potassium chlorate. The pits store and gradually release the nutrients and the water from the fall rains.

In 1978, E.A. Ackerman of the Rare Fruit Council International, Inc., reported on fertilizer experiments with 63 one-year-old and 48 two- and three-year-old seedlings in containers. Better growth was obtained with plants in a mixture of equal amounts of acid sandy muck, vermiculite, and peat, given feedings of 32 g of 14-14-14 slow-release fertilizer (Osmocote), roughly every 2 1/2 months, and 3 gallons (11.4 liters) of well water (pH 7.20) by a drip system every 2 days over a period of 18 months, than plants given other treatments. The addition of chelated iron was of no advantage; chelated zinc retarded growth rate, chelated manganese stopped growth and caused defoliation. Abundant water was found to be essential to survival. Irrigation to promote flowering in the dry season is recommended in Brazil to avoid the detrimental effects of flowering in the rainy season.

Season

The time of fruiting varies with the species and/or cultivar and, of course, the locale. In Rio de Janeiro, *M. cauliflora* fruits in May and *M. jaboticaba* in September. If the trees are heavily irrigated in the dry season, they may bear several crops a year. Trees in southern Florida usually produce 2 crops a year.

Harvesting and Packing

In Brazil, jaboticabas harvested in the interior are shipped crudely in second-hand wooden boxes to urban markets. The toughness of the skin prevents serious bruising if the boxes are handled with some care.

Keeping Quality

Jaboticabas, once harvested, ferment quickly at ordinary temperatures.

Pests and Diseases

If the jaboticaba blooms during a period of drought, many flowers desiccate. If blooming occurs during heavy rains, many flowers will be affected by rust caused by a fungus. The variety 'Sabará' is particularly susceptible to attacks of rust on the flowers and fruits. This is the most serious disease of the jaboticaba in Brazil. The initial signs are circular spots, at first yellow then dark-brown.

Fruit-eating birds are very troublesome to jaboticaba growers in Brazil. To protect the crop, double-folded newspaper pages are placed around individual clusters and tied at the top. If birds are very aggressive, or if there are high winds, the paper must be secured with string at the bottom also. To facilitate this operation, it may be necessary in winter or early spring to do some pruning to make it easier to climb the trees and this will result in protecting a larger portion of the crop. Furthermore, reducing the number of fruits has the effect of increasing the size of those that remain. In Florida, raccoons and opossums make raids on jaboticabas.

Food Uses

Jaboticabas are mostly eaten out-of-hand in South America. By squeezing the fruit between the thumb and forefinger, one can cause the skin to split and the pulp to slip into the mouth. The plant explorers, Dorsett, Shamel and Popenoe, wrote that children in Brazil spend hours "searching out and devouring the ripe fruits." Boys swallow the seeds with the pulp, but, properly, the seeds should be discarded.

Plate LI: JABOTICABA, *Myrciaria cauliflora*

The fruits are often used for making jelly and marmalade, with the addition of pectin. It has been recommended that the skin be removed from at least half the fruits to avoid a strong tannin flavor. In view of the undesirability of tannin in the diet, it would be better to peel most of them. The same should apply to the preparation of juice for beverage purposes, fresh or fermented. The aborigines made wine of the jaboticabas, and wine is still made to a limited extent in Brazil.

Food Value Per 100 g of Edible Portion*	
Calories	45.7
Moisture	87.1 g
Protein	0.11 g
Fat	0.01 g
Carbohydrates	12.58 g
Fiber	0.08 g
Ash	0.20 g
Calcium	6.3 mg
Phosphorus	9.2 mg
Iron	0.49 mg
Carotene	
Thiamine	0.02 mg
Riboflavin	0.02 mg
Niacin	0.21 mg
Ascorbic Acid*	22.7 mg
Amino Acids:	
Tryptophan	1 mg
Methionine	
Lysine	7 mg

*Analyses made in 1955 at the Laboratories FIM de Nutricion, Havana, Cuba.

**Others have shown 30.7 mg.

Toxicity

Regular, quantity consumption of the skins should be avoided because of the high tannin content, inasmuch as tannin is antinutrient and carcinogenic if intake is frequent and over a long period of time.

Medicinal Uses

The astringent decoction of the sun-dried skins is prescribed in Brazil as a treatment for hemoptysis, asthma, diarrhea and dysentery; also as a gargle for chronic inflammation of the tonsils. Such use also may lead to excessive consumption of tannin.

Morton, J. 1987. Jambolan. p. 375–378. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Jambolan

Syzygium cumini Skeels

Syzygium jambolanum DC.

Eugenia cumini Druce

This member of the Myrtaceae is of wider interest for its medicinal applications than for its edible fruit. Botanically it is *Syzygium cumini* Skeels (syns. *S. jambolanum* DC., *Eugenia cumini* Druce, *E. jambolana* Lam., *E. djouat* Perr., Myrtus *cumini* L., *Calyptranthes jambolana* Willd.). Among its many colloquial names are Java plum, Portuguese plum, Malabar plum, black plum, purple plum, and, in Jamaica, damson plum; also Indian blackberry. In India and Malaya it is variously known as *jaman, jambu, jambul, jambool, jambhool, jamelong, jamelongue, jamblang, jiwat, salam*, or *koriang*. In Thailand, it is *wa*, or *ma-ha;* in Laos, va; Cambodia, *pring bai* or *pring das krebey;* in Vietnam, *voi rung;* in the Philippines, *duhat, lomboy, lunaboy* or other dialectal appelations; in Java, *djoowet*, or *doowet*. In Venezuela, local names are *pésjua extranjera* or *guayabo pésjua;* in Surinam, *koeli, jamoen,* or *druif* (Dutch for "grape"); in Brazil, *jambuláo, jaláo, jameláo* or *jambol.*

Description

Plate LII: JAMBOLAN, *Syzygium cumini*

The jambolan is fast-growing, reaching full size in 40 years. It ranges up to 100 ft (30 m) in India and Oceania; up to 40 or 50 ft (12-15 m) in Florida; and it may attain a spread of 36 ft (11 m) and a trunk diameter of 2 or 3 ft (0.6-0.9 m). It usually forks into multiple trunks a short distance from the ground. The bark on the lower part of the tree is rough, cracked, flaking and discolored; further up it is smooth and light-gray. The turpentine-scented evergreen leaves are opposite, 2 to 10 in (5-25 cm) long, 1 to 4 in (2.5-10 cm) wide; oblong-oval or elliptic, blunt or tapering to a point at the apex; pinkish when young; when mature, leathery, glossy, dark-green above, lighter beneath, with conspicuous, yellowish midrib. The fragrant flowers, in 1-to 4-in (2.5-10 cm) clusters, are 1/2 in (1.25 cm) wide, 1 in (2.5 cm) or more in length; have a funnel-shaped calyx and 4 to 5 united petals, white at first, then rose-pink, quickly shed leaving only the numerous stamens.

The fruit, in clusters of just a few or 10 to 40, is round or oblong, often curved; 1/2 to 2 in (1.25-5 m) long, and usually turns from green to light-magenta, then dark-purple or nearly black as it ripens. A white-fruited form has been reported in Indonesia. The skin is thin, smooth, glossy, and adherent. The pulp is purple or white, very juicy, and normally encloses a single, oblong, green or brown seed, up to 1 1/2 in (4 cm) in length, though some fruits have 2 to 5 seeds tightly compressed within a leathery coat, and some are seedless. The fruit is usually astringent, sometimes unpalatably so, and the flavor varies from acid to fairly sweet.

Origin and Distribution

The jambolan is native in India, Burma, Ceylon and the Andaman Islands. It was long ago introduced into and became naturalized in Malaya. In southern Asia, the tree is venerated by Buddhists, and it is commonly planted near Hindu temples because it is considered sacred to Krishna. The leaves and fruits are employed in worshipping the elephant-headed god, Ganesha or Vinaijaka, the personification of "Pravana" or "Om", the apex of Hindu religion and philosophy.

The tree is thought to be of prehistoric introduction into the Philippines where it is widely planted and naturalized, as it is in Java and elsewhere in the East Indies, and in Queensland and New South Wales, also on the islands of Zanzibar and Pemba and Mombasa and adjacent coast of Kenya. In Ghana, it is found only in gardens. Introduced into Israel perhaps about 1940, it grows vigorously there but bears scantily, the fruit is considered valueless but the tree is valued as an ornamental and for forestry in humid zones. It is grown to some extent in Algiers.

By 1870, it had become established in Hawaii and, because of seed dispersal by mynah birds, it occurs in a semiwild state on all the Hawaiian islands in moist areas below 2,000 ft (600 in). There are vigorous efforts to exterminate it with herbicides because it shades out desirable forage plants. It is planted in most of the inhabited valleys in the Marquesas. It was in cultivation in Bermuda, Cuba, Haiti, Jamaica, the French Islands of the Lesser Antilles and Trinidad in the early 20th Century; was introduced into Puerto Rico in 1920; but still has remained little-known in the Caribbean region. At the Lancetilla Experimental Garden at Tela, Honduras, it grows and fruits well. It is seldom planted elsewhere in tropical America but is occasionally seen in Guatemala, Belize, Surinam, Venezuela and Brazil.

The Bureau of Plant Industry of the United States Department of Agriculture received jambolan seeds from the Philippines in 1911, from Java in 1912, from Zanzibar and again from the Philippines in 1920. The tree flourishes in California, especially in the vicinity of Santa Barbara, though the climate is not congenial for production or ripening of fruit. In southern Florida, the tree was rather commonly planted in the past. Here, as in Hawaii, fruiting is heavy, only a small amount of the crop has been utilized in home preserving. The jambolan has lost popularity, as it has in Malaya where it used to be frequently grown in gardens. Heavy crops litter streets, sidewalks and lawns, attracting insects, rapidly fermenting and creating a foul atmosphere. People are eager to have the trees cut down. Where conditions favor spontaneous growth, the seedlings become a nuisance, as well.

Varieties

The common types of jambolan in India are: 1) *Ra Jaman,* with large, oblong fruits, dark-purple or bluish, with pink, sweet pulp and small seeds; 2) *Kaatha,* with small, acid fruits. Among named cultivars are, mainly, **'Early Wild', 'Late Wild', 'Pharenda';** and, secondarily, **'Small Jaman'** and **'Dabka'** ('Dubaka'). In Java, the small form is called *Djoowet kreekil;* a seedless form is *Djoowet booten.* In southern Malaya, the trees are small-leaved with small flower clusters. Farther north, the variety called **'Krian Duat'** has larger, thicker leaves and red inner bark. Fruits with purple flesh are more astringent than the white-fleshed types.

Climate

The jambolan tree grows well from sea-level to 6,000 ft (1,800 m) but, above 2,000 ft (600 m) it does not fruit but can be grown for its timber. It develops most luxuriantly in regions of heavy rainfall, as much as 400 in (1,000 cm) annually. It prospers on river banks and has been known to withstand prolonged flooding. Yet it is tolerant of drought after it has made some growth. Dry weather is desirable during the flowering and fruiting periods. It is sensitive to frost when young but mature trees have been undamaged by brief below-freezing temperatures in southern Florida.

Soil

Despite its ability to thrive in low, wet areas, the tree does well on higher, well-drained land whether it be in loam, marl, sand or oolitic limestone.

Propagation

Jambolan seeds lose viability quickly. They are the most common means of dissemination, are sown during the rainy season in India, and germinate in approximately 2 weeks. Semi-hardwood cuttings, treated with growth-promoting hormones have given 20% success and have grown well.

Budding onto seedlings of the same species has also been successful. Veneer-grafting of scions from the spring flush has yielded 31% survivors. The modified Forkert method of budding may be more feasible. When a small-fruited, seedless variety in the Philippines was budded onto a seeded stock, the scion produced large fruits, some with seeds and some without. Approach-grafting and inarching are also practiced in India. Air-layers treated with 500 ppm indolebutyric acid have rooted well in the spring (60% of them) but have died in containers in the summer.

Culture

Seedlings grow slowly the first year, rapidly thereafter, and may reach 12 ft (3.65 m) in 2 years, and begin bearing in 8 to 10 years. Grafted trees bear in 4 to 7 years. No particular cultural attention seems to be required, apart from frost protection when young and control measures for insect infestations. In India, organic fertilizer is applied after harvest but withheld in advance of flowering and fruiting to assure a good crop. If a tree does not bear heavily, it may be girdled or root-pruned to slow down vegetative growth.

The tree is grown as shade for coffee in India. It is wind-resistant and sometimes is closely planted in rows as a windbreak. If topped regularly, such plantings form a dense, massive hedge. Trees are set 20 ft (6 m) apart in a windbreak; 40 ft (12 m) apart along roadsides and avenues.

Fruiting Season

The fruit is in season in the Marquesas in April; in the Philippines, from mid-May to mid-June. In Hawaii, the crop ripens in late summer and fall. Flowering occurs in Java in July and August and the fruits ripen in September and October. In Ceylon, the tree blooms from May to August and the fruit is harvested in November and December. The main fruiting season in India and southern Florida (where the tree blooms principally in February and March) extends through late May, June and July. Small second crops from late blooms have been observed in October. Individual trees may habitually bear later than others.

Harvesting and Yield

In India, the fruits are harvested by hand as they ripen and this requires several pickings over the season. Indian horticulturists have reported a crop of 700 fruits from a 5-year-old tree. The production of a large tree may be overwhelming to the average homeowner.

Pests and Diseases

In Florida, some jambolan trees are very susceptible to scale insects. The whitefly, *Dialeurodes eugeniae*, is common on jambolans throughout India. Of several insect enemies in South India, the most troublesome are leaf-eating caterpillars: *Carea subtilis, Chrysocraspeda olearia, Phlegetonia delatrbc, 0enospila flavifuscata, Metanastria hyrtaca*, and *Euproctis fraterna*. These pests may cause total defoliation. The leafminer, *Acrocercops phaeospora*, may be a major problem at times. *Idiocerus atkinsoni* sucks the sap of flowering shoots, buds and flower clusters, causing them to fall.

The fruits are attacked by fruit flies *(Dacus diversus* in India), and are avidly eaten by birds and four-footed animals (jackals and civets). In Australia, they are a favorite food of the large bat called "flying fox."

Diseases recorded as found on the jambolan by inspectors of the Florida Department of Agriculture are: black leaf spot *(Asterinella puiggarii);* green scurf or algal leaf spot *(Cephaleuros virescens);* mushroom root rot *(Clitocybe tabescens);* anthracnose *(Colletotrichum gloeosporioides);* and leaf spot caused by *Phyllosticta eugeniae.*

Food Uses

Jambolans of good size and quality, having a sweet or subacid flavor and a minimum of astringency, are eaten raw and may be made into tarts, sauces and jam. Astringent fruits are improved in palatability by soaking them in salt water or pricking them, rubbing them with a little salt, and letting them stand for an hour. All but decidedly inferior fruits have been utilized for juice which is much like grape juice. When extracting juice from cooked jambolans, it is recommended that it be allowed to drain out without squeezing the fruit and it will thus be less astringent. The white-fleshed jambolan has adequate pectin and makes a very stiff jelly unless cooking is brief. The more common purple-fleshed yields richly colored jelly but is deficient in pectin and requires the addition of a commercial jelling agent or must be combined with pectinrich fruits such as unripe or sour guavas, or ketembillas.

Good quality jambolan juice is excellent for sherbet, sirup and "squash". In India, the latter is a bottled drink prepared by cooking the crushed fruits, pressing out the juice, combining it with sugar and water and adding citric acid and sodium benzoate as a preservative.

Food Value Per 100 g of Edible Portion*

Moisture	83.7-85.8 g
Protein	0.7-0.129 g
Fat	0.15-0.3 g
Crude Fiber	0.3-0.9 g
Carbohydrates	14.0 g
Ash	0.32-0.4g
Calcium	8.3-15 mg
Magnesium	35 mg
Phosphorus	15-16.2 mg
Iron	1.2-1.62 mg
Sodium	26.2 mg
Potassium	55 mg
Copper	0.23 mg
Sulfur	13 mg
Chlorine	8 mg
Vitamin A	80 I.U.
Thiamine	0.008-0.03 mg
Riboflavin	0.009-0.01 mg

Niacin	0.2-0.29 mg
Ascorbic Acid	5.7-18 mg
Choline	7 mg
Folic Acid	3 mcg

*Values reported from Asian and tropical American analyses.

Also present are gallic acid and tannin and a trace of oxalic acid.

In Goa and the Philippines, jambolans are an important source of wine, somewhat like Port, and the distilled liquors, brandy and "jambava" have also been made from the fermented fruit. Jambolan vinegar, extensively made throughout India, is an attractive, clear purple, with a pleasant aroma and mild flavor.

Virmani gives the following vinegar analysis: specific gravity, 1.0184; total acidity (as acetic acid), 5.33 per 100 cc; volatile acid (as ascetic acid), 5.072 per 100 cc; fixed acidity, as citric, .275%; total solids, 4.12 per 100 cc; ash, .42; alkalinity of ash, 32.5 (N/10 alkali); nitrogen, .6613 1; total sugars, .995; reducing sugars, .995; non-volatile reducing sugars, .995; alcohol, .159% by weight; oxidation value, (K MnO_1), 186.4; iodine value, 183.7; ester value, 40.42.

Other Uses

Nectar: The jambolan tree is of real value in apiculture. The flowers have abundant nectar and are visited by bees *(Apis dorsata)* throughout the day, furnishing most of the honey in the Western Ghats at an elevation of 4,500 ft (1,370 m) where the annual rainfall is 300 to 400 in (750-1,000 cm). The honey is of fine quality but ferments in a few months unless treated.

Leaves: The leaves have served as fodder for livestock and as food for tassar silkworms in India. In Zanzibar and Pemba, the natives use young jambolan shoots for cleaning their teeth. Analyses of the leaves show: crude protein, 9.1%; fat, 4.3%; crude fiber, 17.0%; ash, 6.0%; calcium, 1.3%; phosphorus, 0.19%. They are rich in tannin and contain the enzymes esterase and galloyl carboxylase which are presumed to be active in the biosynthesis of the tannins.

The essential oil distilled from the leaves is used to scent soap and is blended with other materials in making inexpensive perfume. Its chemical composition has been reported by Craveiro *et al.* in Brazil. It consists mainly of mono- or sesqui-terpene hydrocarbons which are "very common in essential oils."

Bark: Jambolan bark yields durable brown dyes of various shades depending on the mordant and the strength of the extract. The bark contains 8 to 19% tannin and is much used in tanning leather and preserving fishing nets.

Wood: The wood is red, reddish-gray or brownish-gray, with close, straight grain. The very small, oval pores are often connected by waxy belts of loose tissue. The medullary rays are so fine as to be clearly visible only when greatly magnified. When fresh, the sapwood is attacked by powerpost beetles, pinhole borers and ambrosia beetles. Both sapwood and heartwood are perforated by the borer, *Aeolesthes holosericea*, if the bark is left on for as long as 10 months. Air-dried wood is apt to crack and split. When kiln dried, the heartwood is hard, difficult to work but polishes well. It is durable in water and resistant to borers and termites; tends to warp slightly. In India, it is commonly used for beams and rafters, posts, bridges, boats, oars, masts, troughs, well-lining, agricultural implements, carts, solid cart wheels, railway sleepers and the bottoms of railroad cars. It is sometimes made into furniture but has no special virtues to recommend it for cabinetwork. It is a fairly satisfactory fuel.

Medicinal Uses: The jambolan has received far more recognition in folk medicine and in the pharmaceutical trade than in any other field. Medicinally, the fruit is stated to be astringent, stomachic, carminative, antiscorbutic and diuretic. Cooked to a thick jam, it is eaten to allay acute diarrhea. The juice of the ripe fruit, or a decoction of the fruit, or jambolan vinegar, may be administered in India in cases of enlargement of the spleen, chronic diarrhea and urine retention. Water-diluted juice is used as a gargle for sore throat and as a lotion for ringworm of the scalp.

The seeds, marketed in 1/4 inch (7 mm) lengths, and the bark are much used in tropical medicine and are shipped from India, Malaya and Polynesia, and, to a small extent, from the West Indies, to pharmaceutical supply houses in Europe and England. Extracts of both, but especially the seeds, in liquid or powdered form, are freely given orally, 2 to 3 times a day, to patients with diabetes mellitus or glycosuiria. In many cases, the blood sugar level reportedly is quickly reduced and there are no ill effects. However, in some quarters, the hypoglycemic value of jambolan extracts is disclaimed. Mercier, in 1940, found that the aqueous extract of the seeds, injected into dogs, lowered the blood sugar for long periods, but did not do so when given orally. Reduction of blood sugar was obtained in alloxan diabetes in rabbits. In experiments at the Central Drug Research Institute, Lucknow, the dried alcoholic extract of jambolan seeds, given orally, reduced blood sugar and glycosuria in patients.

The seeds are claimed by some to contain an alkaloid, jambosine, and a glycoside, jambolin or antimellin, which halts the diastatic conversion of starch into sugar. The seed extract has lowered blood pressure by 34.6% and this action is attributed to the ellagic acid content. This and 34 other polyphenols in the seeds and bark have been isolated and identified by Bhatia and Bajaj.

Other reported constituents of the seeds are: protein, 6.3-8.5%; fat, 1.18%; crude fiber, 16.9%; ash, 21.72%; calcium, 0.41%; phosphorus, 0.17%; fatty acids (palmitic, stearic, oleic and linoleic); starch, 41%; dextrin, 6.1%; a trace of phytosterol; and 6 to 19% tannin.

The leaves, steeped in alcohol, are prescribed in diabetes. The leaf juice is effective in the treatment of dysentery, either alone or in combination with the juice of mango or emblic leaves. Jambolan leaves may be helpful as poultices on skin diseases. They yield 12 to 13% tannin (by dry weight).

The leaves, stems, flowerbuds, opened blossoms, and bark have some antibiotic activity. A decoction of the bark is taken internally for dyspepsia, dysentery, and diarrhea and also serves as an enema. The root bark is similarly employed. Bark decoctions are taken in cases of asthma and bronchitis and are gargled or used as mouthwash for the astringent effect on mouth ulcerations, spongy gums, and stomatitis. Ashes of the bark, mixed with water, are spread over local inflammations, or, blended with oil, applied to bums. In modern therapy, tannin is no longer approved on burned tissue because it is absorbed and can cause cancer. Excessive oral intake of tannin-rich plant products can also be dangerous to health.

Morton, J. 1987. Malay Apple. p. 378–381. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Malay Apple

Syzygium malaccense Merr. & Perry

Eugenia malaccensis L.

Jambos malaccensis DC.

A delight to the eye in every respect, the Malay apple is much admired for the beauty of the tree, its flowers and its colorful, glistening fruits, without parallel in the family Myrtaceae. Botanically identified as *Syzygium malaccense* Merr. & Perry (syns. *Eugenia malaccensis* L., *Jambos malaccensis* DC.), this species has earned a few alternate English names including Malay rose-apple, mountain apple, water apple, and, unfortunately, Otaheite apple, which is better limited to the ambarella, *Spondias dulcis* Park., and cashew, or French cashew (Guyana) or Otaheite cashew (India) because of its resemblance to the cashew apple, the pseudofruit or swollen fruit-stalk of the cashew nut.

In Malaya there are many local names including *jambu merah, jambu bar, jambu bol, jambu melaka*, *jambu kling* and *jambu kapal*. In Thailand, it is *chom-phu-sa-raek* or *chom-phu-daeng;* in

Cambodia, *chompuh kraham;* in Vietnam, *man hurong tau;* in Indonesia, *darsana, jambu tersana,* or *djamboo bol;* in the Philippines, *makopang-kalabau* or *tersana;* in Guam, *makupa;* in Tahiti, *ahia;* in Hawaii, *ohia.* In the French language it is *jambosier rouge*, *poire de Malaque*, *pomme Malac* (corrupted to pomerac), *pomme de Malaisie,* and *pomme de Tahiti.* Among Spanish names are: *pomarosa,* or *pomarrosa, Malaya* (Puerto Rico); *manzana* (Costa Rica), *marañon japonés* (EI Salvador), *pomarosa de Malaca* (Colombia); *pera de agua* or *pomagás* (Venezuela); and *marañon de Curacao* (Panama), though the somewhat similar plant in Curacao is *S. samarangense* Merr. & Perry, locally called *cashu di Surinam,* in Papiamento, *Curacaose appel,* in Dutch. The latter species has yellowish-white flowers and light-red, greenish-white or cream-colored fruits. (See Java apple pp. 381-2.)

Description

Fig. 102: Glossy, red, juicy, Malay apples (Syzygium *malaccense)* are sold in markets and along streets in warm areas of the Old and New World.

The Malay apple tree is rather fast-growing, reaching 40 to 60 ft (12-18 m) in height, and has an erect trunk to 15 ft (4.5 m) in circumference and a pyramidal or cylindrical crown. Its evergreen leaves are opposite, short-petioled, elliptic-lanceolate or oblanceolate; soft-leathery, dark-green and fairly glossy on the upper surface, paler beneath; 6 to 18 in (15-45 cm) long, 3 1/2 to 8 in (9-20 cm) wide. The veins are indistinct above, but they and the pale midrib are prominent on the underside. New growth is wine-red at first, changing to pink-buff. The abundant flowers, only mildly fragrant, and borne on the upper trunk and along leafless portions of mature branches in short-stalked clusters of 2 to 8, are 2 to 3 in (5-7.5 cm) wide, and composed of a funnel-like base topped by 5 thick, green sepals, 4 usually pinkish-purple to dark-red (sometimes white, yellow or orange) petals, and numerous concolorous stamens to 1 1/2 in (4 cm) long tipped with yellow anthers. Though showy, the flowers are hidden by the foliage until they fall and form a lovely carpet on the ground. The fruit, oblong, obovoid, or bell-shaped, 2 to 4 in (5-10 cm.) long, 1 to 3 in (2.5-7.5 cm) wide at the apex, has thin, smooth, waxy skin, rose-red or crimson or sometimes white with streaks of red or pink, and white, crisp or spongy, juicy flesh of very mild, sweetish flavor. There may be a single oblate or nearly round seed or 2 hemispherical seeds, 5/8 to 3/4 in (1.6-2 cm) in width, light-brown externally, green internally and somewhat meaty in texture. The fruits of some trees are entirely seedless.

Origin and Distribution

The Malay apple is presumed to be a native of Malaysia. It is commonly cultivated from Java to the Philippines and Vietnam, also in Bengal and South India. Portuguese voyagers carried it from Malacca to Goa and from there it was introduced into East Africa. It must have spread throughout the Pacific Islands in very early times for it is featured in Fijian mythology and the wood was used by ancient Hawaiians to make idols. Indeed, it has been recorded that, before the arrival of missionaries in Hawaii, there were no fruits except bananas, coconuts and the Malay apple. The flowers are considered sacred to Pele, the fiery volcano goddess. Captain Bligh conveyed small trees of 3 varieties from the islands of Timor and Tahiti to Jamaica in 1793. The tree was growing under glass in Cambridge, Massachusetts, in 1839, and specimens were fruiting in Bermuda in 1878.

Eggers, who studied the flora of St. Croix, reported seeing naturalized trees in shaded valleys during his stay on the island from 1870 to 1876. The Malay apple was unknown in Puerto Rico in 1903 but must have arrived soon after. Britton and Wilson observed 2 trees 43 ft (13 m) high at Happy Hollow in 1924. Thereafter, the tree was rather frequently planted as an ornamental or wind-break. Perhaps the Portuguese were responsible for its introduction into Brazil, for it is cultivated there, as it is also in Surinam and Panama. Dr. David Fairchild sent seeds from Panama to the United States Department of Agriculture in 1921. In 1929, young trees from the Canal Zone were transported to the Lancetilla Experimental Gardens at Tela, Honduras, where they flourished and fruited. The Malay apple is sometimes seen in other parts of Central America, including Belize, El Salvador and Costa Rica, much more frequently in parks and gardens in Venezuela. The fruits are sold in local markets and along the streets wherever the tree is grown.

Varieties

Ochse mentions an oblong to pear-shaped, white form called *djamboo pootih, djamboo bodas,* or *djamboo kemang,* which, in Java, is less flavorful than the red type. He says that there are many forms because of seedling variation. A large, especially sweet and juicy clone was introduced into the Philippines from Hawaii in 1922.

Climate

The Malay apple is strictly tropical, too tender for Florida and California except under very unusual conditions. It is naturalized and cultivated from sea-level to 9,000 ft (2,740 m) in valleys and on mountain slopes of the lowest forest zone of the Hawaiian Islands, and is grown up to 2,000 ft (610 m) in Ceylon and Puerto Rico. The tree needs a humid climate, with an annual rainfall of 60 in (152 cm) or more.

Soil

The tree grows vigorously on a range of soil types from sand to heavy clay. It tolerates moderately acid soil, reacts unfavorably to highly alkaline situations. In India, it grows best on the banks of ponds, lakes and streams where there is good drainage and no standing water. It is reported to be one of the first trees to spring up in new lava flows in Hawaii.

Propagation

Malay apple seeds germinate readily. Many sprout on the ground under the tree. While seed propagation is common, superior types are multiplied by budding onto their own seedlings. Air-layering has been successful and cuttings have been rooted in sand in Hawaii. Seeds are planted no more than 1 1/2 in (4 cm) deep in nurseries or directly in the field. They will germinate in 2 to 4 weeks and, if in nurseries, the seedlings are transplanted to the field when 8 months old. Cuttings are ready for transplanting in 6 weeks after rooting.

Culture

In India, Malay apple trees are spaced 26 to 32 feet (8-10 m) apart in fields prepared and enriched as for any other crop, and thereafter they require little care except for elimination of weeds and periodic fertilization and plentiful irrigation in very dry weather.

Pests and Diseases

Young Malay apple trees are frequently attacked by termites in India. It is reported that sap-feeders, defoliators, miners and borers have been found on the foliage and on dead stems.

Season

In Java, the tree flowers in May and June and the fruits ripen in August and September. The fruiting season is about the same around Castleton Gardens in Jamaica but at the lower level of Kingston it is earlier and ends during the first week of June. In India, the main crop occurs from May to July and there is often a second crop in November and December. In Puerto Rico, the tree may flower 2 or 3 times a year, in spring, summer and fall, the blooming season covering 40 to 60 days. The spring and fall flowering seasons produce the biggest crops. Fruits mature in 60 days from the full opening of the flowers and they fall quickly after they become fully ripe and deteriorate rapidly. For marketing, they must be hand-picked to avoid damage and to have longer shelf-life.

Yield

The yield varies from 48 to 188 lbs (21-85 kg) per tree.

Food Uses

The ripe fruit is eaten raw though many people consider it insipid. It is best stewed with cloves or other flavoring and served with cream as dessert. Asiatic people in Guyana stew the peeled fruit, cooking the skin separately to make a sirup which they add to the cooked fruit. Malayan people may add the petals of the red-flowered hibiscus *(Hibiscus rosa-sinensis* L.) to make the product more colorful. Malay apples are often cooked with acid fruits to the benefit of both. They are sometimes made into sauce or preserves. The slightly unripe fruits are used for making jelly and pickles..

In Puerto Rico, both red and white table wines are made from the Malay apple. The fruits are picked as soon as they are fully colored (not allowed to fall) and immediately dipped in boiling water for one minute to destroy surface bacteria and fungi. The seeds are removed and, for red wine, the fruits are passed through a meat grinder and the resulting juice and pulp weighed. To this material, they add twice the amount of water and 1 1/2 lbs (680 g) of white sugar per gallon, and pour into sterilized barrels with the mouth covered soon with cheesecloth. Yeast is added and a coil inserted to maintain circulation of the water. The barrels are kept in the coolest place possible for 6 months to 1 year, then the wine is filtered. It will be of a pale-rose color so artificial color is added to give it a rich-red hue. In making white wine, the fruits are peeled, the only liquid is the fruit juice, and less sugar is used, only 1 1/4 lbs (565 g) per gallon, so as to limit alcohol formation over a fermenting period of 3 to 6 months.

In Indonesia, the flowers are eaten in salads or are preserved in sirup. Young leaves and shoots, before turning green, are consumed raw with rice or are cooked and eaten as greens.

Food Value Per 100 g of Edible Portion*	
Moisture	90.3-91.6 g
Protein	0.5-0.7 g
Fat	0.1-0.2 g
Fiber	0.6-0.8 g
Ash	0.26-0.39 g
Calcium	5.6-5.9 mg
Phosphorus	11.6-17.9 mg
Iron	0.2-0.82 mg
Carotene	0.003-0.008 mg
(Vitamin A)	3-10 I.U.
Thiamine	15-39 mcg
Riboflavin	20-39 mcg
Niacin	0.21-0.40 mg
Ascorbic Acid	6.5-17.0 mg

*According to analyses made in Hawaii, El Salvador and Ghana.

Other Uses

Wood: The timber is reddish, soft to hard, tough and heavy, but inclined to warp. It is difficult to work, but is employed for construction, railway ties, and for fashioning bowls and poi-boards in Hawaii.

Medicinal Uses: According to Akana's translation of *Hawaiian Herbs of Medicinal Value*, the astringent bark has been much used in local remedies. It is pounded together with salt, the crushed material is strained through coconut husk fiber, and the juice poured into a deep cut. "The patient must exercise absolute self-control as the liquid bums its way into the flesh and nerves."

In the Molucca, or Spice, Islands, a decoction of the bark is used to treat thrush. Malayans apply a powder of the dried leaves on a cracked tongue. A preparation of the root is a remedy for itching. The root acts as a diuretic and is given to alleviate edema. The root bark is useful against dysentery, also serves as an emmenagogue and abortifacient. Cambodians take a decoction of the fruit, leaves or seeds as a febrifuge. The juice of crushed leaves is applied as a skin lotion and is added to baths. In Brazil, various parts of the plant are used as remedies for constipation, diabetes, coughs, pulmonary catarrh, headache and other ailments. Seeded fruits, seeds, bark and leaves have shown antibiotic activity and have some effect on blood pressure and respiration.

Morton, J. 1987. Java Apple. p. 381–382. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Java Apple

Syzygium samarangense Merr. & Perry

Syzygium javanicum Miq.

Eugenia javanica Lam.

Much less known than the Malay Apple, this member of the Myrtaceae is botanically identified as *Syzygium samarangense* Merr. & Perry (syns. *S. javanicum* Miq.; *Eugenia javanica Lam*. in part; *E. alba* Roxb.). Among its various vernacular names are: samarang rose apple, *djamboe semarang* (Indonesia); *jambu* ayer rhio (Malaya); *pini jambu (Ceylon);jumrool, jamrul*, or *amrool* (India); *chom pu kao*, or *chom pu kio* (Thailand); *makopa* (Philippines); *cashu di Surinam*, or *Curacaose appel* (Curacao); wax apple, wax jambu and water apple, generally.

Description

The tree, 16 to 50 ft (5-15 m) tall, has a short trunk 10 to 12 in (25-30 cm) thick, and open, widespreading crown, and pinkish-gray, flaking bark. The opposite leaves are nearly sessile, elliptic-oblong, rounded or slightly cordate at the base; yellowish to dark bluish-green; 4 to 10 in (10-25 cm) long and 2 to 4 3/4 in (5-12 cm) wide; very aromatic when crushed. Flowers, borne in drooping panicles of 3 to 30 at the branch tips or in smaller clusters in the axils of fallen leaves, are fragrant, yellowish-white, 3/4 to 1 1/2 in (2-4 cm) broad, 4-petalled, with numerous stamens 3/5 to

1 in (1.5-2.5 cm) long. The waxy fruit, usually light-red, sometimes greenish-white or cream-colored, is pear-shaped, narrow at the base, very broad, flattened, indented and adorned with the 4 fleshy calyx lobes at the apex; 1 1/3 to 2 in (3.4-5 cm) long, 1 3/4 to 2 1/8 in (4.5-5.4 cm) wide. The skin is very thin, the flesh white, spongy, dry to juicy, subacid and very bland in flavor. There may be 1 or 2 somewhat rounded seeds 3/16 to 5/16 in (0.5-0.8 cm) wide, or none.

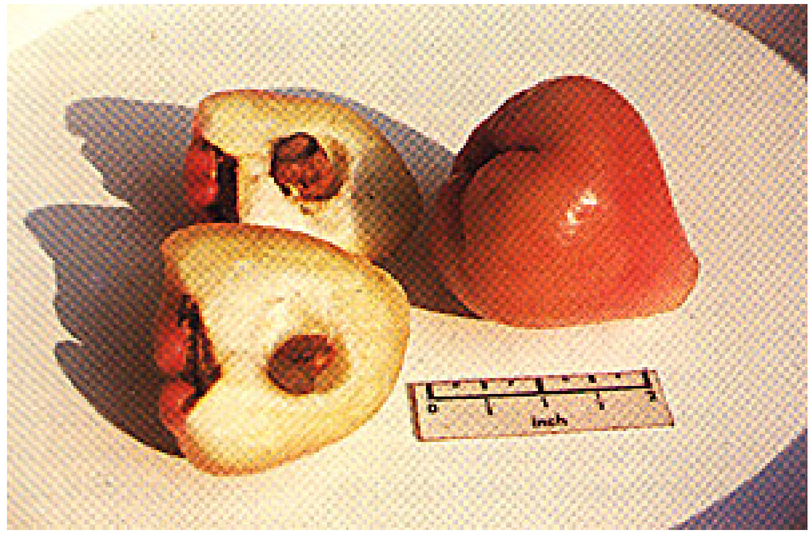

Plate LIII: JAVA APPLE, *Syzygium samarangense*

Origin and Distribution

The tree is indigenous from Malaya to the Andaman and Nicobar Islands where there are wild trees in the coastal forests. It was introduced into the Philippines in prehistoric times and is widely grown throughout those islands. It is common in Thailand, Cambodia, Laos, Vietnam and Taiwan, frequently cultivated in India and in Zanzibar and Pemba, but primarily as an ornamental, seldom for its fruits which are little valued. It was introduced into Jamaica before 1903 and also into Surinam and the islands of Curacao, Aruba and Bonaire. A few trees have been grown in Israel but have borne sparsely.

Climate

The Java apple is extra-tropical, growing only at the lower altitudes–up to 4,000 ft (1,220m)–in India. It does best in parts of the Philippines that have a long dry season.

Soil

The soil must be fertile, or the crops will be small and the fruit quality poor.

Propagation

The trees grow spontaneously from seed. Preferred types are reproduced by layering, budding onto their own rootstocks, or onto seedlings of *S. densiflorum* A. DC., (the beautiful Wild Rose Apple of Malaya, which has edible flowers, undesirable fruits, but is not attacked by termites). Sometimes the Java apple is grafted onto the cultivated Rose Apple (q.v.).

Culture

If planted in orchards, the trees are spaced 26 to 32 ft (8-10 m) apart and are given a minimum of attention.

Season

In Ceylon, the fruits are ripe from March to May; in India, the tree blooms in March and April and the fruit ripens in May and June; in Java, flowering occurs from April to June and fruiting from June to August.

Yield

The Java apple is a heavy bearer on good soil. When 5 years old it may yield a crop of 700 fruits.

Food Uses

In Malaya, the greenish fruits are eaten raw with salt or may be cooked as a sauce. They are also stewed with true apples. The pink fruits are juicier and more flavorful and suitable for eating out-of-hand or cooking without accompaniments except sugar.

Food Value Per 100 g of Edible Portion*	
Moisture	91.40-92.96 g
Protein	0.50 g
Sugar	6.56 g
Iron	0.001 g
Ash	0.21-0.27 g
Calcium	0.01 g
Phosphorus	0.03 g
Sulphuric Acid	0.17%
Citric Acid	0.15%

*Analyses made in the Philippines.

Other Uses

Wood: The wood is red, coarse, hard; used for constructing huts in the Andaman and Nicobar Islands.

Medicinal Uses: The flowers are astringent and used in Taiwan to treat fever and halt diarrhea. Investigators have found their principal constituent to be tannin. They also contain desmethoxymatteucinol, 5-*O*-methyl-4'-desmethoxymatteucinol, oleanic acid and B-sitosterol. They show weak antibiotic action against *Staphylococcus aureus, Mycobacterium smegmatis,* and *Candida albicans.*

Morton, J. 1987. Water Apple. p. 382–383. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Water Apple

Syzygium aqueum Alst.

Eugenia aquea Burm. f.

The water apple is the least of the small group of somewhat similar fruits of the genus *Syzygium* (family Myrtaceae). This species, *S. aqueum* Alst. (syn. *Eugenia aquea* Burm. f.), also known as watery rose apple, is distinguished in Malaya *as jambu chili, jambu ayer, jambu ayer mawar*, or *jambu penawar;* in Indonesia as *djamboo* aer, *djamboo wer*, or *djamboo* wir. In the Philippines, it is called *tambis;* in Thailand, it is *chom-phu-pa.*

Description

The tree may reach 10 or even 32 ft (3-10 m); has a short, crooked trunk branching close to the ground, and a nonsymmetrical, open crown. The opposite leaves, on very short, thick petioles, are obovate- or elliptic-oblong, cordate at the base and clasping the twig; blunt and notched or short-pointed at the apex; 2 to 10 in (5-25 cm) long, 1 to 6 3/8 in (2.5-16 cm) wide; dull, light-green above, yellowish-green beneath; leathery; not aromatic or only slightly so when crushed. Flowers, faintly fragrant, are home in loose terminal or axillary clusters of 3 to 7, mostly hidden by the foliage. The 4-parted calyx and 4 petals are pale-yellow, yellowish-white or pinkish and there are numerous concolorous stamens to 3/4 in (2 cm) long. Thin-skinned and shining, the fruit varies from white, to light-red or red, is pear-shaped with a narrow neck and broad apex; 5/8 to 3/4 in (1.6-2 cm) long, 1 to 1 1/3 in (2.5-3.4 cm) wide. The apex is concave; bears the thick calyx segments and the protruding, slender, bristle-like style. The flesh is white or pink, mildly fragrant, dry or juicy, crisp or spongy, and usually of sweetish but faint flavor. There may be 3 to 6 small seeds, frequently only 1 or 2, but generally the fruits are seedless.

Origin and Distribution

The water apple occurs naturally from southern India to eastern Malaysia. It is commonly cultivated in India, southeastern Asia, and Indonesia. In the Philippines, it grows as though wild in the Provinces of Mindanao, Basilan, Dinagat and Samar. It has never been widely distributed but is occasionally grown in Trinidad and Hawaii. It was introduced into Puerto Rico in 1927 but survived only a few years.

Varieties

In Indonesia, two forms are recognized–one white-fruited and the other red, the color of the latter developing from the base upward. Much variation is seen in the fruits from different trees in Malaya and the flavor of some types is quite acid.

Climate

The water apple is suited only to low altitudes in the tropics and areas where there is rainfall fairly well spaced throughout the year.

Propagation

The tree may be air-layered or budded onto rootstocks of *Eugenia javanica* Lam. or *E. densiflora* A. DC. Experiments in Hawaii proved that cuttings can be successfully rooted.

Culture

Little cultural attention has been given the water apple. In Indonesia, when it is set out in orchards, it is spaced at a 20 to 26 ft (6-8 m) distance from tree-to-tree.

Season

In Malaya there are two crops a year, one in the spring and a second in the fall. In Indonesia, the tree frequently blooms in July and again in September, the fruits ripening in August and November.

Food Uses

The water apple is mainly consumed by children, the appeal being largely its thirst-relieving character. In Indonesia, the fruits are sold in markets in piles or skewered on slender bamboo sticks. Superior types are sometimes served sliced in salads. According to early writings, a water apple salad is a ceremonial dish for new mothers.

Other Uses

Wood: The wood is hard and is fashioned into small pieces of handicraft.

Medicinal Uses: A decoction of the astringent bark is a local application on thrush.

Morton, J. 1987. Rose Apple. p. 383–386. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Rose Apple

Syzyygium jambos Alston

Eugenia jambos L.

Jambosa jambos Millsp.

Like many other fruits to which the word "apple" has been attached, the rose apple in no way resembles an apple, neither in the tree nor in its fruit. It is a member of the myrtle family, Myrtaceae, and is technically known as *Syzygium jambos* Alston (syn. *Eugenia jambos* L.; *Jambosa jambos* Millsp.; *Jambosa vulgaris* DC.; *Caryophyllus jambos* Stokes).

The term "rose apple" (in French, *pomme rose, pommier rose*; in Spanish, *poma rosa, pomarrosa, manzana rosa*, or *manzanita de rosa*) is so widely employed that the species has few alternate names apart from those in the many local dialects of Africa, India, Malaya, southeastern Asia, the East Indies and Oceania. It is sometimes called *jambosier* by French-speaking people, plum rose or malabar plum in the English-speaking West Indies, *pommeroos* or *appelroos* in Surinam, and *jambeiro* or *jambo amarelo* in Brazil; *jaman* in India, and *yambo* in the Philippines.

Description

Fig. 103: The rose apple *(Syzygium jambos)* is a minor fruit, but the tree is a quick-growing source of fuel and other products.

The rose apple tree may be merely a shrub but is generally a tree reaching 25 or even 40 ft (7.5-12 m) in height, and has a dense crown of slender, wide-spreading branches, often the overall width exceeding the height. The evergreen leaves are opposite, lanceolate or narrow-elliptic, tapering to a point; 4 to 9 in (10-22 cm) long, and from 1 to 2 1/2 in (2.5-6.25 cm) wide; somewhat leathery, glossy, dark-green when mature, rosy when young. The flowers are creamy-white or greenish-white, 2 to 4 in (5-10 cm) wide, consisting mostly of about 300 conspicuous stamens to 1 1/2 in (4 cm) long, a 4-lobed calyx, and 4 greenish-white, concave petals. There are usually 4 or 5 flowers together in terminal clusters. Capped with the prominent, green, tough calyx, the fruit is nearly round, oval, or slightly pear-shaped, 1 1/2 to 2 in (4-5 cm) long, with smooth, thin, pale-yellow or whitish skin, sometimes pink-blushed, covering a crisp, mealy, dry to juicy layer of yellowish flesh, sweet and resembling the scent of a rose in flavor. In the hollow center, there are 1 to 4 brown, rough-coated, medium-hard, more or less rounded seeds, 3/8 to 5/8 in (1-1.6 cm) thick, which loosen from the inner wall and rattle when the fruit is shaken. Fragments of the seedcoat may be found in the cavity.

Origin and Distribution

The rose apple is native to the East Indies and Malaya and is cultivated and naturalized in many parts of India, Ceylon and former Indochina and the Pacific Islands. It was introduced into Jamaica in 1762 and became well distributed in Bermuda, the Bahamas, the West Indies and, at low and medium elevations, from southern Mexico to Peru. In Guatemala, the tree may be planted as a living fencepost or in hedgerows around coffee plantations. For this purpose, it is drastically pruned to promote dense growth. It grows wild abundantly, forming solid stands and thickets, in Puerto Rico, the Virgin Islands, Guatemala, Honduras and Panama.

In 1825, eight young trees were taken from Rio de Janeiro to Hawaii by ship, and, in 1853, a United States warship delivered avocado and rose apple trees from Central America to the island of Hilo. The rose apple became naturalized on the islands of Kauai, Molokai, Oahu, Maui and Hawaii. In 1893, it was reported as already cultivated in Ghana. It is semi-naturalized in some areas of West Tropical Africa and on the islands of Zanzibar, Pemba and Reunion. It is believed to have been first planted in Queensland, Australia, about 1896. A tree obtained from an Italian nursery has grown and borne well on the coastal plain of Israel. However, it is not of interest there as a fruit tree but rather as an ornamental.

The rose apple was introduced into Florida, at Jacksonville, before 1877, but, as a fruit tree, it is suited only to the central and southern parts of the state. In California, it is planted as far north as San Francisco for its ornamental foliage and flowers. Because the tree occupies considerable space and the fruit is little valued, the rose apple has not been planted in Florida in recent years, though there are quite a number of specimens remaining from former times.

Climate

The rose apple flourishes in the tropical and near-tropical climates only. In Jamaica, it is naturalized from near sea-level up to an altitude of 3,000 ft (915 m); in Hawaii, from sea-level to 4,000 ft (1,200 m). In India, it ranges up to 4,400 ft (1,350 m); in Ecuador, to 7,500 ft (2,300 m). At the upper limits, as in California, the tree grows vigorously but will not bear fruit.

In India, it does best on the banks of canals and streams and yet tolerates semi-arid conditions. Prolonged dry spells, however, are detrimental.

Soil

A deep, loamy soil is considered ideal for the rose apple but it is not too exacting, for it flourishes also on sand and limestone with very little organic matter.

Propagation

Most rose apple trees are grown from seeds, which are polyembryonic (producing 1 to 3 sprouts), but the seedlings are not uniform in character nor behavior. In India, vegetative propagation has been undertaken with a view to standardizing the crop and also to select and perpetuate dwarf types. Using cuttings, it was found that hardwood does not root even with chemical growth promoters. Treated semihard wood gave 20% success. Air-layers taken in the spring and treated with 1,000 ppm NAA gave 60% success. Air-layers did not root in the rainy season. In budding experiments, neither chip nor "T" buds would take. Veneer grafting in July of spring-flush scions on 1-year-old rootstocks was satisfactory in 31% of the plants. In West Bengal, air-layering is commonly performed in July and the layers are planted in October and November. Fruiting can be expected within 4 years. Sometimes the rose apple is inarched onto its own seedlings.

Culture

Rarely do rose apple trees receive any cultural attention. Some experimental work has shown that seedless, thick-fleshed fruits can be produced by treating opened flowers with growth regulators–naphthoxy acetic acid (NOA), 2,4,5-T, or naphthalene acetic acid.

Season

In Jamaica and Puerto Rico, the rose apple trees bloom and fruit sporadically nearly all year, though somewhat less in summer than at other times. The main season in the Bahamas and in Florida is May through July. The fruiting period varies in different parts of India. In South India, blooming usually occurs in January, with fruit ripening in March and April, whereas in the Circars, ripening takes place in April and May. In the central part of the country, flowering occurs in February, March and April and the fruits ripen from June through July. Then again, it is reported that there are varieties that produce fruit in February and March.

Yield

In India, they say that a mature rose apple tree will yield 5 lbs (2 kg) of fruit each season. The fruits are, of course, very light in weight because they are hollow, but this is a very small return for a tree that occupies so much space.

Keeping Quality

Rose apples bruise easily and are highly perishable. They must be freshly picked to be crisp. Some studies of respiration rate and ethylene production in storage have been made in Hawaii. The fruit is non-climacteric.

Pests and Diseases

The rose apple tree has few insect enemies. In humid climates, the leaves are often coated with sooty mold growing on the honeydew excreted by aphids. They are also prone to leaf spot caused by *Cercospora* sp., *Gloeosporium* sp., and *Phyllosticta eugeniae*; algal leaf spot (*Cephaleuros virescens*); black leaf spot (*Asterinella puiggarii*); and anthracnose (*Glomerella cingulata*). Root rot caused by *Fusarium* sp., and mushroom root rot (*Armillariella (Clitocybe) tabescens*) attack the tree.

Food Uses

Around the tropical world, rose apples are mostly eaten out-of-hand by children. They are seldom marketed. In the home, they are sometimes stewed with some sugar and served as dessert. Culinary experimenters have devised other modes of using the cuplike halved fruits. One stuffs them with a rice-and-meat mixture, covers them with a tomato sauce seasoned with minced garlic, and bakes them for about 20 minutes. Possible variations are limitless. The fruit is made into jam or jelly with lemon juice added, or more frequently preserved in combination with other fruits of more pronounced flavor. It is also made into a sirup for use as a sauce or to flavor cold drinks. In Jamaica, the halved or sliced fruits are candied by stewing them in very heavy sugar sirup with cinnamon.

Food Value Per 100 g of Edible Portion*

Calories	56
Moisture	84.5-89.1 g
Protein	0.5-0.7 g
Fat	0.2-0.3 g
Carbohydrates	14.2 g
Fiber	1.1-1.9 g
Ash	0.4-0.44 g
Calcium	29-45.2 mg
Magnesium	4 mg
Phosphorus	11.7-30 mg
Iron	0.45-1.2 mg
Sodium	34.1 mg

Potassium	50 mg
Copper	0.01 mg
Sulfur	13 mg
Chlorine	4 mg
Carotene	123-235 I.U.
Thiamine	0.01-0.19 mg
Riboflavin	0.028-0.05 mg
Niacin	0.521-0.8 mg
Ascorbic Acid	3-37 mg

*Analyses made in Central America and elsewhere.

Toxicity

The seeds are said to be poisonous. An unknown amount of hydrocyanic acid has been reported in the roots, stems and leaves. An alkaloid, jambosine, has been found in the bark of the tree and of the roots, and the roots are considered poisonous.

Other Uses

Fruit: In 1849, it was announced in Bengal that the ripe fruits, with seeds removed, could be distilled 4 times to make a "rosewater" equal to the best obtained from rose petals.

Branches: The flexible branches have been employed in Puerto Rico to make hoops for large sugar casks, and also are valued for weaving large baskets.

Bark: The bark has been used for tanning and yields a brown dye.

Wood: The sapwood is white. The heartwood is dark-red or brown, fibrous, close-grained, medium-heavy to heavy, strong; and has been used to make furniture, spokes for wheels, arms for easy chairs, knees for all kinds of boats, beams for construction, frames for musical instruments (violins, guitars, etc.), and packing cases. It is also popular for general turnery. It is not durable in the ground and is prone to attack by drywood termites.

The tree grows back rapidly after cutting to a stump and consequently yields a continuous supply of small wood for fuel. Rose apple wood makes very good charcoal.

Leaves: A yellow essential oil, distilled from the leaves, contains, among other properties, 26.84% *dl-a*-pinene and 23.84% *l*-limonene, and can be resorted to as a source of these elements for use in the perfume industry.

Flowers: The flowers are a rich source of nectar for honeybees and the honey is a good amber color. Much comes from the San Cristobal River Valley in Cuba.

Medicinal Uses: In India, the fruit is regarded as a tonic for the brain and liver. An infusion of the fruit acts as a diuretic.

A sweetened preparation of the flowers is believed to reduce fever. The seeds are employed against diarrhea, dysentery and catarrh. In Nicaragua, it has been claimed that an infusion of roasted, powdered seeds is beneficial to diabetics. They say in Colombia that the seeds have an anesthetic property.

The leaf decoction is applied to sore eyes, also serves as a diuretic and expectorant and treatment for rheumatism. The juice of macerated leaves is taken as a febrifuge. Powdered leaves have been rubbed on the bodies of smallpox patients for the cooling effect.

The bark contains 7-12.4% tannin. It is emetic and cathartic. The decoction is administered to relieve asthma, bronchitis and hoarseness. Cuban people believe that the root is an effective remedy for epilepsy.

Morton, J. 1987. Surinam Cherry. p. 386–388. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Surinam Cherry

Eugenia uniflora L.

Eugenia Michelii Lam.

Stenocalyx Michelii Berg

The most widely known of the edible-fruited *Eugenia* species, because of its great adaptability, the Surinam cherry, *E. uniflora* L. (syns. *E. Michelii* Lam.; *Stenocalyx Michelii* Berg; *Plinia rubra* Vell.), is also called Brazil or Brazilian cherry, Cayenne cherry, pitanga, and, unfortunately, Florida cherry. In Spanish it is generally *cereza de cayena;* but *pendanga* in Venezuela; *guinda* in El Salvador; *ñanga-piré* in Argentina; *cereza quadrada* in Colombia. In Guadeloupe and Martinique it is called *cerese à côtes* or *cerises-cotes;* in French Guiana, *cerise de Cayenne, cerise de pays*, or *cerise carée;* in Surinam, *Surinaamsche kersh*, *zoete kers,* or *monkie monkie kersie.*

Description

Fig. 104: The Surinam cherry *(Eugenia uniflora)* is primarily grown as a hedge, the showy fruits being eaten mainly by children.

The shrub or tree, to 25 ft (7.5 m) high, has slender, spreading branches and resinously aromatic foliage. The opposite leaves, bronze when young, are deep-green and glossy when mature; turn red in cold, dry winter weather. They are ovate to ovate-lanceolate, blunt- to sharp-pointed, 1 1/2 to 2 1/2 in (4-6.25 cm) long. Long-stalked flowers, borne singly or as many as 4 together in the leaf axils, have 4 delicate, recurved, white petals and a tuft of 50 to 60 prominent white stamens with pale-yellow anthers. The 7- to 8-ribbed fruit, oblate, 3/4 to 1 1/2 in (2-4 cm) wide, turns from green to orange as it develops and, when mature, bright-red to deep-scarlet or dark, purplish maroon ("black") when fully ripe. The skin is thin, the flesh orange-red, melting and very juicy; acid to sweet, with a touch of resin and slight bitterness. There may be 1 fairly large, round seed or 2 or 3 smaller seeds each with a flattened side, more or less attached to the flesh by a few slender fibers.

Origin and Distribution

The plant is native from Surinam, Guyana and French Guiana to southern Brazil (especially the states of Rio de Janeiro, Paraña, Santa Catharina and Rio Grande do Sul), and to northern, eastern and central Uruguay. It grows wild in thickets on the banks of the Pilcomayo River in Paraguay. It was first described botanically from a plant growing in a garden at Pisa, Italy, which is believed to have been introduced from Goa, India. Portuguese voyagers are said to have carried the seed from Brazil to India, as they did the cashew. It is cultivated and naturalized in Argentina, Venezuela and Colombia; also along the Atlantic coast of Central America; and in some islands of the West Indies–the Cayman Islands, Jamaica, St. Thomas, St. Croix, Puerto Rico, Cuba, Haiti, the Dominican Republic, and in the Bahamas and Bermuda. In 1918, Britton wrote, in the *Flora of Bermuda,* that ". . as it harbors the fruit fly, the tree has been largely cut out in recent years." It is frequently grown in Hawaii, Samoa, India and Ceylon as an ornamental plant and occasionally in tropical Africa, southern China and in the Philippines where it first fruited in 1911. It was long ago planted on the Mediterranean coast of Africa and the European Riviera. The first Surinam cherry was introduced into coastal Israel in 1922 and aroused considerable interest because it produced fruit in May when other fruits are scarce, and it requires so little care; but over 10 years of observation, the yields recorded were disappointingly small.

In Florida, the Surinam cherry is one of the most common hedge plants throughout the central and southern parts of the state and the Florida Keys. The fruits are today mostly eaten by children. In the past, many people allowed the tree to grow naturally and harvested the fruits for culinary use. For a while, small quantities were sold in Miami markets. In temperate zones, the plant is grown in pots for its attractive foliage and bright fruits.

Varieties

There are 2 distinct types: the common bright-red and the rarer dark-crimson to nearly black, which tends to be sweeter and less resinous.

Climate

The Surinam cherry is adapted to tropical and subtropical regions. In the Philippines, it thrives from sea-level to 3,300 ft (1,000 m); in Guatemala, up to 6,000 ft (1,800 m). Young plants are damaged by temperatures below 28º F (-2.22º C), but well-established plants have suffered only superficial injury at 22º F (-5.56º C). The plant revels in full sun. It requires only moderate rainfall and, being deep-rooted, can stand a long dry season.

Soil

The Surinam cherry grows in almost any type of soil–sand, sandy loam, stiff clay, soft limestone–and can even stand waterlogging for a time, but it is intolerant of salt.

Propagation

Seeds are the usual means of propagation. They remain viable for not much longer than a month and germinate in 3 to 4 weeks. Volunteer seedlings can be taken up and successfully transplanted. Layering has been successful in India. The seedlings can be topworked to superior selections by side- or cleft-grafting but they tend to sucker below the graft.

Culture

Surinam cherry seedlings grow slowly; some begin to fruit when 2 years old; some may delay fruiting for 5 or 6 years, or even 10 if in unfavorable situations. They are most productive if unpruned, but still produce a great many fruits when close-clipped in hedges. Quarterly feeding with a complete fertilizer formula promotes fruiting. The plant responds quickly to irrigation, the fruit rapidly becoming larger and sweeter in flavor after a good watering.

Season and Harvesting

The fruits develop and ripen quickly, only 3 weeks after the flowers open. In Brazil, the plants bloom in September and fruits ripen in October; they bloom again in December and January. In Florida and the Bahamas, there is a spring crop, March or April through May or June; and a second crop, September through November, coinciding with the spring and fall rains.

The fruits should be picked only when they are so ripe as to fall into the hand at the lightest touch, otherwise they will be undesirably resinous. Gathering must be done daily or even twice a day.

Yield

In India, pruned bushes yield an average of 6 to 8 lbs (2.7-3.6 kg) per plant. The highest yield obtained in Israel was 2,700 fruits weighing about 24 lbs (11 kg) from one untrimmed plant.

Pests and Diseases

Surinam cherries are highly attractive to Caribbean and Mediterranean fruit flies, but the incidence of infestation was found to vary greatly in Israel from location to location, some plants being unmolested.

The foliage is occasionally attacked by scale insects and caterpillars. A large, extensive hedge along a canal in Dade County blew down in September 1982. Examination showed that the roots had been chewed off and there were about a dozen white grubs up to 2 in (5 cm) long under each plant. These were identified as the larvae of a sugar cane pest that is common in Haiti.

Among diseases encountered in Florida are leaf spot caused by *Cercospora eugeniae, Helminthosporium sp.,* and *Phyllostica eugeniae;* thread blight from infection by *Corticium stevensii;* anthracnose from *Colletotrichum gloeosporioides;* twig dieback and root rot caused by *Rhizoctonia solani;* and mushroom root rot, *Armillariella (Clitocybe) tabescens.*

Food Uses

Children enjoy the ripe fruits out-of-hand. For table use, they are best slit vertically on one side, spread open to release the seed(s), and kept chilled for 2 or 3 hours to dispel most of their resinously aromatic character. If seeded and sprinkled with sugar before placing in the refrigerator, they will become mild and sweet and will exude much juice and serve very well instead of strawberries on shortcake and topped with whipped cream. They are an excellent addition to fruit cups, salads and custard pudding; also ice cream; and can be made into pie or sauce or preserved whole in sirup. They are often made into jam, jelly, relish or pickles. Brazilians ferment the juice into vinegar or wine, and sometimes prepare a distilled liquor.

Food Value Per 100 g of Edible Portion*

Calories	43-51 g
Moisture	85.4-90.70 g
Protein	0.84-1.01 g
Fat	0.4-0.88 g
Carbohydrates	7.93-12.5 g
Fiber	0.34-0.6g
Ash	0.34-0.5 g
Calcium	9 mg
Phosphorus	11 mg
Iron	0.2 mg
Carotene (Vitamin A)	1,200-2,000 I.U.
Thiamine	0.03 mg
Riboflavin	0.04 mg
Niacin	0.03 mg
Ascorbic Acid**	20-30 mg

*A composite of analyses made in Hawaii, Africa, Florida.

**Dr. Margaret Mustard found 33.9-43.9 mg in ripe red fruits; 25.3 in the "black" type.

Toxicity

The seeds are extremely resinous and should not be eaten. Diarrhea has occurred in dogs that have been fed the whole fruits by children. The strong, spicy emanation from bushes being pruned irritates the respiratory passages of sensitive persons.

Other Uses

The **leaves** have been spread over the floors of Brazilian homes. When walked upon, they release their pungent oil which repels flies. The **bark** contains 20 to 28.5% tannin and can be used for treating leather. The **flowers** are a rich source of pollen for honeybees but yield little or no nectar.

Medicinal Uses: In Brazil the leaf infusion is taken as a stomachic, febrifuge and astringent. In Surinam, the leaf decoction is drunk as a cold remedy and, in combination with lemongrass, as a febrifuge. The leaves yield essential oil containing citronellal, geranyl acetate, geraniol, cineole, terpinene, sesquiterpenes and polyterpenes.

Morton, J. 1987. Rumberry. p. 388–390. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Rumberry

Myrciaria floribunda Berg.

Myrciaria protracta Berg.

Eugenia floribunda West ex Willd.

A tiny fruit, formerly in demand, the rumberry, *Myrciaria floribunda* Berg. (syns. *M. protracta* Berg.; *Eugenia floribunda* West ex Willd.), is also called guavaberry, *mirto* or *murta* in Puerto Rico; guaveberry in St. Martin and St. Eustatius; *guayabillo* in Guatemala; *coco-carette, merisier-cerise*, or *bois de basse batard* in Guadeloupe and Martinique; *cabo de chivo* in El Salvador; *escobillo* in Nicaragua; *mije* or *mije colorado* in Cuba; *mijo* in the Dominican Republic; *bois mulatre* in Haiti; *roode bosch guave, saitjaberan,* or *kakrioe hariraroe tataroe* in Surinam. In Venezuela the names *guayabito* and *guayabillo blanco* are applied to the related species, *M. caurensis* Steyerm, as well as to some other plants.

Description

This is an attractive shrub or slender tree reaching 33 or even 50 ft (10-15 m) in height, with reddish-brown branchlets, downy when young, and flaking bark. The evergreen, opposite leaves are ovate, elliptical, or oblong-lanceolate, pointed at the apex; 1 to 3 3/16 in (2.5-8 cm) long, 1/3 to 1 3/16 in (0.8-3 cm) wide; glossy, slightly leathery, minutely dotted with oil glands. The flowers, borne in small axillary or lateral clusters, are white, silky-hairy with about 75 prominent white stamens. The fruit is round or oblate, 5/16 to 5/8 in (8-16 mm) in diameter; dark-red (nearly black) or yellow-orange; highly aromatic and of bittersweet, balsam-like flavor; with one globular seed. In Surinam, according to Pulle, there are sometimes deformed fruits, rounded, flattened, leathery, dehiscent, and to 3/4 in (2 cm) across.

Plate LIV: RUMBERRY, *Myrciaria floribunda*

Origin and Distribution

The rumberry occurs wild over a broad territory–Cuba, Hispaniola, Jamaica, Puerto Rico (including Vieques), the Virgin Islands, St. Martin, St. Eustatius, St. Kitts, Guadeloupe, Martinique, Trinidad, southern Mexico, Belize, Guatemala, El Salvador to northern Colombia; also Guyana, Surinam and French Guiana, and eastern Brazil. It has been occasionally cultivated in Bermuda, rarely elsewhere, but, throughout its natural range, when land is cleared for pastures, the tree is left standing for the sake of its fruits. The plant was introduced into the Philippines in the early 1900's and has been included in propagation experiments in Hawaii. There is a healthy fruiting specimen at Fairchild Tropical Garden, Miami.

Varieties

O.W. Barrett wrote in 1928: "There are 3 or 4 varieties in the dry hills of St. Croix; these vary as to size and color, but all are intensely aromatic." In St. John, they say the fruits produced by wild trees on Bordeaux Mountain and along Reef Bay Trail are "unusually good".

Climate and Soil

In Puerto Rico, the rumberry grows naturally in dry and moist coastal forests from sea-level to an elevation of 700 ft (220 m). In Vieques and the Virgin Islands, it abounds in dry forests up to 1,000 ft (300 m). In South Florida it is growing well, but as a small tree, on oolitic limestone.

Food Uses

In Cuba, the fruits are relished out-of-hand and are made into jam, and the fermented juice is rated as *"una bebida exquisita"* (an exquisite beverage). People on the island of St. John use the preserved fruits in tarts. The local "guavaberry liqueur" is made from the fruits "with pure grain alcohol, rum, raw sugar and spices" and it is a special treat at Christmastime. In the past, a strong wine and a heavy liqueur were exported from St. Thomas to Denmark in "large quantities".

Other Uses

In Camaguey, Cuba, the rumberry is included among the nectar sources visited by honeybees.

Medicinal Uses: The fruits are sold by herbalists in Camaguey for the purpose of making a depurative sirup; and the decoction is taken as a treatment for liver complaints.

Related Species

The **camu-camu,** *Myrciaria dubia* McVaugh (syns. *M. paraensis* Berg; *M. spruceana* Berg), is also called *camocamo* in Peru and *cacari* in Brazil. It is a shrub, or bushy tree, to 43 ft (13 m) high with minute prickly hairs on the young branchlets and petioles. The opposite leaves are broad- or narrow-ovate, or elliptic, often lop-sided; 1 3/4 to 4 in (4.5-10 cm) long and 5/8 to 1 3/4 in (1.6-4.5 cm) wide, pointed at the apex, rounded at the base where the margins curve inward to the petiole, forming winglike appendages. Fragrant flowers, nearly sessile, are borne in 4's in or near the leaf axils; have tiny, white petals and about 125 stamens 1/4 to 3/8 in (6-10 mm) long. The fruit is nearly round, 3/8 to 1 in (1-2.5 cm) wide, yellow at first, becoming maroon to purple-black and soft and juicy when ripe. It is of acid or sweet flavor and contains 3 seeds. Locally it is considered good fish food.

This species occurs abundantly wild in swamps along rivers and lakes, especially the Rio Mazán near Iquitos, Peru, and in Amazonian Brazil and Venezuela, often with the base of the trunk under water, and, during the rainy season, the lower branches are also submerged for long periods.

Seeds were brought to Florida by William F. Whitman in 1964, and plants were raised, he says, in an "acid hammock sand soil" and regularly watered. One plant bore rather heavily in 1972, mainly in late summer with a few scattered fruits the following winter. One plant was 12 ft (3.65 m) tall and equally broad in 1974. In Brazil, the fruit is borne mainly from November to March.

Half-ripe fruits have been found to contain 1,950 to 2,700 mg of ascorbic acid per 100 g edible portion, values comparable to the high ranges of the Barbados cherry, q.v. These findings led to a certain amount of exploitation of the fruit, which must be harvested by boat. There is a trial plot at Manaus, Brazil, and some experimental plantings in Peru and the juice is frozen or bottled and exported to the United States for the production of "vitamin C" tablets for the "health food" market. In plantations, in non-flooded land a single plant may bear 400 to 500 fruits. On flooded land, the per-plant harvest has been 1,000 fruits.

Though there are still people who can be persuaded to believe that "natural vitamin C" is superior to synthetic, the commercial prospects for the camu-camu are no brighter than those for the Barbados cherry. In 1969, V.L.S. Charley, Consultant to Beecham Products, Brentford, England, in assessing prospects for the camu-camu, with its "very slight flavour characteristics", declared that the idea that natural vitamin C, *per se,* had some magical quality is not now acceptable ... there is little doubt that the presence of a full, clean, well-balanced flavour is more commercially important than the possession of a high ascorbic acid content."

Morton, J. 1987. Grumichama. p. 390–391. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Grumichama

Eugenia brasiliensis Lam.

Eugenia dombeyi Skeels

An often admired but still very minor fruiting member of the Myrtaceae, the grumichama, *Eugenia brasiliensis* Lam. (syn. *E. dombeyi* Skeels), is also called *grumixama*, *grumichameira*, or *grumixameira* in Brazil, and sometimes Brazil cherry elsewhere.

Description

The highly ornamental tree is slender, erect, usually to 25 or 35 ft (7.5-10.5 m) high, short-trunked and heavily foliaged with opposite, oblong-oval leaves 3 1/2 to 5 in (9-16 cm) long, 2 3/8 in (5-6 cm) wide, with recurved margin; glossy, thick, leathery, and minutely pitted on both surfaces. They persist for 2 years. New shoots are rosy. The flowers, borne singly in the leaf axils, are 1 in (2.5 cm) wide; have 4 green sepals and 4 white petals, and about 100 white stamens with pale-yellow anthers. The long-stalked fruit is oblate, 1/2 to 3/4 in (1.25-2 cm) wide; turns from green to bright-red and finally dark-purple to nearly black as it ripens, and bears the persistent, purple- or red-tinted sepals, to 1/2 in (1.25 cm) long, at its apex. The skin is thin, firm and exudes dark-red juice. The red or white pulp is juicy and tastes much like a true subacid or sweet cherry

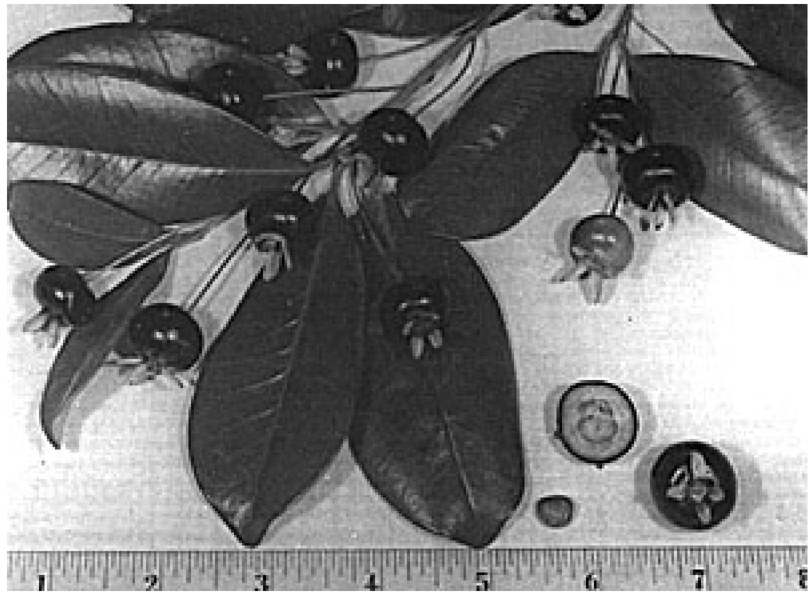

Fig. 105: The grumichama *(Eugenia brasiliensis)* is more cherry-like than many so-called "cherries" but handicapped by small size, apical sepals and large seeds.

except for a touch of aromatic resin. There may be 1 more or less round, or 2 to 3 hemispherical, hard, light-tan or greenish-gray seeds to 1/2 in (1.25 cm) wide and half as thick.

Origin and Distribution

The grumichama is native and wild in coastal southern Brazil, especially in the states of Parana and Santa Catarina. It is cultivated in and around Rio de Janeiro, also in Paraguay. A specimen was growing in Hope Gardens, Jamaica, in 1880 and a tree was planted in the Botanical Gardens, Singapore, in 1888, fruited in 1903. It has long since vanished from both of these locations. An attempt to grow it in the Philippines in the early 1920's did not meet with success. Neither did a trial in Israel. An early introduction, perhaps by Don Francisco de Paula Marin in 1791, was made in Hawaii and the tree was adopted into numerous local gardens.

The United States Department of Agriculture received seeds from Mauritius in 1911 (S.P.I. #30040); plants and seeds from Bahia, Brazil, in 1914 (S.P.I. #36968), and more seeds from Mauritius in 1922 (S.P.I. #54797). Plants were set out at the Plant Introduction Station in Miami and prospered. Other plantings were made in California where it seemed even better adapted but has apparently disappeared. The United States Department of Agriculture raised seedlings at Puerto Arturo, Honduras, and transferred some plants to the Lancetilla Experimental Garden at Tela in 1926. They flourished there and flowered and fruited well.

Over the years there have been mild efforts to encourage interest in the virtues of the grumichama in Florida, mainly because of the beauty and hardiness of the tree and the pleasant flavor of the fruit but the sepals are a nuisance and there is too little flesh in proportion to seed for the fruit to be taken seriously.

Varieties

Variety *leucocarpus* Berg. in Brazil becomes a large tree to 65 ft (20 m) high and has fruits with white flesh. It is not as common as the red-fleshed type.

Climate

The grumichama is subtropical, surviving temperatures of 26º F (-3.33º C) in Brazil. It is better suited to Palm Beach than to southern Florida. In Hawaii, the tree fruits best from sea-level to an altitude of no more than 300 ft (90 m).

Soil

The grumichama does better on acid sand in Central Florida than it does on limestone in the south.

It is reported to prefer deep, fertile, sandy loam. Sturrock says it grows well in rich clay in Cuba but is adversely affected by the long, dry season.

Propagation

Wilson Popenoe stated that propagation in Brazil is entirely by seeds which remain viable for several weeks and germinate in about a month. Fenzi says that seeds, cuttings and air-layers are employed, and Sturrock has mentioned that grafting is easy.

Culture

The grumichama is of slow growth when young unless raised in a mixture of peat moss and sand and then given a thick layer of peat moss around the roots when setting out, and kept heavily fertilized. In Hawaii, it has taken 7 years to reach 7 ft. Fruiting begins when the plants are 4 to 5 years old.

Season

The tree is regarded as remarkable for the short period from flowering to fruiting. In Florida, it has been in full bloom in late April and loaded with fruits 30 days later. The crop ripens quickly over just a few days. In Hawaii, the trees bloom and fruit from July to December, with the main crop in the fall. Trees in Brazil vary considerably in time of flowering and fruiting so that the overall season extends from November to February.

Pests

In Hawaii, the fruits are heavily attacked by the Mediterranean fruit fly.

Food Uses

Fully ripe grumichamas are pleasant to nibble out-of-hand. in Hawaii, half-ripe fruits are made into pie, jam or jelly.

Food Value Per 100 g of Edible Portion*

Moisture	83.5 g
Protein	0.102 g
Fiber	0.6 g
Ash	0.43 g
Calcium	39.5 mg
Phosphorus	13.6 mg
Iron	0.45 mg
Carotene	0.039 mg
Thiamine	0.044 mg
Riboflavin	0.031 mg
Niacin	0.336 mg
Ascorbic Acid	18.8 mg

*Analyses made in Honduras.

Medicinal Uses

The bark and leaves contain 1.5% of essential oil. The leaf or bark infusion–1/3 oz (10 g) of plant material in 10 1/2 oz (300 g) water-is aromatic, astringent, diuretic and taken as a treatment for rheumatism at the rate of 2 to 4 cups daily, in Brazil.

Morton, J. 1987. Pitomba. p. 392. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Pitomba

Eugenia luschnathiana Klotzsch ex O. Berg.

Phyllocalyx luschnathianus Berg.

The pitomba, *Eugenia luschnathiana* Klotzsch ex O. Berg. (syn. *Phyllocalyx luschnathianus* Berg.) is also called *uvalha do campo*, *ubaid do campo*, or *uvalheira* in Brazil.

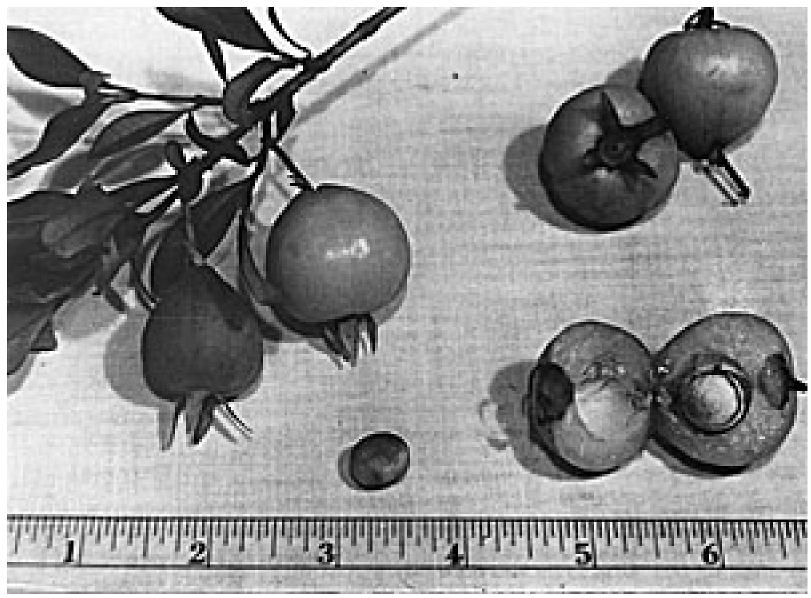

Fig. 106: Little-known, the orange-yellow pitomba *(Eugenia luschnathiana)* is of fair size and thick-fleshed when well-irrigated and fertilized.

It is an attractive, slow-growing tree to 20 or 30 ft (6-9 m) high, with dense foliage. The evergreen, opposite, short-petioled, oblong-lanceolate leaves, 1 to 3 in (2.5-7.5 cm) long, are glossy, dark-green on the upper surface, paler beneath. New growth is temporarily coated with bronze hairs on the underside. The long-stalked, 4-petalled, white flowers are borne singly in the leaf axils.

The fruit, broad-obovate, faintly 4-lobed, 1 to 1 1/4 in (2.5-3.2 cm) long, is bright orange-yellow with 4 or 5 green sepals 1/2 in (1.25 cm) long protruding from the apex. The skin is thin, tender, and the pulp golden-yellow, apricot-like in texture, soft, melting, juicy, aromatic and slightly acid, faintly resinous in flavor. In the central cavity there may be one round seed or 2 to 4 irregular, angular seeds, light-tan and 3/8 to 5/8 in (1-1.6 cm) in diameter.

This little-known species is native to the State of Bahia, Brazil, is cultivated to a limited extent locally and is grown in the botanical garden in Rio de Janeiro. Seeds were brought to the United States from Brazil by plant explorers for the federal Department of Agriculture in 1914 (S.P.I. #37017). A very few specimens, scarcely more than shrubs, have been grown to the fruiting stage in southern Florida. The pitomba was at first considered promising for this area but has made no progress at all in the last 40 years.

When in good soil, well-fertilized and frequently and heavily watered, the tree begins to bear when less than 3 1/2 ft (a little over 1 m) high. There is much variation in the size of fruits produced by seedlings. Sturrock made some selections and grafted them successfully. Flowers appear in late spring and early summer in Florida and the fruiting season is in midsummer. In Brazil the fruits ripen in November and December. The fruits are there used mainly for jelly, preserves, and carbonated beverages.

Morton, J. 1987. Sapodilla. p. 393–398. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sapodilla

Manilkara zapota van Royen

Manilkara achras Fosb.

Manilkara zapotilla Gilly

One of the most interesting and desirable of all tropical fruit trees, the sapodilla, a member of the family Sapotaceae, is now known botanically as *Manilkara zapota* van Royen (syns. *M. achras* Fosb., *M. zapotilla* Gilly; *Achras sapota* L., *A. zapota* L.; *Sapota achras* Mill.).

Among numerous vernacular names, some of the most common are: *baramasi* (Bengal and Bihar, India); *buah chiku* (Malaya); *chicle* (Mexico); *chico* (Philippines, Guatemala, Mexico);

chicozapote (Guatemala, Mexico, Venezuela); *chikoo* (India); *chiku* (Malaya, India); dilly (Bahamas; British West Indies); *korob* (Costa Rica); *mespil* (Virgin Islands); *mispel, mispu* (Netherlands Antilles, Surinam); *muy* (Guatemala); *muyozapot* (El Salvador); naseberry (Jamaica; British West Indies); neeseberry (British West Indies; *nispero* (Puerto Rico, Central America, Venezuela); *nispero quitense* (Ecuador); sapodilla plum (India); *sapota* (India); sapotí (Brazil); sapotille (French West Indies); tree potato (India); *Ya* (Guatemala; Yucatan); *zapota* (Venezuela); *zapote* (Cuba); *zapote chico* (Mexico; Guatemala); *zapote morado* (Belize); *zapotillo* (Mexico).

Description

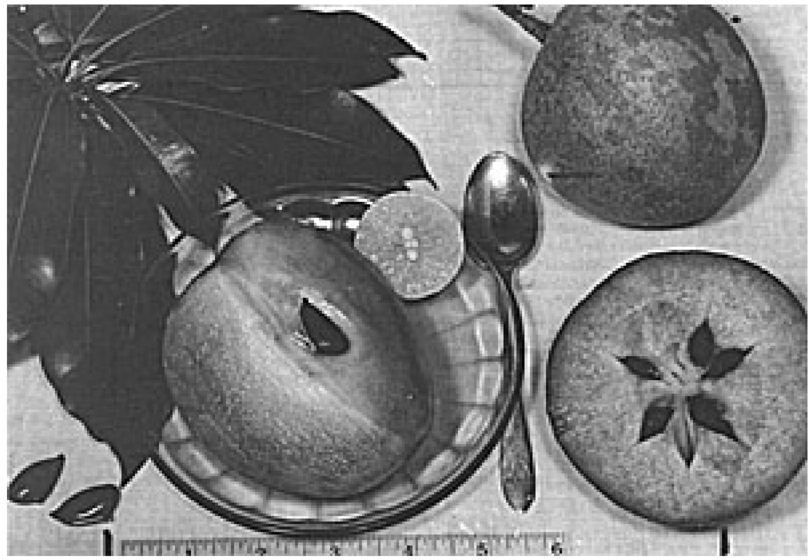

Fig. 107: The sapodilla *(Manilkara zapota) is* sweet, luscious, practical and borne abundantly by a handsome, drought- and wind-resistant tree.

The sapodilla is a fairly slow-growing, long-lived tree, upright and elegant, distinctly pyramidal when young; to 60 ft (18 m) high in the open but reaching 100 ft (30 m) when crowded in a forest. It is strong and wind-resistant, rich in white, gummy latex. Its leaves are highly ornamental, evergreen, glossy, alternate, spirally clustered at the tips of the forked twigs; elliptic, pointed at both ends, firm, 3 to 4 1/2 in (7.5-11.25 cm) long and 1 to 1 1/2 in (2.5-4 cm) wide. Flowers are small and bell-like, with 3 brown-hairy outer sepals and 3 inner sepals enclosing the pale-green corolla and 6 stamens. They are borne on slender stalks at the leaf bases. The fruit may be nearly round, oblate, oval, ellipsoidal, or conical; varies from 2 to 4 in (5-10 cm) in width. When immature it is hard, gummy and very astringent. Though smooth-skinned it is coated with a sandy brown scurf until fully ripe. The flesh ranges in color from yellowish to light- or dark-brown or sometimes reddish-brown; may be coarse and somewhat grainy or smooth; becomes soft and very juicy, with a sweet flavor resembling that of a pear. Some fruits are seedless, but normally there may be from 3 to 12 seeds which are easily removed as they are loosely held in a whorl of slots in the center of the fruit. They are brown or black, with one white margin; hard, glossy; long-oval, flat, with usually a distinct curved hook on one margin; and about 1/4 in (2 cm) long.

Origin and Distribution

The sapodilla is believed native to Yucatan and possibly other nearby parts of southern Mexico, as well as northern Belize and Northeastern Guatemala. In this region there were once 100,000,000 trees. The species is found in forests throughout Central America where it has apparently been cultivated since ancient times. It was introduced long ago throughout tropical America and the West Indies, the Bahamas, Bermuda, the Florida Keys and the southern part of the Florida mainland. Early in colonial times, it was carried to the Philippines and later was adopted everywhere in the Old World tropics. It reached Ceylon in 1802.

Cultivation is most extensive in coastal India (Maharastra, Gujarat, Andhra Pradesh, Madras and Bengal States), where plantations are estimated to cover 4,942 acres (2,000 ha), while Mexico has 3,733.5 acres (1,511 ha) devoted to the production of fruit (mainly in the states of Campeche and

Veracruz) and 8,192 acres (4,000 ha) primarily for extraction of chicle (see under "Other Uses") as well as many dooryard and wild trees. Commercial plantings prosper in Sri Lanka, the Philippines, the interior valleys of Palestine, as well as in various countries of South and Central America, including Venezuela and Guatemala.

Cultivars

In most areas, types are distinguished merely by shape, as 'Round' and 'Oval' in Saharanpur, India. Several named cultivars are grown for commercial or home use in western and southern India: **'Kalipatti',** small, early, high quality; **'Calcutta Special',** large, late; **'Pilipatti',** small, midseason to late; **'Bhuripatti',** small, midseason; **Jumakhia',** small, in clusters, late; **'Mohan Gooti',** small, midseason, not very sweet; **'Kittubarti',** very small, ridged, very sweet; **'Kittubarti Big',** large, but of inferior quality; **'Cricket Ball',** very large, with crisp, granular, very sweet flesh but not distinctive in flavor; **'Dwarapudi',** similar, but not quite as big, sweet and very popular; **'Bangalore'**, large, ridged, and **'Vavivalasa'** are oval and popular in the Circars but are only medium-sweet and bear poorly.

Other prominent cultivars in India are **'Jonnavalosa-I',** of medium size, pale-fleshed, sweet; **'Jonnavalosa-Il',** of medium size, ridged, with yellowish-pink flesh, sweet but not agreeable in flavor; **'Jonnavalosa Round',** large, ridged, with cream-colored flesh, very sweet; **'Gauranga'**, small, lop-sided, ridged, very sweet, bears heavily; **'Ayyangar'**, large, very thick-skinned, sweet, rose-scented; **'Thagarampudi',** of medium size, thin-skinned, very sweet; **'Oaka',** small, rounded to oval, of good flavor and popular. Among the lesser-known are **'Badam', 'Bhuri', 'Calcutta Round', 'CO. 1'** ('Cricket Ball' X 'Long Oval'), **'Dhola diwani', 'Fingar', 'Gavarayya', 'Guthi', 'Kali',** and **'Vanjet'.**

A dwarf type called **'Pot'** bears early and can be maintained as a pot specimen for 10 years.

Henry Pittier, in 1914, described what he deemed a "remarkable variety" called *nispero de monte* at Patiño, Panama. The trees do not exceed 26 ft (8 m) in height and bear small, oblate fruits in dense clusters.

In Indonesia, sapodillas are classed in two main groups: 1) Sawo maneela, normal-size trees having narrow, pointed leaves; and 2) Sawo apel, low, shrublike trees, with oblong leaves broadest above the middle. Belonging to group #1 are the common cultivars **'Sawo betawi'** (fruit large, in clusters of 2-4, popular, perishable, ripening in 3 days from picking); **'Sawo koolon'** (fruit large, solitary, thick skinned, with firm flesh, shipping well); **'Sawo madja'** (large, with persistent scurf, pulp of fine texture, sweet with an acid tang). Belonging to group #2 are **'Sawo apel bener'** (fruits small in clusters of 3-6, thick-skinned); **'Sawo apel klapa'** (fruits medium-size, with persistent scurf). Some others are little grown because the fruits are either very small, too sandy, too gummy, or too dry.

In Mexico, some superior selections are known merely as **'SCH-02','SCH-03','SCH-07', 'SCH-08',** and **'SCH-28'.**

In Florida, seedling selections of high quality have been named and vegetatively reproduced. The first of these was **'Russell'** from Islamorada in the Florida Keys, named and propagated by R.H. Fitzpatrick. It is nearly round, up to 4 in (10 cm) in diameter and length, brown-scurfy with gray patches, and luscious, reddish flesh. It is not a dependable bearer. The second, **'Prolific',** a seedling grown at the Agricultural Research and Education Center, Homestead, and released in 1941, is round-conical, 2 1/2 to 3 1/2 in (6.25-9 cm) long and broad, with smooth, pinkish-tan flesh. The skin is lighter than that of the 'Russell' and tends to lose much of the scurf as it ripens. The tree bears early, consistently and heavily. Of later selection, **'Modello'** is a good quality fruit but not a heavy producer; **'Seedless'** yields poorly; **'Brown Sugar'** is a good, regular, high yielder; handles and keeps well.

Some introduced cultivars being tested in Florida include: **'Boetzberg', 'Larsen', 'Morning Star', 'Jamaica 8',** and **'Jamaica 10'. 'Tikal',** a recent seedling selection, seems very promising. It is light-brown, elliptic to conical, much smaller than 'Prolific', but of excellent flavor and comes into season very early. Several cultivars not recommended because of low yield in southern Florida are **'Addley', 'Adelaide', 'Big Pine Key', 'Black', 'Jamaica No. 4', 'Jamaica No. 5', 'Martin'** and **'Saunders'.**

In 1951, in Jamaica, I visited an English gentleman who had a very special sapodilla tree which bore great quantities of tiny sapodillas, no more than 1 1/2 in (4 cm) in diameter. They were all seedless and he served them chilled, whole.

In the Philippines, selected cultivars, **'Ponderosa', 'Java', 'Sao Manila', 'Native', 'Formosa', 'Rangel',** and the 'Prolific' from Florida are maintained by the Bureau of Plant Industry for propagation and distribution to farmers. 'Sao Manila' fruits mature in 190 days and ripen 3 to 5 days after picking.

Hybridization studies have been conducted in India.

Climate

The sapodilla grows from sea level to 1,500 ft (457 m) in the Philippines, up to 4,000 ft (1,220 m) in India, to 3,937 ft (1,200 in) in Venezuela, and is common around Quito, Ecuador, at 9,186 ft (2,800 m). It is not strictly tropical, for mature trees can withstand temperatures of 26º to 28º F (-3.33º to -2.2º C) for several hours. Young trees are tenderer and apt to be killed by 30º F (-1.11º C) unless the stem is banked with sand or wrapped with straw and burlap during the cold spell. A number of sapodilia trees have lived for a few years in California without fruiting and then have succumbed to cold. Cool nights are considered a constant limiting factor. However, I have learned of one tree in a protected location in the Sacramento Valley that has survived for many years, reaching a large size and fruiting regularly. The sapodilla seems equally at home in humid and relatively dry atmospheres.

Soil

The sapodilla grows naturally in the calcareous marl and disintegrated limestone of its homeland, therefore it should not be surprising that it is so well adapted to southern Florida and the Florida Keys. Nevertheless, it flourishes also in deep, loose, organic soil, or on light clay, diabase, sand or lateritic gravel. Good drainage is essential, the tree bearing poorly in low, wet locations. It is highly drought-resistant, can stand salt spray, and approaches the date palm in its tolerance of soil salinity, rated as ECe 14.20.

Propagation

Seeds remain viable for several years if kept dry. The best seeds are large ones from large fruits. They germinate readily but growth is slow and the trees take 5 to 8 years to bear. Since there is great variation in the form, quality and yield of fruits from seedling trees, vegetative propagation has long been considered desirable but has been hampered by the gummy latex. In India, several methods are practiced: grafting, inarching, ground-layering and air-layering. Grafts have been successful on several rootstocks: sapodilla, *Bassia latifolia, B. longifolia, Sideroxylon dulcificum* and *Mimusops hexandra.* The last has been particularly successful, the grafts growing vigorously and fruiting heavily.

In Florida, shield-budding, cleft-grafting and side-grafting were moderately successful but too slow for large-scale production. An improved method of side-grafting was developed using year-old seedlings with stems 1/4 in (6 mm) thick. The scion (young terminal shoot) was prepared 6 weeks to several months in advance by girdling and defoliating. Just before grafting the rootstock was scored just above the grafting site and the latex "bled" for several minutes. After the stock was notched and the scion set in, it was bound with rubber and given a protective coating of wax or asphalt. The scion started growing in 30 days and the rootstock was then beheaded. Some years later, further experiments showed that better results were obtained by omitting the pre-conditioning of the scion and the bleeding of the latex. The operator must work fast and clean his knife frequently. The scions are veneer-grafted and then completely covered with plastic, allowing free gas exchange while preventing dehydration. Success is deemed most dependent on season: the 2 or 3 months of late summer and early fall.

In the Philippines, terminal shoots are completely defoliated 2 to 3 weeks before grafting onto rootstock which has been kept in partial shade for 2 months. However, inarching is there considered superior to grafting, giving a greater percentage of success. Homeowners often find air-layering easier and more successful than grafting, and air-layered trees often begin bearing within 2 years after planting.

In India, 50% success has been realized in top-working 20-year-old trees--cutting back to 3 1/2 ft (1 m) from the ground and inserting scions of superior cultivars.

Culture

Seedlings for grafting are best grown in full sun, kept moist and fertilized with 8-4-8 N P K every 45 days.

Trees set out in commercial groves should be spaced 30 to 45 ft (9-13.5 m) apart each way.

In India, the plants are placed in deep, pre-fertilized pits and manured twice a year, sometimes with the addition of castor bean meal or residue of neem seed *(Azadirachta indica* A. Juss.), wood ash and/or ammonium sulfate. In an experiment at Marathwada Agricultural University, Parbhani, India, with 8-year-old trees planted at 12 m, application of 28 oz (800 g) N/tree increased trunk size and number and weight of fruits. Combined application of this amount of N plus 6 1/4 oz (176 g) P and 5 3/4 oz (166 g) K/tree gave the highest fruit yield. Fertilizer experiments over a period of 25 years at Gujarat Agricultural University revealed that N alone increases yield by 70%, a combination of N and P elevates yield by 90%, and combined N and K, 128%, over that of control (unfertilized) trees. Of course, optimum nutrient formulas depend on the character of the soil. In South Florida's limestone a mixed fertilizer of N, P, K, Mg in a 4-7-5-3 ratio is recommended in spring, summer and fall.

Most mature sapodilla trees receive no watering, but irrigation in dry seasons will increase productivity. In some parts of India, brackish or saline water is sometimes used to reduce vegetative growth and promote fruiting.

Season

The fruits mature 4 to 6 months after flowering. In the tropics, some cultivars bear almost continuously. In India, the main season is from December to March. The trees bear from May to September in Florida, with the peak of the crop in June and July. In Mexico, there are two peak seasons: February-April and October-December.

Harvesting

Most people find it difficult to tell when a sapodilla is ready to pick. With types that shed much of the "sand" on maturity, it is relatively easy to observe the slight yellow or peach color of the ripe skin, but with other types it is necessary to rub the scurf to see if it loosens readily and then scratch the fruit to make sure the skin is not green beneath the scurf. If the skin is brown and the fruit separates from the stem easily without leaking of the latex, it is fully mature though still hard and must be kept at room temperature for a few days to soften. It is best to wash off the sandy scurf before putting the fruit aside to ripen. It should be eaten when firm-soft, not mushy.

In the Bahamas, children bury their "dillies" in potholes in the limestone to ripen, or the fruits may be wrapped in sweaters or other thick material and put in drawers to hasten softening. Fruits picked immature will shrivel as they soften and will be of inferior quality, sometimes with small pockets of gummy latex.

In commercial groves, it is judged that when a few fruits have softened and fallen from the tree, all the full-grown fruits may be harvested for marketing. If in any doubt, the grower should cut open a few fruits to make sure the seeds are black (or very dark-brown). Pickers should use clippers or picking poles with bag and sharp notch at the peak of the metal frame to cut the fruit stem.

In India, the fruits are spread out in the shade to allow any latex at the stem end to dry before packing. The fruits ship well with minimal packing.

Yield

The 'Prolific' sapodilla yields 6 to 9 bushels per tree annually; or, 200 to 450 lbs (90 to 180 kg). 'Brown Sugar' yields 5 to 8 bushels. In India, it is said that a productive tree will bear 1,000 fruits in its 10th year and the yield increases steadily. At 30-35 years of age, the tree should produce 2,500 to 3,000 fruits annually. A great deal depends on the cultivar. A 10-year-old 'Oval' tree gave 1,158 fruits weighing 184 lbs (128.8 kg), while a 10-year-old 'Cricket Ball' bore 353 fruits weighing 112 lbs (50 kg). Hand-pollination has been found to increase fruit set.

Keeping Quality and Storage

Mature, hard sapodillas will ripen in 9 to 10 days and rot in 2 weeks at normal summer temperature and relative humidity. More than 50 years ago, sapodillas were shipped from Java to Holland, held at 40º-50º F (4.44-10º C) for 3 days, and they ripened satisfactorily after arrival.

They were smoked over burning straw for a few hours before packing. Storage trials in Malaya demonstrated that mature, hard sapodillas stored at 68º F (20º C) win ripen in 10 days and remain in good condition for another 5 days. In Venezuela, mature fruits held at 68º F (20º C) and 90% relative humidity were in excellent condition at the end of 23 days. Lower temperatures, in efforts to prolong storage life, seriously retard ripening and lower fruit quality. Low relative humidity causes shriveling and wrinkling. Humid conditions promote sogginess. If long storage is necessary, the fruits may be kept at 59º-68º F (15º-20º C) in a controlled atmosphere of 85-90% relative humidity, 5-10% (v/v) CO_2,with total removal Of C2H4 to delay ripening.

Firm-ripe sapodillas may be kept for several days in good condition in the home refrigerator. At 35º F (1.67º C), they can be kept for 6 weeks. Fully ripe fruits frozen at 32º F (0º C) keep perfectly for 33 days.

Pests and Diseases

In general, the sapodilla tree remains supremely healthy with little or no care. In India, it is sometimes attacked by a bark-borer, *Indarbela (Arbela) tetraonis.* Mealybugs may infest tender shoots and deface the fruits. A galechid caterpillar *(Anarsia)* has caused flower buds and flowers to dry up and fall. In Indonesia, caterpillars of *Tarsolepis remicauda* may completely defoliate the tree. A caterpillar, *Nephopteryx engraphella,* feeds on the leaves, flower buds and young fruits in parts of India. The ripening and overripe fruits are favorite hosts of the Mediterranean, Caribbean, Mexican and other fruit flies.

Various scales, including *Howardia biclavis, Pulvinaria* (or *Chloropulvinaria) psidii, Rastrococcus iceryoides,* and pustule scale, *Asterolecanium pustulans* Ckll., may lead to black sooty mold caused by the fungus *Capnodium sp.* on stems, foliage and fruits. In some years, during winter and spring in Florida, a rust (possibly *Uredo sapotae)* may affect the foliage of some cultivars. A leaf spot *(Septoria* sp.) has caused defoliation in a few locations. The moth of a leaf miner *(Acrocercops gemoniella)* is active on young leaves. Other minor enemies have been occasionally observed.

In India, it may be necessary to spread nets over the tree to protect the fruits from fruit bats.

Food Uses

Generally, the ripe sapodilla, unchilled or preferably chilled, is merely cut in half and the flesh is eaten with a spoon. It is an ideal dessert fruit as the skin, which is not eaten, remains firm enough to serve as a "shell". Care must be taken not to swallow a seed, as the protruding hook might cause lodging in the throat. The flesh, of course, may be scooped out and added to fruit cups or salads. A dessert sauce is made by peeling and seeding ripe sapodillas, pressing the flesh through a colander, adding orange juice, and topping with whipped cream. Sapodilla flesh may also be blended into an egg custard mix before baking.

It was long proclaimed that the fruit could not be cooked or preserved in any way, but it is sometimes fried in Indonesia and, in Malaya, is stewed with lime juice or ginger. I found that Bahamians often crush the ripe fruits, strain, boil and preserve the juice as a sirup. They also add mashed sapodilla pulp to pancake batter and to ordinary bread mix before baking. My own experiments showed that a fine jam could be made by peeling and stewing cut-up ripe fruits in water and skimming off a green scum that rises to the surface and appears to be dissolved latex, then adding sugar to improve texture and sour orange juice and a strip of peel to offset the increased sweetness. Skimming until all latex scum is gone is the only way to avoid gumminess. Cooking with sugar changes the brown color of the flesh to a pleasing red.

One lady in Florida developed a recipe for sapodilla pie. She peeled the ripe fruits, cut them into pieces as apples are cut, and filled the raw lower crust, sprinkled 1/2 cup of raisins over the fruit, poured over evenly 1/2 cup of 50-50 lime and lemon juice to prevent the sapodilla pieces from becoming rubbery, and then sprinkled evenly 1/2 cup of granulated sugar. After covering with the top crust and making a center hole to release steam, she baked for 40 minutes at 350º F (176.67º C). In India, it has been shown that ripe fruits can be peeled and sliced, packed in metal cans, heated for 10 minutes at 158º F (70º C), then treated for 6 minutes at a vacuum of 28 in Hg, vacuum double-seamed, and irradiated with a total dose of 4×10^5 rads at room temperature. This process provides an acceptable canned product.

Ripe sapodillas have been successfully dried by pretreatment with a 60% sugar solution and osmotic dehydration for 5 hours, and the product has retained acceptable quality for 2 months.

Mr. Edward Smith of Crescent Place, Trinidad, made sapodilla wine and told me that it was very good. Young leafy shoots are eaten raw or steamed with rice in Indonesia, after washing to eliminate the sticky sap.

Food Value

Immature sapodillas are rich in tannin (proanthocyanadins) and very astringent. Ripening eliminates the tannin except for a low level remaining in the skin.

Analyses of 9 selections of sapodillas from southern Mexico showed great variation in total soluble solids, sugars and ascorbic acid content. Unfortunately, the fruits were not peeled and therefore the results show abnormal amounts of tannin contributed by the skin:

Moisture ranged from 69.0 to 75.7%; ascorbic acid from 8.9 to 41.4 mg/100 g; total acid, 0.09 to 0.15%; pH, 5.0 to 5.3; total soluble solids, 17.4º to 23.7º Brix; as for carbohydrates, glucose ranged from 5.84 to 9.23%, fructose, 4.47 to 7.13%, sucrose, 1.48 to 8.75%, total sugars, 11.14 to 20.43%, starch, 2.98 to 6.40%. Tannin content, because of the skins, varied from 3.16 to 6.45%.

Toxicity

The seed kernel (50% of the whole seed) contains 1% saponin and 0.08% of a bitter principle, sapotinin. Ingestion of more than 6 seeds causes abdominal pain and vomiting.

Other Uses

Chicle: A major by-product of the sapodilla tree is the gummy latex called "chicle", containing 15% rubber and 38% resin. For many years it has been employed as the chief ingredient in chewing gum but it is now in some degree diluted or replaced by latex from other species and by synthetic gums.

Chicle is tasteless and harmless and is obtained by repeated tapping of wild and cultivated trees in

Yucatan, Belize and Guatemala. It is coagulated by stirring over low fires, then poured into molds to form blocks for export. Processing consists of drying, melting, elimination of foreign matter, combining with other gums and resins, sweeteners and flavoring, then rolling into sheets and cutting into desired units.

The dried latex was chewed by the Mayas and was introduced into the United States by General Antonio Lopez de Santa Ana about 1866 while he was on Staten Island awaiting clearance to enter this country. He had a supply in his pocket for chewing and gave a piece to the son of Thomas Adams. The latter at first considered the possibility of using it to make dentures, then decided it was useful only as a masticatory. He found he could easily incorporate flavoring and thus soon launched the chicle-based chewing-gum industry. In 1930, at the peak of production, nearly 14,000,000 lbs (6,363,636 kg) of chicle were imported.

Efforts have been made to extract chicle from the leaves and unripe fruit but the yield is insufficient. It has been estimated that 3,200 leaves would be needed to produce one pound (0.4535 kg) of gum.

Among miscellaneous uses: the latex is employed as birdlime, as an adhesive in mending small articles in India; it has been utilized in dental surgery, and as a substitute for gutta percha. The Aztecs used it for modeling figurines.

Timber: Sapodilla wood is strong and durable and timbers which formed lintels and supporting beams in Mayan temples have been found intact in the ruins. It has also been used for railway crossties, flooring, native carts, tool handles, shuttles and rulers. The red heartwood is valued for archer's bows, furniture, bannisters, and cabinetwork but the sawdust irritates the nostrils. Felling of the tree is prohibited in Yucatan because of its value as a source of chicle.

Bark: The tannin-rich bark is used by Philippine fishermen to tint their sails and fishing lines.

Medicinal Uses: Because of the tannin content, young fruits are boiled and the decoction taken to stop diarrhea. An infusion of the young fruits and the flowers is drunk to relieve pulmonary complaints. A decoction of old, yellowed leaves is drunk as a remedy for coughs, colds and diarrhea. A "tea" of the bark is regarded as a febrifuge and is said to halt diarrhea and dysentery. The crushed seeds have a diuretic action and are claimed to expel bladder and kidney stones. A fluid extract of the crushed seeds is employed in Yucatan as a sedative and soporific. A combined decoction of sapodilla and chayote leaves is sweetened and taken daily to lower blood pressure. A paste of the seeds is applied on stings and bites from venomous animals. The latex is used in the tropics as a crude filling for tooth cavities.

Morton, J. 1987. Sapote. p. 398–402. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Sapote

Pouteria sapota (Jacq.) H.E. Moore & Stearn

Pouteria mammosa (L.) Cronquist

Lucuma mammosa Gaertn.

*Achradelpha mammosa*Cook

The word "sapote" is believed to have been derived from the Aztec "tzapotl", a general term applied to all soft, sweet fruits. It has long been utilized as a common name for *Pouteria sapota* (Jacq.) H.E. Moore & Stearn (syns. *P. mammosa* (L.) Cronquist, *Lucuma mammosa* Gaertn., *Achradelpha mammosa* Cook, *Vitellaria mammosa* Radlk., *Calocarpum mammosum* Pierre, *C. sapota* Merrill, *Sideroxylon sapota* Jacq.). Alternate vernacular names include *sapota, zapote,*

zapote colorado, zapote mamey, lava-zapote, zapotillo, mamey sapote, mamee sapote, mamee zapote, mamey colorado, mamey rojo, mammee or *mammee apple* or red sapote. In El Salvador, it is known as *zapote grande*, in Colombia as *zapote de carne*; in Cuba, it is *mamey*, which tends to confuse it with *Mammea americana* L., a quite different fruit widely known by that name. The usual name in Panama is *mamey de la tierra*; in Haiti, *sapotier jaune d'oeuf*, or *grand sapotillier*; in Guadeloupe, *sapote à creme*; in Martinique, *grosse sapote*; in Jamaica, it is marmalade fruit or marmalade plum; in Nicaragua, it may be called *guaicume*; in Mexico, *chachaas* or *chachalhaas* or *tezonzapote*; in Malaya and the Philippines, *chico-mamei*, or *chico-mamey*.
The sapote belongs to the family Sapotaceae, the same family as the sapodilla (*Manilkara zapota* van Royen) which has also been called *sapote*, *zapote*, or *zapote chico* to distinguish it from the larger fruit.

Description


Plate LV: SAPOTE, *Pouteria sapota*

The sapote tree is erect, frequently to 60 ft (18 m) sometimes to 100 or 130 ft (30 or 40 m) with short or tall trunk to 3 ft (1 m) thick, often narrowly buttressed, a narrow or spreading crown, and white, gummy latex. The evergreen or deciduous leaves, clustered at the branch tips, on petioles 3/4 to 2 in (2-5 cm) long, are obovate, 4 to 12 in (10-30 cm) long, and 1 1/2 to 4 in (4-10 cm) wide, pointed at both ends. The small, white, to pale-yellow 5-parted flowers emerge in clusters of 6 to 12 in the axils of fallen leaves along the branches. The fruit may be round, ovoid or elliptic, often bluntly pointed at the apex, varies from 3 to 9 in (7.5-22.8 cm) long, and ranges in weight from 1/2 lb to 5 lbs (227 g-2.3 kg). It has rough, dark-brown, firm, leathery, semi-woody skin or rind to 1/16 in (1.5 mm) thick, and salmon-pink to deep-red, soft flesh, sweet and pumpkin-like in flavor, enclosing 1 to 4 large, slick, spindle-shaped, pointed seeds, hard, glossy-brown, with a whitish, slightly rough hilum on the ventral side. The large kernel is oily, bitter, and has a strong bitter-almond odor.

Origin and Distribution

The sapote occurs naturally at low elevations from southern Mexico to northern Nicaragua. It is much cultivated and possibly also naturalized up to 2,000 ft (600 m) and occasionally found up to 5,000 ft (1,500 m) throughout Central America and tropical South America. It is abundant in Guatemala. In the West Indies, it is planted to a limited extent from Trinidad to Guadeloupe, and in Puerto Rico, Haiti and Jamaica, but mainly in Cuba where it is often grown in home gardens and along streets and for shading coffee because it loses its leaves at the period when coffee plants need sun, and the fruit is extremely popular. It is grown only occasionally in Colombia, Ecuador, Venezuela and Brazil. It was introduced into the Philippines by the early Spaniards but is grown only around Cavite and Laguna on Luzon and Cagayan on Mindanao. From the Philippines, it was carried to southern Vietnam where the fruit is eaten when very ripe.

The sapote has existed in Florida for at least a century. The prominent horticulturist, Pliny Reasoner, included it in his report in the U.S. Department of Agriculture's Pomological Bulletin in 1887. Subsequently, seeds were brought into the United States on various occasions. In 1914, the Office of Foreign Seed and Plant Introduction received seeds from the Costa Rican National Museum, San José (P.I. #39357). Mr. Ramon Arias-Feraud supplied seeds from Panama in 1918 (P.I. #46236). In July, 1919, seeds from Laguna, Philippines, were sent by the Bureau of Agriculture, Manila (P.I. #47516). More seeds from Costa Rica were presented by Mr. Carlos Werckle in October, 1919 (P.I. #47956). Seeds of a superior selection were obtained and planted at the Federal Experiment Station, Mayaguez, Puerto Rico, in 1939.

Despite the favorable comments that accompanied these and other introductions, the sapote was represented by only a few scattered trees in southern Florida for a long time. One of the discouraging factors was the tree's slowness incoming into bearing. William J. Krome, a leading pioneer, planted a seedling on his property in Homestead in 1907 and it bore its first fruits in 1949, after having suffered repeated setbacks from freezes and hurricanes over the years, and it was then only 18 ft (5 1/2 m) high. Other trees in more protected locations had fared much better.

The arrival of many Cubans in Dade County during the past 2 decades has created an active demand for the fruits and for the trees for home planting, and some commercial orchards of 5 to 20 acres (2-8 1/3 ha) or more have been established. In 1983, one man with 15 trees in his backyard was selling the fruits to Cuban people and bringing in seedlings 5 ft (1 1/2 in) high from the Dominican Republic at $100 each. Such enthusiasm has spurred efforts to develop practical methods of vegetative propagation and one expert propagator is now selling grafted trees at $10.50 each, wholesale. In the fall of 1984, a nursery had acquired a stock of 1,000 of these trees and one customer bought them all. Thus has the status of the sapote risen dramatically in southern Florida because of an ethnic change in the population.

Varieties

There is much seedling variation in the sapote. Superior selections have been made in Cuba, Central America and in Florida in recent years. The following named cultivars are being cultivated domestically or commercially, or merely being tested in Florida:

'AREC No. 3'–Seed received from Isle of Pines, Cuba, 1940. Seedling grown at AREC, Homestead. Grafted trees planted later. Fruit medium to large, 14 to 26 oz (400-740 g). Flesh pink; of poor to good quality; contains 3-4 seeds. Ripens July-Sept. Tree of medium size, a fair bearer; probably useful source of seeds for rootstocks.

'Cayo Hueso'–A selection from the Dominican Republic; favored by Cubans.

'Chenox'–Obtained by Lawrence Zill from Belize. Grafted trees being tested at AREC, Homestead, and elsewhere.

'Copan' ('AREC No. 1')–Seed received from Cuba in 1938. Seedling set out in field at AREC, Homestead, 1940. Grafted trees planted out in 1975; later propagated by nurseries. Fruit of medium size; 15-32 oz (425-900 g). Flesh red, of excellent quality; contains 1 seed. Fruit ripens in July-Aug. Tree is of spreading habit and medium in size. Leaves turn red in Dec., then become brown and are shed in spring.

'Cuban No. 1'–Believed to have originated in Cuba but introduced from El Salvador. Fruit large; 9 in (22.8 cm) long; weighs 2.2 lbs (1 kg).

'Flores'–A Guatemalan selection introduced by Tom Economou of Miami and being tested at AREC, Homestead.

'Francisco Fernandez'–A Cuban selection named for the Miami man who introduced it into Florida.

'Magana'–Introduced from El Salvador in 1961. Seedling set in field at AREC, Homestead, in 1952. Grafted trees planted in 1975. Later propagated by nurseries. Fruit large to very large; 26 to 85 oz (740-2,400 g). Flesh pink, of good to excellent quality; contains 1 seed. Fruit matures in less than 12 mos (Apr.-May). Tree is small, slow-growing; may fruit 1 yr. after planting. Bears poorly in Puerto Rico; very well in Florida. Evergreen.

'Mayapan' ('AREC No. 2')–Seed sent from Isle of Pines, Cuba, in 1940. Fruit a little above medium size; 18 to 40 oz (510-1,135 g). Skin very scurfy. Flesh red, of good quality though slightly fibrous; contains 1 seed. Tree is erect and tall. Grafted trees slow to fruit but produce well after the lapse of a few years.

'Pantin'(or **'Key West')**–In 1956, Pantin family in Miami provided budwood from a seedling tree in Key West. Fruit of medium size; 14 to 40 oz (400-1,130 g). Flesh pink to red, of excellent quality, fiberless; contains 1 seed. Tree is tall. Grafted trees grow slowly at first, bear little or no fruit for 2-3 years, then growth rate increases and yield is good. Leaves become brown in winter. Grafted trees sold by nurseries.

'Progreso'–Obtained by Lawrence Zill from Belize. Grafted trees being tested at AREC, Homestead, and elsewhere.

'Tazumal'–AREC, Homestead, received seedling tree from El Salvador in 1949. Grafted and planted several trees in 1975. Fruit is of medium size, 14 to 30 oz (400-850 g). Flesh pink, of good quality; contains 1-2 seeds. First crop ripens Jan.-Feb.; second crop, July-Aug. Tree is of medium size, fast-growing, bears regularly and heavily. Grafted trees sold by nurseries. Usually evergreen.

In western Puerto Rico, there are some high-yielding trees producing large fruits 2.2 lbs (1 kg) or more in weight having dark-red flesh.

Climate

The sapote tree is limited to tropical or near-tropical climates. In Central America, it flourishes from sea-level up to 2,000 ft (610 m); it is less common at 3,000 ft (914 m); and rare at 4,000 ft (1,220 m). Occasional trees have survived at 5,000 ft (1,500 m) but these grow slowly and fruit maturity is considerably delayed. Young specimens are highly cold-sensitive and the large leaves of the tree are subject to damage by cold winds. The sapote has been found too tender for California. It thrives in regions of moderate rainfall–about 70 in (178 cm) annually–and is intolerant of prolonged drought. Even a short dry spell may induce shedding of leaves.

Soil

The tree makes its best growth on the heavy soils–deep clay and clay loam–of Guatemala but it does well on a wide range of soil types, even infertile, porous sand. It was originally believed unsuited to the oolitic limestone soils of southern Florida. However, with adequate planting holes, it has proved to be long-lived and fruitful in Dade County. The tree will not thrive where there is poor drainage, a high water table, or impermeable subsoil restricting root development.

Propagation

Sapote seeds lose viability quickly and must be planted soon after removal from the fruit. They normally germinate in 2 to 4 weeks. Removal of the hard outer coat will speed germination. The seeds must be planted with the more pointed end upward and protruding 1/2 in (1.25 cm) above the soil in order to assure good form in the seedling. Rodents are attracted to the seeds and cause considerable losses in Cuba. Seedlings should be grown only in experimental plantings intended for selection of desirable characters, or for use as rootstocks. Normally seedlings will not bear until they are 8 to 10 years old and they do not necessarily come true from seed. In Cuba, seeds are taken only from esteemed trees that are isolated from those of low quality in order to avoid any detrimental influence through cross-pollination. For fruit production, the sapote is best propagated vegetatively and it will then produce fruit in 1 to 4 years, depending on the cultivar. Air-layering is seldom successful. Cuttings treated with indolebutyric acid fail to root. Various methods of grafting have been tried. Approach-grafting has been commonly practiced in Cuba and is a reliable but somewhat cumbersome technique. Chip-budding has given good results at times. Side-veneer grafting is considered most feasible in Mexico and Florida. It has been achieved with 80 to 98% success utilizing 1-yr-old defoliated trees in the February-May dry season, but still presents difficulties. Ing. Filiberto Lazo, a horticulturist of long experience in Cuba, has provided detailed instructions for tip-grafting which he proved to be practical. The seedlings for use as rootstocks are first grown in 1-quart (.94 liter) containers and, when the first tender leaves appear, are transplanted into gallon (3.8 liter) containers and kept in semi-shade until the leaves are full-grown and dark-green. At this stage they are given more sun and are fertilized and watered faithfully. Within a year the stem will be 3/4 in (2 cm) thick and ready for grafting. An important point is to select budwood (scion) that is not as thick as the rootstock. The scion may be prepared by one of two methods: a) select from a tree that you wish to propagate a branch that has flowered; cut off the tip just below the leaves. About 10 to 12 days later the lateral buds of the beheaded branch begin to swell and this is the time to clip off the scion, 8 in (20 cm) in length, wrap it in a damp cloth, and proceed to graft as soon as possible; or b) clip off the terminal 8 in (20 cm) or more of a branch that has flowered, then immediately cut off the apex with the leaves, wrap the decapitated scion in a damp cloth and keep in the nursery until you see the lateral buds of the scion begin to swell; then proceed to graft.

The first cut in the rootstock should be a transverse one with pruning shears, leaving the stem about 1 ft (30 cm) high. Because of the copious latex, one must wait for it to drain out before going ahead. When the flow stops, take the scion (prepared either way), clip off 2 in (5 cm) or more from the base, leaving the scion about 6 in (15 cm) long. Using the budding knife, make a diagonal cut from 2 1/2 in (6.25 cm) below the tip downward, the slant terminating at the side opposite the side where it was begun. A reverse cut of the same length is made in the tip of the rootstock so that the base of the scion and the tip of the rootstock will fit together perfectly and the bark will match up. The scion must then be tightly bound to the rootstock with polyethylene ribbon, leaving no air-space, and covering all of the scion up to 2 1/2 in (6.25 cm) above the rootstock. A rubber band is put around over the polyethylene to make sure the wrapping is completely secure. When the scion has developed mature leaves, this is a sign that the graft has taken. The plastic is removed from the scion except for the part covering the graft which is left on until the scion has developed a quantity of leaves and displays distinct vigor. The grafted plant is ready to set out in the field one year later. Inferior cultivars, or grafted trees that have been frozen back, can be topworked by veneer-grafting mature or "juvenile-like" scions onto interstocks (seedling tops prepared for the purpose).

Spacing

Planting distances may vary with the fertility of the soil and the form and growth habit of the cultivar. On rich soil, sapote trees of spreading habit should be no less than 30 ft (9 m) apart each way. Lazo preferred a spacing of 40 ft (12 m) on an equilateral triangle. Where the soil is less fertile and the cultivar is fairly compact, the distance may be reduced to 25 ft (7.5 m).

Culture

Sapote trees do not require elaborate care, but should be given the advantage of adequate holes, pre-enriched, and routine fertilizer applications, at first high in nitrogen to stimulate vegetative growth. When nearing fruiting age, the tree will benefit from applications of a balanced fertilizer in spring and fall, the amount increasing each year. In dry seasons, frequent watering is desirable until the tree is well established. Grafted trees grow more slowly than seedlings and do not grow as tall, which is a distinct advantage in harvesting.

Harvesting and Yield

it is not easy to determine when the sapote is sufficiently mature to harvest. Some say the fruits are picked when they show a reddish tinge. Actually, in Cuba, 10 or 12 fruits from each tree are sampled by removing a small part of the rind and judging the color of the flesh. If it has achieved maximum color for that particular cultivar, the entire crop is deemed ready to pick. Fruits are not harvested from trees in active vegetative growth (a state called "primavera"), because they will never ripen completely. Harvesting of large trees requires a picking pole with a cutter and a basket to catch the fruits; or workers must use ladders and twist the fruit until the stem breaks. Trees that become too tall may be topped so that the crop will be within reach. After picking, the stem is close-clipped and the fruits are packed in boxes or baskets to avoid injury. There are no available figures on productivity but it is said in Cuba that trees on fertile soil will live for at least 100 years and bear abundantly throughout their lives.

Keeping Quality

A fully mature sapote will ripen in a few days. If shipped right after picking, the fruits can be sent to distant markets. In the past, they were exported from Mexico and Cuba to the United States.

Pests and Diseases

Sapote leaves and roots are attacked by the West Indian sugar cane root borer, *Diaprepes abbreviatus,* in Puerto Rico. The red spider mite, *Tetranychus bimaculatus,* may infest the leaves.

The fungus, *Colletotrichum gloeosporioides*, causes anthracnose on the leaves and fruit stalks in rainy seasons and causes fruits to fall prematurely. Leafspot resulting from attack by the fungus *Phyllosticta sapotae* occurs in Cuba and the Bahamas but seldom in Puerto Rico. In addition, black leaf spot *(Phyllachora sp.)* and root rot *(Pythium sp.)* may occur in Florida.

Food Uses

The sapote is credited with sustaining Cortez and his army in their historic march from Mexico City to Honduras. The fruit is of such importance to the Indians of Central America and Mexico that they usually leave this tree standing when clearing land for coffee plantations or other purposes. They generally eat the fruit out-of-hand or spooned from the half-shell. In urban areas, the pulp is made into jam or frozen as sherbet. In Cuba, fibrous types are set aside for processing.

A prominent dairy in Miami has for many years imported sapote pulp from Central America to prepare and distribute commercially as "Spanish sherbet". In Cuba, a thick preserve called "*crema de mamey colorado* "is very popular. The pulp is sometimes employed as a filler in making guava cheese.

The decorticated seeds, called *zapoyotas, sapuyules,* or *sapuyulos*, strung on sticks or cords, are marketed in the Isthmus of Tehuantepec, Mexico, and in Central America. The kernel is boiled, roasted and mixed with cacao in making chocolate–some say to improve the flavor, others say to increase the bulk, in which case it is actually an adulterant. In Costa Rica, it is finely ground and made into a special confection. Around Oaxaca, in southern Mexico, the ground-up kernel is mixed with parched corn, or cornmeal, sugar and cinnamon and prepared as a nutritious beverage called "pozol".

Food Value Per 100 g of Edible Portion*

Calories	114.5
Moisture	55.3-73.1 g
Protein	0.188-1.97 g
Fat	0.09-0.25 g
Carbohydrates	1.41-29.7 g
Fiber	1.21-3.20 g
Ash	0.89-1.32 g
Calcium	28.2-121.0 mg
Phosphorus	22.9-33.1 mg
Iron	0.52-2.62 mg
Carotene	0.045-0.665 mg
Thiamine	0.002-0.025 mg
Riboflavin	0.006-0.046 mg
Niacin	1.574-2.580 mg
Ascorbic Acid	8.8-40.0 mg

Amino Acids:	
Tryptophan	19 mg
Methionine	12 mg
Lysine	90 mg

*Analyses made in Cuba and Central America.

Toxicity

De la Maza, in 1893, reported that the seed has stupefying properties, and this may be due to its HCN content. One is cautioned not to rub the eyes after handling the green fruit because of the sap exuding from the cut or broken stalk. The milky sap of the tree is highly irritant to the eyes and caustic and vesicant on the skin. The leaves are reportedly poisonous.

Other Uses

Seeds: Early in the 19th Century, the seeds were used in Costa Rica to iron starched fine linen. The seed kernel yields 45 to 60% of a white, semi-solid, vaseline-like oil which is edible when freshly extracted and refined. It is sometimes used in soap and considered to have a greater potential in the soap industry, in cosmetics and pharmaceutical products. It was used in olden times to fix the colors on painted gourds and other articles of handicraft. The seeds have served as a source of Noyeau scent in perfumery. The nectar of the flowers is gathered by honeybees.

Trees: The trees are seldom cut for timber, unless they bear poor quality fruit. There is very little sapwood. The heartwood is buff or brown when fresh, becoming reddish with age; sometimes resembles mahogany but is redder and more or less mottled with darker tones. It is fine-grained, compact, generally hard and fairly heavy, strong, easy to work and fairly durable. It is rated as suitable for cabinetwork and is made into furniture, but mostly serves for building carts, and for shelving and house frames.

Medicinal Uses: In Santo Domingo, the seed kernel oil is used as a skin ointment and as a hair dressing believed to stop falling hair. In Mexico, 2 or 3 pulverized kernels are combined with 10 oz (300 g) castor oil for application to the hair. In 1970, clinical tests at the University of California at Los Angeles failed to reveal any hair-growth promoting activity but confirmed that the oil of sapote seed is effective in stopping hair-fall caused by seborrheic dermatitis. The oil is employed as a sedative in eye and ear ailments. The seed residue after oil extraction is applied as a poultice on painful skin afflictions.

A seed infusion is used as an eyewash in Cuba. In Mexico, the pulverized seed coat is reported to be a remedy for coronary trouble and, taken with wine, is said to be helpful against kidney stones and rheumatism. The Aztecs employed it against epilepsy. The seed kernel is regarded as a digestive; the oil is said to be diuretic. The bark is bitter and astringent and contains lucumin, a cyanogenic glycoside. A decoction of the bark is taken as a pectoral. In Costa Rica a "tea" of the bark and leaves is administered in arteriosclerosis and hypertension. The milky sap is emetic and anthelmintic and has been used to remove warts and fungal growths on the skin.

Related Species

The **green sapote,** *Pouteria viridis* Cronq., (syns. *Calocarpum viride* Pitt.; *Achradelpha viridis* O.F. Cook), is called *injerto, injerto verde* or *raxtul* in Guatemala; *zapote injerto* in Costa Rica; white faisan or red faisan in Belize. The tree is erect, to 40 or even 80 ft (12-24 m) in height, its young branches densely brown-hairy. It possesses an abundance of white, gummy latex. The leaves are clustered at the tips of flowering branches and irregularly alternate along non-fruiting limbs. They are oblanceolate, pointed, 4 to 10 in (10-25 cm) long, 2 to 2 3/4 in (5-7 cm) wide; hairy on the upper midrib and downy-white beneath. Flowers, borne in groups of 2 to 5 in the leaf axils and massed along leafless branches, are tubular, 5-lobed, pinkish or ivory and silky-hairy. The fruit varies from nearly round to ovoid, pointed at the apex and sometimes at the base; may be 3 1/2 to 5 in (9-12.5 cm) long and 2 1/2 to 3 in (6.25-7.5 cm) thick, with thin, olive-green or yellow-green skin dotted with red-brown and clinging tightly to the flesh. The flesh is light-russet, of fine texture, melting, fairly juicy and sweet; of better flavor than the sapote. There may be 1 or 2 dark-brown, shiny, elliptic or ovate seeds to 2 in (5 cm) long, with a large, dull, grayish hilum on one surface. The fruit is picked while hard and held until soft. The flesh is generally eaten raw, spooned from the skin, but a preserve is made from it in Guatemala.

The tree is native and common in the wild in Guatemala and Honduras; rarer in Costa Rica and southward to Panama; at elevations between 3,000 and 7,000 ft (900-2,100 in). The fruits are commonly marketed.

In 1916, 50 seeds from fruits on the market in Guatemala were introduced by the United States Department of Agriculture (S.P.I. #43788). Experimental plantings were made in California and Florida. More seeds were sent by Dr. Wilson Popenoe from the Lancetilla Experimental Garden at Tela, Honduras, in 1929 (S.P.I. #80383). Other introductions followed. There were no survivors in California or Florida in 1940. Trees 8 to 10 ft (2.4-3 m) high at the Agricultural Research and Education Center, Homestead, Florida, were killed by a flood in 1948. A private experimenter, William Whitman, obtained budwood from Honduras in 1954 and grafted it onto sapote rootstock. Other such grafts were made by a commercial fruit grower and the first fruits were borne in 1961. Subsequently, grafted trees were offered for sale by the Brooks-Tower Nursery and various seedlings have been distributed to private growers. The tree seems to flourish with little care on rich hammock soil but needs regular fertilizing on limestone. The Cuban May beetle feeds on the leaves. Seedlings begin to bear when 8 to 10 years old. The crop ripens in fall and winter.

Food Value Per 100 g of Edible Portion*	
Moisture	68.1-69.5 g
Protein	0.152-0.283 g
Fat	0.24-0.28 g
Fiber	1.2-1.6 g
Ash	0.69-1.38 g
Calcium	18.6-35.7 mg
Phosphorus	22.1-23.6 mg
Iron	0.57-0.74 mg

Carotene	0.031-0.069 mg
Thiamine	0.009-0.011 mg
Riboflavin	0.027 mg
Niacin	1.88-1.189 mg
Ascorbic Acid	49.9-62.3 mg

*Analyses made in Guatemala.

The latex (chicle) has been commercially collected and marketed like that from the sapodilla for use in chewing gum. The wood is reddish, fine-grained, compact, strong, durable; occasionally used in construction, carpentry, turnery, and for furniture and paneling in Guatemala.

Morton, J. 1987. Canistel. p. 402–405. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Canistel

Pouteria campechiana Baehni

Pouteria campechiana var. *nervosa* Baehni

Pouteria campechiana var. *palmeri* Baehni

The canistel, *Pouteria campechiana* Baehni, has been the subject of much botanical confusion as is evidenced by its many synonyms: *P. campechiana* var. *nervosa* Baehni; *P. campechiana* var. *palmeri* Baehni; *P. campechiana* var. *salicifolia* Baehni; *Lucuma campechiana* HBK.; *L. Heyderi* Standl.; *L. laeteviridis* Pittier; *L. multiflora* Millsp. NOT A. DC.; *L. nervosa* A. DC.; *L. palmeri* Fernald; *L. rivicoa* Gaertn.; *L. rivicoa* var. *angustifolia* Miq.; *L. salicifolia* HBK.; *Richardella salicifolia* Pierre; *Sideroxylon campestre* T.S. Brandeg.; *Vitellaria campechiana* Engl.; *V. salicfolia* Engl.

It is the showiest fruit of the family Sapotaceae but generally underevaluated in horticultural literature and by those who have only a casual acquaintance with it.

Colloquial names applied to this species include: egg-fruit, canistel, ti-es, yellow sapote (Cuba, Hawaii, Jamaica, Puerto Rico, Bahamas, Florida); canistel, *siguapa, zapotillo* (Costa Rica); *costiczapotl, custiczapotl fruta de huevo, zapote amarillo* (Colombia); *cakixo, canizte, kanis, kaniste, hantzé, kantez, limoncillo, mamee ciruela, zapotillo de montana* (Guatemala); *huevo vegetal* (Puerto Rico, Venezuela); *mammee sapota,* eggfruit, *ti-es* (Bahamas); *mamey cerera, mamey cerilla, mamee ciruela, kanizte* (Belize); *atzapotl* (the fruit), *atzapolquahuitl* (the tree), *caca de niño, cozticzapotl, cucumu, mamey de Campechi, mamey de Cartagena, huicumo, huicon, kan 'iste', kanixte, kanizte, palo huicon, zapote amarillo, zapote de niño, zapote borracho* (drunken sapote, perhaps because the fallen fruits ferment on the ground); *zapote mante, zubul* (Mexico); *guaicume, guicume, zapotillo, zapotillo amarillo* (El Salvador); *zapote amarillo* (Nicaragua); *boracho,* canistel, toesa (Philippines).

Description

Fig. 108: Glossy, yellow, long-keeping, highly nutritious, the canistel *(Pouteria campechiana)* deserves wider recognition as a good food.

The canistel tree is erect and generally no more than 25 ft (8 m) tall, but it may, in favorable situations, reach height of 90 to 100 ft (27-30 m) and the trunk may attain diameter of 3 ft (1 m). Slender in habit or with a spreading crown, it has brown, furrowed bark and abundant white, gummy latex. Young branches are velvety brown. The evergreen leaves, alternate but mostly grouped at the branch tips, are relatively thin, glossy, short- to long-stemmed, oblanceolate, lanceolate-oblong, or obovate, bluntly pointed at the apex, more sharply tapered at the base; 4 1/2 to 11 in (11.25-28 cm) long, 1 1/2 to 3 in (4-7.5 cm) wide. Fragrant, bisexual flowers, solitary or in small clusters, are borne in the leaf axils or at leafless nodes on slender pedicels. They are 5- or 6-lobed, cream-colored, silky-hairy, about 5/16 to 7/16 in (8-11 mm) long.

The fruit, extremely variable in form and size, may be nearly round, with or without a pointed apex or curved beak, or may be somewhat oval, ovoid, or spindle-shaped. It is often bulged on one side and there is a 5-pointed calyx at the base which may be rounded or with a distinct depression. Length varies from 3 to 5 in (7.5-12.5 cm) and width from 2 to 3 in (5-7.5 cm), except in the shrubby form, var. *palmeri*, called *huicon*–4 to 9 ft (1.5-3 m) high–which has nearly round fruits only 1 in (2.5 cm) long. When unripe the fruit is green-skinned, hard and gummy internally. On ripening, the skin turns lemon-yellow, golden-yellow or pale orange-yellow, is very smooth and glossy except where occasionally coated with light-brown or reddish-brown russetting.

Immediately beneath the skin the yellow flesh is relatively firm and mealy with a few fine fibers. Toward the center of the fruit it is softer and more pasty. It has been often likened in texture to the yolk of a hard-boiled egg. The flavor is sweet, more or less musky, and somewhat like that of a baked sweet potato. There may be 1 to 4 hard, freestone seeds, 1/4 to 2 1/8 in (2-5.3 cm) long and 1/2 to 1 1/4 in (1.25-3.2 cm) wide, near-oval or oblong-oval, glossy and chestnut-brown except for the straight or curved ventral side which is dull light-brown, tan or grayish-white. Both ends are sharp-tipped.

Origin and Distribution

The canistel is sometimes erroneously recorded as native to northern South America where related, somewhat similar species are indigenous. Apparently, it occurs wild only in southern Mexico (including Yucatan), Belize, Guatemala and El Salvador. It is cultivated in these countries and in Costa Rica (where it has never been found wild), Nicaragua and Panama, Puerto Rico, Jamaica, Cuba (where it is most popular and commercialized in Pinar del Rio), the Bahamas, southern Florida and the Florida Keys. Some writers have reported the canistel as naturalized on the Florida Keys, in the Bahamas and Cuba, but specimens that appear to be growing in the wild are probably on the sites of former homesteads. Oris Russell, who has explored hundreds of acres of coppices in the Bahamas, has never seen the canistel or its close relative, *P. domingensis* Baehni, in a wild state. He says that abandoned plantings can be completely overgrown by coppice in 3 to 4 years. Also, it is possible that a seedling might arise from the seed of a fruit carried into the woods by an animal or tossed away by a human. Mango trees are sometimes unintentionally planted in this way in southern Florida, especially if the seed lands in a hedge which provides a moist and shady site and physical protection.

Plate LVI: CANISTEL, *Pouteria campechiana*

Seeds from Cuba were planted at the Lancetilla Experimental Garden, La Lima, Honduras, in 1927. Dr. Victor M. Patiflo bought fruits in a Cuban market in 1957 and had the seeds planted at the Estacion Agricola Experimental de Palmira, Colombia. He reported that several trees were growing well there in 1963. The canistel is included in experimental collections in Venezuela. The tree was introduced at low and medium elevations in the Philippines before 1924 and it reached Hawaii probably around the same time. Attempts to grow it in Singapore were not successful. In 1949 there were a few canistel trees growing in East Africa.

Varieties

There are apparently no named cultivars but certain types are so distinct as to have been recorded as different species in the past. The spindle-shaped form (called mammee sapota or eggfruit) was the common strain in the Bahamas for many years, at least as far back as the 1920's. The rounded, broader form began to appear in special gardens in the 1940's, and the larger types were introduced from Florida in the 1950's

In 1945, large, handsome, symmetrical fruits were being grown under the names *Lucuma salicifolia* and yellow sapote at the Agricultural Research and Education Center and at Palm Lodge

Tropical Grove, Homestead, Florida, but these were soon classified as superior strains of canistel. Some fruits are muskier in odor and flavor than others, some are undesirably dry and mealy, some excessively sweet. An excellent, non-musky, fine-textured, rounded type of medium size has been selected and grown by Mr. John G. DuPuis, Jr., at his Bar-D Ranch in Martin County. It is well worthy of dissemination. There is considerable variation as to time of flowering and fruiting among seedling trees.

Climate

The canistel needs a tropical or subtropical climate. In Guatemala, it is found at or below 4,600 ft (1,400 in) elevation. In Florida, it survives winter cold as far north as Palm Beach and Punta Gorda and in protected areas of St. Petersburg. It has never reached fruiting age in California. It requires no more than moderate precipitation; does well in regions with a long dry season.

Soil

The canistel is tolerant of a diversity of soils–calcareous, lateritic, acid-sandy, heavy clay. It makes best vegetative growth in deep, fertile, well-drained soil but is said to be more fruitful on shallow soil. It can be cultivated on soil considered too thin and poor for most other fruit trees.

Propagation

Canistel seeds lose viability quickly and should be planted within a few days after removal from the fruit. If decorticated, seeds will germinate within 2 weeks; otherwise there may be a delay of 3 to 5 months before they sprout. The seedlings grow rapidly and begin to bear in 3 to 6 years. There is considerable variation in yield and in size and quality of fruits. Vegetative propagation is preferred in order to hasten bearing and to reproduce the best selections. Side-veneer grafting, cleft grafting, patch budding and air-layering are usually successful. Cuttings take a long time to root.

Culture

Mulching is beneficial in the early years. A balanced fertilizer applied at time of planting and during periods of rapid growth is advisable though the tree does not demand special care. Outstanding branches should be pruned back to avoid wind damage and shape the crown.

Pests and Diseases

Few pests and diseases attack the canistel. In Florida only scale insects and the fungi, *Acrotelium lucumae* (rust); *Colletotrichum gloeosporioides* (fruit spot); *Elsinoë lepagei* (leaf spot and scab); and *Gloeosporium* (leaf necrosis) have been recorded for this species. The tree is nearly always vigorous and healthy.

Fruiting Season and Harvesting

Blooming extends from January to June in Mexico (26). In Cuba, flowers are borne mostly in April and May though some trees flower all year. The canistel. has the advantage of coming into season in late fall and winter, when few other tropical fruits are available. The fruits generally mature from September to January or February in the Bahamas, from November or December to February or March in Florida. In Cuba, the main fruiting season is from October to February but some trees produce more or less continuously throughout the year. The mature but still firm fruits should be clipped to avoid tearing the skin. When left to ripen on the tree, the fruits split at the stem end and fall. A severe drop in temperature will cause firm-mature fruits to split and drop to the ground.

Storage and Shipment

If kept at room temperature, the fruits will soften to eating-ripe in 3 to 10 days. They should not be allowed to become too soft and mushy before eating. Ripe fruits can be kept in good condition in the vegetable tray of a home refrigerator for several days.

Freshly picked, hard fruits have been successfully shipped from Florida to fruiterers and other special customers in New York City and Philadelphia by Palm Lodge Tropical Grove, Homestead.

Unfortunately, no studies have been made to determine optimum temperature and humidity levels for long-term storage and long-distant shipment. This is an ideal fruit for export to European markets where its bright color, smoothness and appealing form would be especially welcome in the winter season.

Food Uses

The fact that the canistel is not crisp and juicy like so many other fruits seems to dismay many who sample it casually. Some take to it immediately. During World War II when RAF pilots and crewmen were under training in the Bahamas, they showed great fondness for the canistel and bought all they could, find in the Nassau market.

Some Floridians enjoy the fruit with salt, pepper and lime or lemon juice or mayonnaise, either fresh or after light baking. The pureed flesh may be used in custards or added to ice cream mix just before freezing. A rich milkshake, or "eggfruit nog", is made by combining ripe canistel pulp, milk, sugar, vanilla, nutmeg or other seasoning in an electric blender.

The late Mrs. Phyllis Storey of Homestead made superb 'mock-pumpkin" pie with 1 1/2 cups mashed canistel pulp, 2/3 cup brown sugar, 1/2 teaspoon salt, 1/4 teaspoon nutmeg, 1 teaspoon lime juice, 2 beaten eggs, 2 cups evaporated milk or light cream. The mixture is poured into one crust and baked for 1 hr at 250º F (121º C).

Others have prepared canistel pancakes, cupcakes, jam, and marmalade. Mrs. Gladys Wilbur made canistel "butter" by beating the ripe pulp in an electric blender, adding sugar, and cooking to a paste, with or without lemon juice. She used it as a spread on toast. The fruit could also be dehydrated and reduced to a nutritious powder as is being done with the lucmo (q.v.) and this might well have commercial use in pudding mixes.

Food Value

Canistels are rich in niacin and carotene (provitamin A) and have a fair level of ascorbic acid. The following analyses show that the canistel excels the glamorized carambola *(Averrhoa carambola* L.) in every respect except in moisture and fiber content, and riboflavin.

Food Value Per 100 g of Edible Portion*	
Calories	138.8
Moisture	60.6 g

Protein	1.68 g
Fat	0.13 g
Carbohydrates	36.69 g
Fiber	0.10 g
Ash	0.90 g
Calcium	26.5 mg
Phosphorus	37.3 mg
Iron	0.92 mg
Carotene	0.32 mg
Thiamine	0.17 mg
Riboflavin	0.01 mg
Niacin	3.72 mg
Ascorbic Acid	58.1 mg
Amino Acids:	
Tryptophan	28 mg
Methionine	13 mg
Lysine	84 mg

*According to analyses made at the Laboratorio FIM de Nutricion in Havana.

Other Uses

Latex extracted from the tree in Central America has been used to adulterate chicle. The **timber** is fine-grained, compact, strong, moderately to very heavy and hard, and valued especially for planks and rafters in construction. The **heartwood** is grayish-brown to reddish-brown and blends into the sapwood which is somewhat lighter in color. The darker the color, the more resistant to decay.

Medicinal Uses: A decoction of the astringent bark is taken as a febrifuge in Mexico and applied on skin eruptions in Cuba. A preparation of the seeds has been employed as a remedy for ulcers.

In 1971, a pharmaceutical company in California was exploring a derivative of the seed of *Pouteria sapota* (mamey, q.v.) which seemed to be active against seborrheic dermatitis of the scalp. Since they were having difficulty in procuring sufficient seeds for study, I suggested that they test the more readily available seeds of the canistel. They found these acceptable and were pursuing the investigation when last heard from.

Morton, J. 1987. Lucmo. p. 405–406. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Lucmo

Pouteria lucuma O. Ktze.

Pouteria insignis Baehni

Lucuma obovata HBK.

This is a rare case of a species of ancient cultivation, little-known outside its homeland, that has recently found a place in modern food processing. The lucmo, *Pouteria lucuma* O. Ktze. (syns. *P. insignis* Baehni, *Lucuma obovata* HBK. and perhaps *L. bifera* Mol.; also *Richardella lucuma* Aubr.; *Achras lucuma* Ruiz & Pavón), is called *lucumo* in Chile and Peru; *lucma* in Ecuador; *lucuma* or *rucma* in Colombia; and *mamón* in Costa Rica.

Description

This attractive tree ranges from 25 to 50 ft (8-15 m) in height, has a dense, rounded crown, velvety hairs on its young branchlets, and copious milky latex. The evergreen leaves, clustered at the tips of small branches, are obovate, oval or elliptic, blunt at the apex, pointed at the base, 5 to 10 in (12.5-25 cm) long; thin or slightly leathery; dark-green on the upper surface, pale and sometimes brown-hairy on the underside. The profuse flowers, borne singly or 2 or 3 together in the leaf axils, are tubular, yellowish-green, with hairy sepals and 5- to 7-lobed mouth about 1/2 in (1.25 cm) across. The fruit is oblate, ovate or elliptic, pointed or depressed at the apex; 3 to 4 in (7.5-10 cm) long, with thin, delicate skin, brownish-green more or less overlaid with russet, and bright-yellow, firm, dry, mealy, very sweet pulp, permeated with latex until almost overripe. There may be 1 to 5, usually 2, rounded or broad-oval, dark-brown, glossy seeds with a whitish hilum on one flattish side.

Origin and Distribution

The lucmo was first seen and reported by Europeans in Ecuador in 1531. Archaeologists have found it frequently depicted on ceramics at burial sites of the indigenous people of coastal Peru. It is native and cultivated in the highlands of western Chile and Peru and possibly southeastern Ecuador where it is known to have been cultivated since ancient times. It is grown also, to a limited extent, in the Andes of eastern Bolivia and the fruit is sold in the markets of La Paz. It is most popular in central Chile, less so in Ecuador. In 1776, it was reported as planted only in the warmest parts of northern Chile. In 1912, there were a few trees growing in gardens around San José, Costa Rica where the lucmo was introduced by returning exiles in the first half of the 19th Century. In 1915, O.F. Cook collected seeds at Ollantaytambo, Peru, for the United States Department of Agriculture (S.P.I. #41332). In January of 1922, Wilson Popenoe introduced seeds from Santiago, Chile (S.P.I. #54653). There have been several attempts to grow the tree in southern Florida. It has not lived long. One specimen actually bore fruit at the Fairchild Tropical Garden, developed galls, and eventually succumbed. The lucmo grows well in parts of Mexico and Hawaii but the fruit is not widely favored.

Climate

This species is not tropical, but grows at temperate elevations–between 9,000 and 10,000 ft (2,700-3,000 m) in Peru. It is adapted to fairly dry locations.

Season

The tree blooms and fruits all year. Mature fruits fall to the ground but they are not edible until they have been kept on hand for several days. Peruvian Indians bury them in stored grain, cured hay, chaff, dry leaves or other materials until they become soft.

Food Uses

The fruit is eaten raw, out-of-hand, when fully ripe but Costa Ricans find that, though the flavor is appealing at first, one soon finds it repulsive because of the peculiar aftertaste. The lucmo has been stewed in sirup, used as pie-filling, and made into preserves. Currently, some fruits are being shipped from Chile to England where they are being used in making ice cream. A dehydrated, powdered product is being produced by a tomato cannery in Peru.

Other Uses

The wood is pale, compact, durable, and used for construction in Peru.

Morton, J. 1987. Abiu. p. 406–408. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Abiu

Pouteria caimito Radlk.

Lucuma caimito Roem. & Schult.

Achras caimito Ruiz & Pavón

A minor member of the Sapotaceae, the abiu, *Pouteria caimito* Radlk. (syns. *Lucuma caimito* Roem. & Schult.; *Achras caimito* Ruiz & Pavón), has acquired few vernacular names. In Colombia, it is called *caimito, caimito amarilla, caimo* or *madura verde*; in Ecuador, *luma* or *cauje*; in Venezuela, *temare*; in Brazil, *abiu, abi, abio, abieiro* or *caimito*. It is called yellow star apple in Trinidad.

Description

The tree has a pyramidal or rounded crown; is generally about 33 ft (10 m) high but may reach 115 ft (35 m) in favorable situations. A gummy latex, white or reddish, exudes from wounds in the bark. The leaves are alternate and highly variable; may be ovate-oblong, obovate or elliptic; 4 to 8 in (10-20 cm) long, 1 1/4 to 2 3/8 in (3-6 cm) wide; short-pointed at the apex, sometimes long-tapering at the base; smooth or with a few scattered hairs. The flowers, borne singly or in groups of 2 to 5 in the leaf axils, are cylindrical, 4- to 5-lobed, white or greenish; 1/6 to 1/3 in (4-8 mm) long. The fruit, downy when young, is ovoid, elliptical or round; 1 1/2 to 4 in (4-10 cm) long, sometimes having a short nipple at the apex; with smooth, tough, pale-yellow skin when ripe and fragrant, white, mucilaginous, translucent, mild-flavored, sweet or insipid pulp containing 1 to 4 oblong seeds, brown, with a pale hilum on one side. Until fully ripe, the fruit is permeated with latex and is very gummy and astringent.

: ABIU, *Pouteria caimito*

Fig. 109: The pale-yellow abiu (*Poutertai caimito*) as sold in the native market of Buenaventura, Colombia. The fruit is gummy with latex until it becomes fully ripe.

Origin and Distribution

The abiu is a denizen of the headwaters of the Amazon. It grows wild on the lower eastern slopes of the Andes from southwestern Venezuela to Peru. It is often cultivated around Iquitos, Peru. In Ecuador, it is common in the Province of Guayas and the fruits are sold in the markets of Guayaquil. It is much grown around Pará, Brazil; less frequently near Rio de Janeiro, and to a limited extent at Bahia. In Colombia, it is fairly common in the regions of Caquetá, Meta and Vaupés and it abounds in the adjacent areas of Amazonas, Venezuela. It has been growing for many years in Trinidad.

The plant explorers, Dorsett, Shamel and Popenoe, collected seeds for the United States Department of Agriculture in Bahia in 1914 (S.P.I. #37929). In 1915, seeds were received from Lavoras, Minas, Brazil (S.P.I. #41003). This species has been planted several times at the Agricultural Research and Education Center, Homestead, Florida, but most of the young plants have been killed by winter cold. A few trees planted in 1953 fruited in 1962.

Varieties

There is much variation in the form, size and quality of the fruits of seedling trees, some having firm flesh, some soft; and some are insipid, while others have agreeable flavor. At Puerto Ospina, along the Putamayo River in Colombia, there is a type that fruits in 4 years. The fruit is round and large. Near the River Inirida, in Vaupés, Colombia, there is a type that bears in one year from seed, but the fruits are small with little pulp.

Climate

The abiu is strictly tropical or near-tropical. It thrives best in a year-around warm and moist climate, yet Popenoe noted that it does well in somewhat cooler Rio de Janeiro. In Peru it has not been found above 2,000 ft (650 m), though in Colombia, it can be grown up to an elevation of 6,000 ft (1,900 m).

Soil

The tree is naturally suited to fertile, wet soil. It is subject to chlorosis in the limestone of southern Florida.

Season

The fruits are in season in March and April in Ecuador. They are sold in some Brazilian markets from September to April but only a few are seen in the much shorter season of February and March at Bahia. Fruits have matured in October in Florida. The abiu can be picked while underripe and firm for transport to markets.

Propagation and Culture

In Brazil, the washed seeds are dried in the shade and then planted, 3 together and 2 in (5 cm) deep in enriched soil. They will germinate in 15 to 20 days. When the seedlings are 4 in (10 cm) high, the 2 weakest are removed. The strong one is set out when 12 to 16 in (30-40 cm) high. Spacing is 17 x 20 ft (6 x 5 m). One year later, the lower branches are pruned. Fruiting will begin in 3 years; will be substantial in 5 years.

Pests and Diseases

Actually, the fruit has little value commercially because it is commonly damaged by small insects (*bichos* in Spanish and Portuguese). In Brazil, the chief pests are said to be fruit flies.

Food Uses

In Colombia, people who wish to eat the abiu. are advised to grease their lips beforehand to keep the gummy latex from clinging to them. It is mostly eaten out-of-hand but, in Pará, some types are used to make ices and ice cream.

Food Value Per 100 g of Edible Portion*	
Calories	95
Moisture	74.1 g
Protein	2.1 g
Lipids	1.1 g
Glycerides	22.0 g
Fiber	3.0 g
Ash	0.7 g
Calcium	96.0 mg

Phosphorus	45.0 mg
Iron	1.8 mg
Vitamin B,	0.2 mg
Vitamin B2	0.2 mg
Niacin	3.4 mg
Ascorbic Acid	49.0 mg
Amino Acids (mg per g of nitrogen [N 6.25])	
Lysine	316 mg
Methionine	178 mg
Threonine	219 mg
Tryptophan	57 mg

*According to analyses made in Brazil.

Other Uses

Wood: The wood is dense and heavy, hard, and valued for construction.

Medicinal Uses: In Brazil, the pulp, because of its mucilaginous nature, is eaten to relieve coughs, bronchitis and other pulmonary complaints. The latex is given as a vermifuge and purge and is applied on abscesses.

Morton, J. 1987. Star Apple. p. 408–410. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Star Apple

Chrysophyllum cainito L.

Achras caimito Ruiz & Pavon

One of the relatively minor fruits of the family Sapotaceae, the star apple or goldenleaf tree, *Chrysophyllum cainito* L. (syn. *Achras caimito* Ruiz & Pavon), has acquired a moderate assortment of regional names. In Spanish, it is usually *caimito* or *estrella*; in Portuguese, *cainito* or *ajara*; in French, generally, *caimite* or *caimitier*; in Haiti, *pied caimite* or *caimitier a feuilles d'*or; in the French West Indies, *pomme surette*, or *buis*; in the Virgin Islands, cainit; in Trinidad and Tobago, it is caimite or kaimit; in Barbados, star-plum; in Colombia, it may be *caimo, caimo morado* (purple variety) or *caimito maduraverde* (green variety); in Bolivia, *caimitero*, or *murucuja*; in Surinam, *sterappel*, *apra* or *goudblad boom*; in French Guiana, *macoucou*; in Belize, damsel; in El Salvador, *guayabillo*; in Argentina, *aguay* or *olivoa*. The Chinese in Singapore call it "chicle durian".

Description

Plate LVIII: STAR APPLE, *Chrysophyllum cainito*

The star apple tree is erect, 25 to 100 ft (8-30 m) tall, with a short trunk to 3 ft (1 m) thick, and a dense, broad crown, brown-hairy branchlets, and white, gummy latex. The alternate, nearly evergreen, leaves are elliptic or oblong-elliptic, 2 to 6 in (5-15 cm) long, slightly leathery, rich green and glossy on the upper surface, coated with silky, golden-brown pubescence beneath when mature, though silvery when young. Small, inconspicuous flowers, clustered in the leaf axils, are greenish-yellow, yellow, or purplish-white with tubular, 5-lobed corolla and 5 or 6 sepals. The fruit, round, oblate, ellipsoid or somewhat pear-shaped, 2 to 4 in (5-10 cm) in diameter, may be red-purple, dark-purple, or pale-green. It feels in the hand like a rubber ball. The glossy, smooth, thin, leathery skin adheres tightly to the inner rind which, in purple fruits, is dark-purple and 1/4 to 1/2 in (6-12.5 mm) thick; in green fruits, white and 1/8 to 3/16 in.(3-5 mm) thick. Both have soft, white, milky, sweet pulp surrounding the 6 to 11 gelatinous, somewhat rubbery, seed cells in the center which, when cut through transversely, are seen to radiate from the central core like an asterisk or many-pointed star, giving the fruit its common English name. The fruit may have up to 10 flattened, nearly oval, pointed, hard seeds, 3/4 in (2 cm.) long, nearly 1/2 in (1.25 cm) wide, and up to 1/4 in (6 mm) thick, but usually several of the cells are not occupied and the best fruits have as few as 3 seeds. They appear black at first, with a light area on the ventral side, but they dry to a light-brown.

Origin and Distribution

It is commonly stated that the star apple is indigenous to Central America but the eminent botanists Paul Standley and Louis Williams have declared that it is not native to that area, no Nahuatl name has been found, and the tree may properly belong to the West Indies. However, it is more or less naturalized at low and medium altitudes from southern Mexico to Panama, is especially abundant on the Pacific side of Guatemala, and frequently cultivated as far south as northern Argentina and Peru. It was recorded by Ciezo de Leon as growing in Peru during his travels between 1532 and 1550. It is common throughout most of the Caribbean Islands and in Bermuda. In Haiti, the star apple was the favorite fruit of King Christophe and he held court under the shade of a very large specimen at Milot. The United States Department of Agriculture received seeds from Jamaica in 1904 (S.P.I. #17093). The star apple is grown occasionally in southern Florida and in Hawaii where it was introduced before 1901. There are some trees in Samoa and in Malaya though they do not bear regularly. The tree is grown in southern Vietnam and in Kampuchea for its fruits but more for its ornamental value in West Tropical Africa, Zanzibar, and the warmer parts of India. It was introduced into Ceylon in 1802, reached the Philippines much later but has become very common there as a roadside tree and the fruit is appreciated.

Varieties

Apart from the two distinct color types, there is little evidence of such pronounced variation that growers would be stimulated to make vigorous efforts to select and propagate superior clones. William Whitman of Miami observed a tree yielding heavy crops of well-formed, high quality fruits in Port-au-Prince, Haiti, from late January to the end of June. He brought budwood to Florida in 1953. Grafted progeny and trees grown from air-layers have borne well here even prior to reaching 10 ft (3 m) in height. This introduction, named the "Haitian Star Apple", is propagated commercially for dooryard culture. Seeds of the Port-au-Prince tree have produced seedlings that have performed poorly in Florida.

Climate

The star apple tree is a tropical or near-tropical species ranging only up to 1,400 ft (425 m) elevation in Jamaica. It does well only in the warmest locations of southern Florida and on the Florida Keys. Mature trees are seriously injured by temperatures below 28º F (-2.22º C) and recover slowly. Young trees may be killed by even short exposure to 31º F (-0.56º C).

Soil

The tree is not particular as to soil, growing well in deep, rich earth, clayey loam, sand, or limestone, but it needs perfect drainage.

Propagation

Star apple trees are most widely grown from seeds which retain viability for several months and germinate readily. The seedlings bear in 5 to 10 years. Vegetative propagation hastens production and should be more commonly practiced. Cuttings of mature wood root well. Air-layers can be produced in 4 to 7 months and bear early. Budded or grafted trees have been known to fruit one year after being set in the ground. In India, the star apple is sometimes inarched on star apple seedlings. Grafting on the related satinleaf tree *(C. oliviforme* L.) has had the effect of slowing and stunting the growth.

Culture

During the first 6 months, the young trees should be watered weekly. Later irrigation may be infrequent except during the flowering season when watering will increase fruit-set. Most star apple trees in tropical America and the West Indies are never fertilized but a complete, well-balanced fertilizer will greatly improve performance in limestone and other infertile soils.

Harvesting

Star apples are generally in season from late winter or early spring to early summer. They do not fall when ripe but must be hand-picked by clipping the stem. Care must be taken to make sure that they are fully mature. Otherwise the fruits will be gummy, astringent and inedible. When fully ripe, the skin is dull, a trifle wrinkled, and the fruit is slightly soft to the touch.

Yield

In India, a mature star apple tree may bear 150 lbs (60 kg) of fruits in the short fruiting season of February and March.

Keeping Quality

Ripe fruits remain in good condition for 3 weeks at 37.4º to 42.8º F (3º-6º C) and 90% relative humidity.

Pests and Diseases

Larvae of small insects are sometimes found in the ripe fruits.

The, main disease problem in the Philippines is stem-end decay caused by species of *Pestalotia* and *Diplodia*. In Florida, some fruits may mummify before they are full-grown.

The foliage is subject to leaf spots from attack by *Phomopsis* sp., *Phyllosticta* sp., and *Cephaleuros virescens*, the latter known as algal leaf spot or green scurf.

Birds and squirrels attack the fruits if they are left to fully ripen on the tree.

Food Uses

Star apples must not be bitten into. The skin and rind (constituting approximately 33% of the total) are inedible. When opening a star apple, one should not allow any of the bitter latex of the skin to contact the edible flesh. The ripe fruit, preferably chilled, may be merely cut in half and the flesh spooned out, leaving the seed cells and core. A combination of the chopped flesh with that of mango, citrus, pineapple, other fruits and coconut water is frozen and served as Jamaica Fruit Salad Ice. An attractive way to serve the fruit is to cut around the middle completely through the rind and then, holding the fruit stem-end down, twisting the top gently back and forth. As this is done, the flesh will be felt to free itself from the downward half of the rind, and the latter will pull away, taking with it the greater part of the core.

In Jamaica, the flesh is often eaten with sour orange juice, a combination called "matrimony"; or it is mixed with orange juice, a little sugar, grated nutmeg and a spoonful of sherry and eaten as dessert called "strawberries and-cream". Bolivians parboil the edible portion, and also prepare it as a decoction. An emulsion of the slightly bitter seed kernels is used to make imitation milk-of almonds, also nougats and other confections.

Food Value Per 100 g of Edible Portion*	
Calories	67.2
Moisture	78.4-85.7 g
Protein	0.72-2.33 g
Carbohydrates	14.65 g
Fiber	0.55-3.30 g
Ash	0.35-0.72 g
Calcium	7.4-17.3 mg
Phosphorus	15.9-22.0 mg

Iron	0.30-0.68 mg
Carotene	0.004-0.039 mg
Thiamine	0.018-0.08 mg
Riboflavin	0.013-0.04 mg
Niacin	0.935-1.340 mg
Ascorbic Acid	3.0-15.2 mg
Amino Acids:	
Tryptophan	4 mg
Methionine	2 mg
Lysine	22 mg

*Analyses made in Cuba and Central America.

Toxicity

The seeds contain 1.2% of the bitter, cyanogenic glycoside, lucumin; 0.0037% pouterin; 6.6% of a fixed oil; 0.19% saponin; 2.4% dextrose and 3.75% ash. The leaves possess an alkaloid, also resin, resinic acid, and a bitter substance.

Other Uses

Wood: The tree is seldom felled for timber unless there is a particular need for it. The heartwood is pinkish or red-brown, violet, or dark-purple; fine-grained, compact, heavy, hard, strong, tough but not difficult to work; durable indoors but not outside in humid conditions. It has been utilized for heavy construction and for deluxe furniture, cabinetwork and balustrades.

Latex: The latex obtained by making incisions in the bark coagulates readily and has been utilized as an adulterant of gutta percha. It was formerly proposed as a substitute for wax on the shelves of wardrobes and closets.

Medicinal Uses: The ripe fruit, because of its mucilaginous character, is eaten to sooth inflammation in laryngitis and pneumonia. It is given as a treatment for diabetes mellitus, and as a decoction is gargled to relieve angina. In Venezuela, the slightly unripe fruits are eaten to overcome intestinal disturbances. In excess, they cause constipation. A decoction of the rind, or of the leaves, is taken as a pectoral. A decoction of the tannin-rich, astringent bark is drunk as a tonic and stimulant, and is taken to halt diarrhea, dysentery and hemorrhages, and as a treatment for gonorrhea and "catarrh of the bladder". The bitter, pulverized seed is taken as a tonic, diuretic and febrifuge. Cuban residents in Miami are known to seek the leaves in order to administer the decoction as a cancer remedy. Many high-tannin plant materials are believed by Latin Americans to be carcinostatic. In Brazil, the latex of the tree is applied on abscesses and, when dried and powdered, is given as a potent vermifuge. Else where, it is taken as a diuretic, febrifuge and remedy for dysentery.

Morton, J. 1987. Japanese Persimmon. p. 411–416. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Japanese Persimmon

Diospyros kaki L.

In great contrast to the native American persimmon, *Diospyros virginiana* L., which has never advanced beyond the status of a minor fruit, an oriental member of the family Ebenaceae, *D. kaki* L. f ., is prominent in horticulture. Perhaps best-known in America as the Japanese, or Oriental, persimmon, it is also called kaki (in Spanish, *caqui),* Chinese plum or, when dried, Chinese fig.

Description

The tree, reaching 15 to 60 ft (4.5-18 m) is long-lived and typically round-topped, fairly open, erect or semi-erect, sometimes crooked or willowy; seldom with a spread of more than 15 to 20 ft (4.5-6 m). The leaves are deciduous, alternate, with brown-hairy petioles 3/4 in (2 cm) long; are ovate-elliptic, oblong-ovate, or obovate, 3 to 10 in (7.5-25 cm) long, 2 to 4 in (5-10 cm) wide, leathery, glossy on the upper surface, brown-silky beneath; bluish-green, turning in the fall to rich yellow, orange or red. Male and female flowers are usually borne on separate trees; sometimes perfect or female flowers are found on male trees, and occasionally male flowers on female trees. Male flowers, in groups of 3 in the leaf axils, have 4-parted calyx and corolla and 24 stamens in 2 rows. Female flowers, solitary, have a large leaflike calyx, a 4-parted, pale-yellow corolla, 8 undeveloped stamens and oblate or rounded ovary bearing the style and stigma. Perfect flowers are intermediate between the two. The fruit, capped by the persistent calyx, may be round, conical, oblate, or nearly square, has thin, smooth, glossy, yellow, orange, red or brownish-red skin, yellow, orange, or dark-brown, juicy, gelatinous flesh, seedless or containing 4 to 8 flat, oblong, brown seeds 3/4 in (2 cm) long. Generally, the flesh is bitter and astringent until fully ripe, when it becomes soft, sweet and pleasant, but dark-fleshed types may be non-astringent, crisp, sweet and edible even before full ripening.

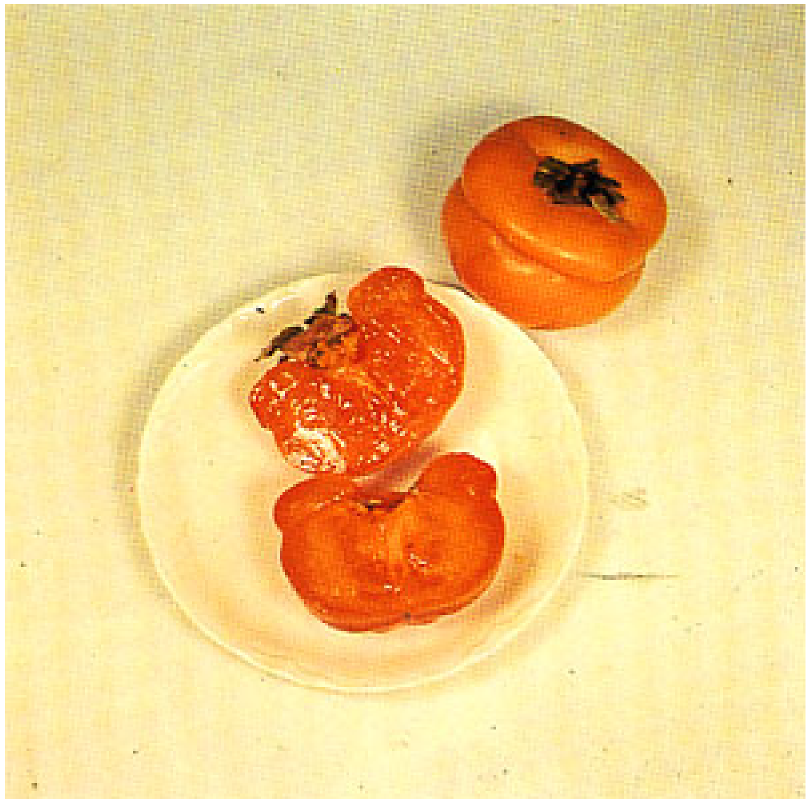

Plate LIX: JAPANESE PERSIMMON, *Diospyros kaki* 'Tamopan'

Origin and Distribution

The tree is native to Japan, China, Burma and the Himalayas and Khasi Hills of northern India. In China it is found wild at altitudes up to 6,000-8,000 ft (1,830-2,500 m) and it is cultivated from Manchuria southward to Kwangtung. Early in the 14th Century, Marco Polo recorded the Chinese trade in persimmons. Korea has long-established ceremonies that feature the persimmon. Culture in India began in the Nilgiris. The tree has been grown for a long time in North Vietnam, in the mountains of Indonesia above 3,500 ft (1,000 m) and in the Philippines. It was introduced into Queensland, Australia, about 1885.

It has been cultivated on the Mediterranean coast of France, Italy, and other European countries, and in southern Russia and Algeria for more than a century. The first trees were introduced into Palestine in 1912 and others were later brought in from Sicily and America.

Seeds first reached the United States in 1856 when they were sent from Japan by Commodore Perry. Grafted trees were imported in 1870 by the U.S. Department of Agriculture and distributed to California and the southern states. Other importations were made by private interests until 1919. Seeds, cuttings, budwood and live trees of numerous types were brought into the United States at various times from 1911 to 1923 by government plant explorers and the tree has been found best adapted to central and southern California, Arizona, Texas, Louisiana, Mississippi, Georgia, Alabama, southeastern Virginia, and northern Florida. A few specimens have been grown in southern Maryland, eastern Tennessee, Illinois, Indiana, Pennsylvania, New York, Michigan and Oregon.

By 1930, California had over 98,000 bearing trees and nearly 97,000 non-bearing, on 3,000 acres (1,214 ha). California production in 1965 amounted to 2,100 tons. Real estate development reduced persimmon groves to 540 acres by 1968. In 1970, California produced 1,600 tons–92% of the total U.S. crop.

In parts of Central America, Japanese persimmons have been planted from sea-level to 5,000 ft (1,524 m). The tree was first grown in Brazil by Japanese immigrants. By 1961, the total crop was 2,271,046,000 fruits, mainly in the State of Ceará, followed by Pernambuco and Piaui, with Bahia far behind. At present, the largest orchards are mainly in the States of Sao Paulo, Parana and Rio Grande do Sul, with lesser groves in Minais Gerais and Espirtu Santo. Of 111,412 acres (45,088 ha) all told, 60,336 acres (24,418 ha) are in Ceará. Israel and Italy have developed commercial plantings, and cultivar trials began in 1976 with a view to establishing persimmon-growing for export in southeastern Queensland.

Cultivars

Of the 2,000 cultivars known in China, cuttings of 52, from the provinces of Honan, Shensi and Shansi, were brought into the United States in 1914. J. Russell Smith, an esteemed economic-geographer, collected a number of types near the Great Wall of China in 1925 and some of the trees still survive in his derelict orchard in the Blue Ridge Mountains of southern Virginia. Over 800 kinds are grown in Japan but less than 100 are considered important. Among prominent cultivars are the non-astringent **'Fuyu', 'Jiro', 'Gosho'** and **'Suruga';** the astringent **'Hiratanenashi', 'Hachiya', 'Aizumishirazu', 'Yotsumizo'** and **'Yokono'.** It was formerly believed that the flesh color and astringency can vary considerably depending on whether or not the flowers were effectively pollinated, and cultivars were classed as: 1) Pollination Constants; and 2) Pollination Variants.

Plate LX: JAPANESE PERSIMMON, *Diospyros kaki* 'Tanenashi'

It has been recently discovered that there are two different mechanisms affecting astringency; one is degree of pollination, the other is the amount of ethanol produced in the seeds and accumulated in the flesh. Pollination Variant fruits with naturally high levels of ethanol lose astringency on the tree. So does Pollination Constant 'Fuyu' but other non-astringent Pollination Constant cultivars have been found to have low levels of ethanol. Pomologists at Kyoto University, Japan, have classified 40 cultivars into 4 types depending upon the ways or degrees their fruits lose astringency on the tree and upon flesh color –Pollination Constant Non-astringent (PCNA), Pollination Variant Non-astringent (PVNA), Pollination Variant Astringent (PVA) and Pollination Constant Astringent (PCA). They evidently have not studied seedless cultivars.

Dr. H.H. Hume, of the University of Florida, separated 13 seeded and seedless (or nearly seedless) cultivars according to the earlier pollination classification, and Drs. Camp and Mowry added **'Fuyu'**. The following 8 comprise *Group 1:*

'Costata'–conical, pointed, somewhat 4-sided, 2 5/8 in (6.5 cm) long, 2 1/8 in (5.4 cm) wide, with salmon-yellow skin, light-yellow flesh, with no seeds; or dark flesh and a few seeds. Astringent until fully ripe, then sweet; late (Oct.-Nov. in Florida). Keeps very well.

'Fuyu' (or 'Fuyugaki')–oblate, faintly 4-sided, 2 in (5 cm) long; 2 3/4 in (7 cm) wide; skin deep-orange; flesh light-orange; firm when ripe; non-astringent even when unripe; with few seeds or none. Keeps well; excellent packer and shipper. It is the most popular non-astringent persimmon in Florida. **'Matsumoto Early Fuyu'** ripens three weeks earlier.

'Hachiya'–oblong-conical, 3 3/4 in (9.5 cm) long, 3 1/4 in (8.25 cm) wide; skin glossy, deep orange-red; flesh dark-yellow with occasional black streaks; astringent until fully ripe and soft, then sweet and rich. Seedless or with a few seeds. Midseason to late. Much used in Japan for drying. Tree vigorous, well-formed and prolific in Kulu Valley, India. Scanty bearer in southeastern United States; does well on *D.* v*irginiana* in Florida, but tends to growth-ring cracking; often prolific in California.

'Ormond'–oblong-conical, 2 5/8 in (6.5 cm) long, 1 7/8 in (4.7 cm) thick. Skin reddish-yellow with thin bloom; flesh orange-red, moderately juicy; seeds large. Very late (Nov. and Dec. in Florida). Keeps well.

'Tamopan'–Introduced from China in 1905, again in 1916 (S.P.I. Nos. 16912, 16921, 26773). Broad oblate, somewhat 4-sided; indented around the middle or closer to the base; 3 to 5 in (7.5-12.5 cm) wide; skin thick, orange-red; flesh light-orange, usually astringent until fully ripe, then sweet and rich. In some parts of China and Japan said to be non-astringent. Seedless or nearly so. Of medium quality; late (Nov.) in Florida; midseason in California. Was being grown commercially in North Carolina and at Glen St. Mary, Florida, in 1916.

'Tanenashi'–round-conical, 3 1/3 in (8.3 cm) long, 3 3/8 in (8.5 cm) wide; skin light-yellow or orange, turning orange-red; thick; flesh yellow, astringent until soft, then sweet; seedless. Early; prolific. Much esteemed. Much used for drying in Japan. Leading cultivar in southeastern United States without pollination. In California tends to bear in alternate years.

'Triumph'–oblate, faintly 4-sided; of small to medium size; skin yellowish to dark orange-red. Flesh yellowish-red, translucent, soft, juicy; seedless or with 5 to 8 seeds; astringent until fully ripe, then sweet. Of high quality. Medium-late. In Florida begins in September and lasts until mid-November.

'Tsuru'–long-conical, pointed; 3 3/8 in (8.5 cm) long, 2 3/8 in (6 cm) wide; skin bright orange-red, turning red with purple bloom when mature; flesh orange-yellow or dark-yellow, granular; astringent until fully ripe; with few or no seeds. Very late.

Group 2:

'Gailey'–roundish to conical with rounded apex; small; skin dull-red, pebbled; flesh dark, firm, juicy, of good flavor. Bears many male flowers regularly and is planted for cross-pollination.

'Hyakume'–round-oblong to round-oblate, somewhat 4-angled and flat at both ends; 2 3/4 in (7 cm) long, 3 1/8 in (8 cm) wide; skin pale dull-yellow to light-orange, with brown russeting when ripe; flesh dark-brown, crisp, sweet, non-astringent whether hard or ripe. Midseason. Fairly good quality; somewhat unattractive externally. Stores and ships well.

'Okame'–round-oblate, 2 3/8 in (6 cm) long, 3 1/8 in (8 cm) wide; skin orange-yellow turning to bright-red with waxy bloom; flesh light but brownish around the seeds; sometimes seedless; sweet, of excellent quality. Fairly early, beginning about Sept. 1 in Florida. Productive.

'Yeddo-ichi'–oblate, 2 1/2 in (6.25 cm) long, 3 in (7.5 cm) wide; skin dark orange-red with a bloom; flesh dark-brown with purplish tint; sweet, rich, non-astringent whether hard or ripe. Of high quality.

'Yemon'–oblate, 4-sided; 2 1/4 in (5.7 cm) long, 3 1/4 in (8.25 cm) wide; skin light-yellow becoming reddish with orange-yellow mottling; flesh red-brown or light-colored, astringent at first, sweet after softening; seedless or with few seeds and then dark around the seeds. Of high quality, but becomes too soft for shipping.

'Zengi' ('Zengimaru')–round or round-oblate, 1 3/4 in (4.5 cm) long, 2 1/4 in (5.6 cm) wide. Skin dark orange-red or yellow-red; flesh dark with black streaks; sweet even when hard; with some seeds. Early, prolific; of medium quality.

Cultivars that are especially hardy in Maryland, Pennsylvania and Virginia include: 'Atome', 'Benigaki', 'Delicious', 'Eureka', 'Great Wall', 'Manerh', 'Okame', 'Peiping', 'Pen', 'Shaumopan', 'Sheng,' 'Tsurushigaki', 'Yokono', etc.

'Delicious' is oblate, medium to large; skin is smooth, light-red; flesh light-yellow, non-astringent when hard, but more flavorful when soft; contains a few seeds; tree is vigorous and a regular bearer.

'Eureka' (from Texas) is oblate, medium to large, puckered at calyx, bright orange-red, astringent; of good quality; drought and frost-resistant; late (Nov. in Florida). One of the most satisfactory in Florida.

'Great Wall' is small, flat, 4-sided with fine black stripes extending from the calyx; astringent, dry-fleshed; tree is vigorous, a biennial bearer; does well in Florida.

'Hanafuyu' is oblate, non-astringent and usually seedless; late-midseason; tree is small, bears regularly but yield is low; prone to premature shedding of fruit; fairly common in northern Florida.

'Ichikikeijiro' is medium-large, orange, non-astringent; early-ripening; tree is not vigorous but still this cultivar is among the best of the non-astringent class in Florida.

'Jumbu' resembles 'Fuyu' but is somewhat more conical and larger; non-astringent; edible either firm or soft. Ripens a little later than 'Tuyu'; of good quality.

'Ogasha' is oblate, non-astringent and usually seedless; prone to immature shedding of fruit; fairly common in northern Florida.

'Sheng' is large, ribbed, puckered at calyx, astringent; popular in Florida; bears annually when pollinated.

'Shogatsu' is flattened, non-astringent, of fair quality; bears an abundance of male flowers. Does well in Florida.

'Siajo' is small, astringent, of good quality and flavor; performs well in Florida.

'Taber No. 23' is round to oblate with flat apex; fairly small; skin is dark-red, stippled. Begins to ripen in September in Florida.

'Yamato Hyakume' is large, with red skin; has little tannin when seed content is low; tends to growth-ring cracking; is a heavy bearer in Florida.

'Yokono' is large, orange-red, astringent, of good quality; bears well but tends to shed fruit; keeps well.

Maru is a group name for several roundish types of Japanese persimmon with brilliant orange-red skin, cinnamon-colored flesh; medium to small in size; flesh is juicy, sweet, richly flavored; they have excellent keeping quality after ripening, store and ship well and are very decorative.

At the Pornological Station, Coonor, India, an unnamed type and a named cultivar, **'Dai Dai Maru'** have performed well. The unnamed cultivar is broad at the base, large, attractive, deep-red, astringent until fully ripe, then very sweet; bears well regularly. The tree is semi-erect.

'Dai Dai Maru' has a broadly rounded apex, is of medium size; orange-red, glossy, with a slight bloom; has dark flesh, is not edible until fully cured; seedless unless cross-pollinated; bears good crops regularly. The tree is of semi-erect habit.

In Brazil, cultivars are sorted into 3 groups. *Group 1*, 'Sibugaki', includes those that are yellow-fleshed, always astringent whether seedless or not ('Taubaté', 'Hachiya', 'Trakoukaki', 'Hatemya', etc.).

'Taubatá', the most popular of this group, is round, slightly flattened, large, yellow-fleshed, very astringent; highly perishable, lasting only 3 to 4 days after ripening.

Group 2, 'Amagaki', includes those that are yellow-fleshed, never astringent whether seedless or not ('Jiro', 'Tuyu', 'Hannagosho').

'Hannagosho' is of excellent quality but in Florida is slow in losing astringency and the tree is deficient in male flowers.

'Jiro' is second to 'Fuyu' in importance in Japan; is of high quality and ships well. The fruit is colorful and the tree vigorous in Florida.

Group 3, 'Variavel', or 'Variaveis', includes those that are astringent when they have several seeds, and partially or totally non-astringent when they have only one or a few seeds. The flesh is yellow when there are no seeds and dark when seeds are present ('Rama Forte', 'Guiombo', 'Luiz de Queiroz', 'Hyakume', 'Chocolate', etc.).

'Guiombo' (perhaps the same as 'Korean') is one of the best in Florida, with thin skin; but it is a biennial bearer when young.

'Rama Forte', the most popular of this group is oblate, medium to large, with dark-yellow flesh, or dark-brown when there are many seeds; keeps well–8 to 10 days at room temperature after ripening; yields 30% more than 'Taubaté' and its branches are less apt to break under a heavy crop.

The Instituto Agronomico do Estado de Sao Paulo has developed various promising hybrids.

In 1922, seeds of 'Kai Sam T'sz' (chicken-heart persimmon) from Canton, China, were sent to the United States Department of Agriculture as a subtropical cultivar which might be appropriate for southern Florida and the West Indies in contrast to the hardier types brought in from Japan and northern and central China, but it seems to have soon dropped out of sight.

Among commercial cultivars in Japan not already mentioned are:

'Suruga' (distributed in 1959); orange-red, non-astringent, very sweet, keeps well.

'Gosho', orange-red, non-astringent, sweet, of high quality but giving a low yield because of excessive shedding of immature fruits.

'Hiratanenashi', oblate, somewhat 4-sided, astringent, thick-skinned; seedless; of high quality, but keeps only a short time after curing; mostly used for drying.

'Aizumishirazu', rounded, astringent, black-spotted around seeds; of fair quality; bears well.

'Yotsumizo', small, astringent, usually seedless, sweet after curing; bears well; often dried.

Of six cultivars tested in Queensland ('Tanenashi', 'Hyakume', 'Dai Dai Maru', 'Tsuru Magri', 'Flat Seedless', and 'Nightingale'), all grafted on *D. lotus*, only 'Nightingale' proved satisfactory in fruit quality and yield in an assessment made after 3 years of fruiting.

'Nightingale' is classed as PCA (pollination constant, astringent); is conical, 3 1/2 in (9 cm) long; red; of distinctive flavor; with an average of 2 1/2 seeds per fruit. The tree is semi-dwarf and fairly precocious.

Pollination

Some cultivars in certain locations and under some conditions, will fruit abundantly without cross-pollination, but this trait is not dependable. In commercial groves, the cultivar known as **'Gailey',** which regularly produces many male flowers, is interplanted to insure adequate pollination. The formula is one male for every 8 female trees, uniformly dispersed throughout the grove; or 12 to 24 pollinating trees per acre (30-60 per ha). Japanese farmers sometimes plant the pollinating trees as a hedge around the grove. If hand-pollination of early cultivars is necessary, unopened male buds are collected, dried, opened and the pollen separated and stored. When needed, it is mixed with skimmed milk or club moss (*Lycopodium*) and applied at 1/7 to 2/7 oz per acre (10-20 g per ha).

If the flowers are not effectively pollinated, the entire crop of fruit may fall prematurely. This is a fault of the cultivar 'Isu' in Japan. Losses can be reduced by girdling the tree after flowering but the practice has the effect of retarding growth. If the weather is hot and dry at blooming time, pollination will be inadequate and very few fruits will be set. The maintenance of bee colonies (1 or 2 hives for every 2 1/2 acres, or per ha) in persimmon orchards will enhance pollination, especially in cultivar 'Fuyu'.

Climate

The Japanese persimmon needs a subtropical to mild-temperate climate. It will not fruit in tropical lowlands. In Brazil, the tree is considered suitable for all zones favorable to Citrus, but those zones with the coldest winters induce the highest yields. The atmosphere may range from semi-arid to one of high humidity.

Trees in the Middle Atlantic States have been known to have withstood temperatures as low as 20º F (-6.67º C) and to have remained in excellent condition and fruitful after 40 years.

Soil

The tree is not particular as to soil, and does well on any moderately fertile land with deep friable subsoil. In Florida, a sandy loam with clay subsoil promotes good growth. While the young tree needs plentiful watering, good drainage is essential.

Propagation

Indonesians propagate the tree by means of root suckers. In the Orient, selected cultivars are raised from seed or grafted onto wild rootstocks of the same species, or onto the close relative, *D. lotus* L. In the eastern United States, the trees are grafted onto the native American persimmon, *D. virginiana*. This rootstock significantly contributes to cold-resistance. California growers have found *D. kaki* the most satisfactory rootstock, *D. lotus* rootstock resulting in much lower yields.

Seeds for the production of rootstocks need no pretreatment. They are planted in seedbeds or directly in the nursery row 8 to 12 in (20-30 cm) apart with 3 to 3 1/2 ft (0.9-1.06 m) between the rows. After a season of growth, they may be whip-grafted close to the surface of the soil, using freshly cut scions or scions from dormant trees kept moist in sphagnum moss.

Cleft-grafting is preferred on larger stock and for top-working old trees. In India, cleft-grafting on stem has been 88.9% successful; while cleft-grafting on crown and tongue-grafting on stem have been 73.4% successful when the grafted plants were left for 2 weeks at about 77º F (25º C) and relative humidity of 75% for 2 weeks before planting.

In the Kulu Valley, India, scions are grafted onto 2-year-old *D. lotus* seedlings which are mounded with earth to cover the graft until it begins to sprout. At the Fruit Research Station, Kandaghat, 2-year-old *D. lotus* seedlings were used as rootstock for veneer and tongue grafts from cv 'Hachiya' between late June and the third week of August. Success rates ranged from 80 to 100%.

In Palestine, trees grafted on *D. lotus* and grown on light soil are dwarfish, fruit heavily at first, but are weak and short-lived. Those grafted on *D. virginiana* are larger and vigorous and bear heavily consistently. The only disadvantage is that the shallow root system fans out to 65 ft (20 m) from the base of the tree and wherever the roots are injured by cultivation, suckers spring up and become a nuisance.

Culture

The soil should be well prepared–deeply plowed and enriched with organic matter. Trees should be set out at spacings ranging from 15 x 5 ft (4.5 x l.5 m) to 20 x 20 ft (6 x 6 m), depending on the habit of the cultivar. In Japan, 404.7 plants per acre (1,000 per ha) may be installed at the outset, to be thinned down to 85 trees per acre (200 per ha) in 10-15 years.

Good results have been obtained with a fertilizer mixture of 4 to 6% N, 8 to 10% P and 3 to 6% K at the rate of 1 lb (.45 kg) per tree per year of age. Generally the application is made in spring, but some growers apply half in the spring, half in July. Over-fertilization or excessive amounts of nitrogen fertilizers will cause shedding of fruits.

Young trees are pruned back to 2 1/2 ft to 3 ft (.74-.91 m) when planted and later the new shoots are thinned with a view to forming a well-shaped tree. Some cultivars tend to develop a willowy growth and require cutting back occasionally to avoid the development of weak branches which break when heavy with fruit. Annual pruning during the first 4 to 5 winters is desirable in some cultivars. If a tree tends to overbear and shows signs of decline, it should be drastically cut back to give it a fresh start.

After flowering, the trees should be irrigated every 3 weeks on light soil, every month on heavier soil, until time for harvest. One California grower, with trees on deep river loam, has provided furrow irrigation every 2 weeks from April through September. Branches are fragile and must be propped when heavily laden with fruits.

Cropping and Yield

Many cultivars begin to bear 3-4 years after planting out; others after 5-6 years. Shedding of many blossoms, immature and nearly mature fruits is characteristic of the Japanese persimmon as well as the tendency toward alternate bearing. The annual yield of a young tree ranges from 50 to 96 lbs (22.6-40.8 kg); of a full-grown tree, 330 to 550 lbs (150-250 kg). Estimated yield in Brazil is 6.5 tons per acre (15 tons per ha), but yields will vary with the cultivar and cultural practices.

Harvesting takes place in fall and early winter. Late ripening cultivars may be picked after hard frosts or light-snowfall. Japan produces about 300,000 tons per year.

Japanese growers use color charts to determine when each cultivar is ready for harvest. Astringent cultivars are picked when fully mature but hard and are cured before marketing.

Curing

In the Orient, much of the crop is left in piles covered by bamboo mats to cure (near-freeze) naturally and is marketed throughout the winter. In some parts of China, the fruit is cured in covered pits by introducing the smoke from burning dung. There are several other methods of curing: soaking in vinegar or immersing in boiling water and letting stand for 12 hours. 'Hachiya' fruits kept in warm water –104º F (40º C)–for 24 hours will be firm and non-astringent 2 days after treatment. One practice is to leave the astringent fruits in lime water for 2 days but tests have shown no advantage of a lime solution over pure water except that lime disinfects and can prevent the rotting that might follow soaking.

In Japan, the fruits may be sprayed with ethanol, or stored for 10 days to 2 weeks in kegs which previously contained *sake;* or they may be stored in air-tight containers with ethylene gas for 3 days. Carbon dioxide is widely employed and the treatment consists of storing in a 95% CO_2

atmosphere for 24 hours at 68º to 77º F (20º-25º C), but the fruit softens very quickly thereafter. In Brazil, successful curing has been achieved by immersing 'Taubate' persimmons in 1,000 ppm solution of ethephon (an ethylene generator) for 1 hour and then storing at room temperature for 4 days. Large quantities are cured by exposure to the fumes of alcohol (aguardiente), acetylene gas from combustion of calcium carbonate, or gas from burning sawdust, in hermetically sealed chambers at temperatures between 68º and 82.4º F (20º and 28º C) at relative humidity of 80%. Various other chemical processes and gamma radiation have been successfully employed in other countries.

A simple method was discovered in California some years ago. The newly picked fruits were merely pierced once at the apex with a needle dipped in alcohol, then the fruits were layered with straw in a tightly closed box for 10 days. The homeowner may merely keep the fruits at room temperature in a closed vessel or plastic bag for 2-4 days with bananas, pears, tomatoes, apples, or other fruits which give off ethylene gas. In India, the persimmons are individually paper-wrapped and placed in alternate rows with 'Kieffer' pears in a closed container and are edible in 3 days. Non-astringent cultivars need no curing.

Packing, Keeping Quality and Storage

In California, persimmons are graded by size, then tissue-wrapped and packed in peach boxes for rail shipment in refrigerated cars. Packing in other areas is similar. Astringent types soften in 2 or 3 days after treatment and quickly become overripe. Non-astringent types are usually harder than astringent types when picked, and they therefore ship and keep better. Persimmons have been kept for 2 months at 30º F (-1.11º C) and 85-90% relative humidity. 'Triumph' is frequently stored in Israel for as long as 4 months at 30º F (-1.11º C). Persimmons have been kept in good condition for several months in sealed 0.06 mm polyethylene bags at 32º F (0º C).

Spraying the bearing branches with gibberellic acid 3 days before harvest has retarded maturity on the tree; has doubled the storage life of astringent types after curing.

Pests and Diseases

In Brazil, premature fall of 'Fuyu' is partly linked to heavy infestation by the mite, *Aceria diospyri*. Spraying with Sevin 85 ppm 3 times at 30-day intervals right after petal fall controls the mite and increases yield. *Retithrips syriacus* feeds on and blemishes the leaves and fruit skin in Palestine but has been controlled by spraying with nicotine sulfate. The greenhouse thrips *(Heliothrips haemorrhoidalis)* blemishes fruits in Queensland. San José scale is combatted by a dormant application of Bordeaux in diesel emulsion in India. In Florida, white peach scale, *Pseudaulacaspis pentagona*, has required control and a twig girdler, *Onsideres cingulatus,* has been troublesome. Also, a flat-headed borer drills into the bark and the wood causing oozing of gum and decline in vigor. The main enemies in the eastern United States are mealybugs which distort young shoots and kill all new growth unless controlled. They do not seriously affect mature trees.

In Brazil and Queensland, fruit flies may attack the fruits, especially in dry years. Tree-ripe persimmons are sought by all kinds of birds, especially by parrots and crows in India, where flying foxes are a nocturnal menace. The less astringent types seem to be preferred by all of these predators. Bird-repellent sprays have given good control in Queensland. There, sunburn affects marketability especially of 'Tanenashi' and 'Tsuru magri'.

In India, low germination rates of planted seeds has been traced to dry rot caused by *Penicillium* sp. It can be controlled by pretreatment with an appropriate fungicide.

D. lotus rootstock is subject to root rot and crown gall in Florida but resistant to wilt caused by *Cephalosporium diospyri* which induces severe defoliation and has killed trees on *D. virginiana* rootstock. In Brazil, *Cercospora* may spot the leaves, and a virus causes "mosaic"–mottling of leaves and premature leaf fall, shedding of flowers, and necrotic spots on fruits; also a different necrosis on the tree and the bark of shoots, twigs and branches that causes die-back. Anthracnose occurs on fruits that have slightly cracked or have been pierced by insects. In Florida, leaf spot, algal leaf spot, twig blight, twig dieback, root rot, thread blight and other fungal diseases may occur.

Food Uses

Fully ripe Japanese persimmons are usually eaten out-of-hand or cut in half and served with a spoon, preferably after chilling. Some people prefer to add lemon juice or cream and a little sugar. The flesh may be added to salads, blended with ice cream mix or yogurt, used in pancakess, cakes, gingerbread, cookies, gelatin desserts, puddings, mousse, or made into jam or marmalade. The pureed pulp can be blended with cream cheese, orange juice, honey and a pinch of salt to make an unusual dressing.

Ripe fruits can be frozen whole or pulped and frozen in the home freezer. Large quantities of 'Tamopan' are preserved by drying. Drying is commonly practiced in Brazil and the dried fruit is popular throughout the country. Some California growers dry the 'Hachiya' by a Chinese method. The fruits are picked when mature but firm, are peeled and hung up by their stems for 30-50 days to dry in the sun. Kneading every 4-5 days is necessary to give uniform texture and improve flavor. Then they are taken down and sweated for 10 days in heaps under mats. Sugar crystals form on the surface. Lastly, they are hung up again to dry in the wind. In the Orient, the peelings are dried separately and are mixed in with fruits when packed for sale. An inferior product is made by slitting the skin with a knife, then spreading the fruits out on mats to dry for several weeks, then sweating them in piles, and the product is sold at a very low price.

In Indonesia, ripe fruits are stewed until soft, then pressed flat and dried in the sun. Early travelers called such fruits "red figs". Intestinal compaction from consumption of persimmons in Israel has been eliminated by drying the fruits before marketing, and some dried fruits are now being exported to Europe. Surplus persimmons may be converted into molasses, cider, beer and wine. Roasted seeds have served as a coffee substitute.

Food Value Per 100 g of Edible Portion*

Calories	77
Moisture	78.6 g
Protein	0.7 g
Fat	0.4 g
Carbohydrates	19.6 g

Calcium	6 mg
Phosphorus	26 mg
Iron	0.3 mg
Sodium	6 mg
Potassium	174 mg
Magnesium	8 mg
Carotene	2,710 I.U.
Thiamine	0.03 mg
Riboflavin	0.02 mg
Niacin	0.1 mg
Ascorbic Acid	11 mg

*Average values.

The astringent substance in the persimmon, generally called "tannin", has been much studied and variously defined as knowledge of tannins and other phenols has unfolded. To put it simply, it is classed as a condensed tannin (proanthocyanidin) of complex structure.

One would be wise to eat only fully ripe persimmons from which the tannin has been almost entirely eliminated. The skin, which retains some tannin, should not be eaten.

Other Uses

Tannin from unripe Japanese persimmons has been employed in brewing *sake*, also in dyeing and as a wood preservative. Juice of small, inedible wild persimmons, crushed whole, calyx, seeds and all, is diluted with water and painted on paper or cloth as an insect- and moisture-repellent.

The **wood** of the tree is fairly hard and heavy, black with streaks of orange-yellow, salmon, brown or gray; close-grained; takes a smooth finish and is prized in Japan for fancy inlays, though it has an unpleasant odor.

Medicinal Uses: A decoction of the calyx and fruit stem is sometimes taken to relieve hiccups, coughs and labored respiration.

Morton, J. 1987. Mabolo. p. 418–419. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mabolo

Diospyros blancoi A. DC.

A minor member of the family Ebenaceae, more admired for its ornamental than its edible value, the mabolo has appeared in literature for many years under the illegitimate binomial *Diospyros discolor* Willd. In 1968, Dr. Richard Howard, Director of the Arnold Arboretum, Harvard University, proposed the adoption of *D. blancoi* A. DC., and this is now regarded as the correct botanical designation for this species. The fruit is sometimes called velvet apple, or, in India, peach bloom. In Malaya, it is *buah mantega* (butter fruit)–a term now often applied to the avocado–, or *buah sakhlat*, or *sagalat* (scarlet fruit). Mabolo (or mabulo) is the most common of the several Philippine dialectal names. Another, *kamagon*, is rendered *camagon* in Spanish.

Description

The mabolo varies in form from a small straggly tree with drooping branches, to an erect, straight tree to 60 or even 100 ft (18-33 m), with stout, black, furrowed trunk to 50 in (80 cm) thick. It is rather slow-growing. The evergreen, alternate leaves, oblong, pointed at the apex, rounded or pointed at the base, are 6 to 9 in (15-22.8 cm) long, 2 to 3 1/2 in (5-9 cm) wide; leathery, dark-green, smooth and glossy on the upper surface, silvery-hairy underneath. New leaves are showy, pale-green or pink and silky-hairy. The tubular, 4-lobed, waxy, faintly fragrant blooms are short-stalked, creamy-white, downy. Male flowers 1/4 in (6 mm) wide, in small clusters, and female flowers, 1/2 in (12.5 mm) wide, and solitary, are borne on separate trees. Attractive and curious, the oval or oblate fruit, 2 to 4 in (5-10 cm) wide, has thin, pink, brownish, yellow, orange or purple-red skin, densely coated with short, golden-brown or coppery hairs, and is capped at the base with a dull-green, stiff calyx. The fruits are often borne in pairs, very close together on opposite sides of a branch. A strong, unpleasant, cheese-like odor is given off by the whole fruit but emanates from the skin, for it is absent in the peeled flesh, which is whitish, firm, mealy, somewhat like that of an overripe apple; moist but not very juicy; of mild, more or less sweet flavor, suggesting a banana-flavored apple. There may be 4 to 8 brown, smooth, wedge-shaped seeds, about 1 1/2 in (4 cm) long and 1 in (2.5 cm) wide, standing in a circle around the central core, though the fruits are often completely seedless. Each seed is covered with a whitish membrane that is transparent when fresh, opaque when dried.

Plate LXII: MABOLO, *Diospyros blancoi*

Origin and Distribution

The mabolo is indigenous to the low and medium altitude forests of the Philippine Islands from the island of Luzon to the southernmost of the Sulu Islands, and is commonly cultivated for its fruit and even more as a shade tree for roadsides. The tree was introduced into Java and Malaya, and, in 1881, into Calcutta and the Botanical Garden in Singapore, though it existed in Singapore before that date. In recent times, it has been decreasing in numbers in Malaya. It is only occasionally planted in India and then mainly as an ornamental because of the attractiveness of the foliage and the fruits.

Seeds were sent to the United States Department of Agriculture by W.S. Lyon, of the Philippine Bureau of Agriculture, in 1906, with a note of admiration for the tree and the exterior of the fruit but not the interior; still, more seeds were sent in 1909 and the seedlings thrived at the Plant Introduction Station in Miami. There are occasional specimens grown elsewhere in southern Florida and some scattered around the Caribbean area, in Jamaica, Puerto Rico, Cuba, Trinidad and the Lancetilla Experimental Garden in Honduras where plants were received from the Philippines in 1926 and seeds from Cuba in 1927. There are a few in Bermuda and in Hawaii where the mabolo first fruited in 1928. Nowhere has the mabolo gained the favor it enjoys in its homeland.

Varieties

Mabolo trees vary in the degree of hairiness on the twigs and leaves. Burkill (in Malaya) and Mendiola (in the Philippines) refer to mabolos with red and copper-colored skin as distinct races. A race with purplish-red skin and unusually sweet flavor was long ago introduced into Malaya. In 1921, budded trees of a superior seedless cultivar called **'Manila'** were shipped to the United

States Department of Agriculture by P.J. Wester, who was then Horticulturist in charge of the Manila Experiment Station. The parent tree in the Philippines had a history of bearing crops of oblate, sweet, juicy fruits, 80% of them seedless, 20% having 1 to 3 seeds. Another seedless Philippine cultivar was named **'Valesca'.**

Mendiola (1926) wrote that seedless mabolos "are easily distinguished from the seedy ones as they are flatter. It is believed by some horticulturists and growers that these seedless fruits come from branches that are bud sports . . . it is impossible to confirm or deny this claim until it is known how much parthenocarpy has to do with . . . these seedless forms . . . the genus Diospyros is, in a number of cases, parthenocarpic."

Propagation

The tree is generally grown from seeds. Shield-budding has been successfully practiced in the Philippines and is the preferred means of perpetuating superior types.

Cultivation

Male trees must be planted near the female trees for effective pollination and fruit production. The tree does best in loam but flourishes very well in almost any soil with little care. It is rarely fertilized and seems to need no protective spraying.

Season

In India, the mabolo blooms in March and April and the fruits ripen in July and August. The main season in Florida is June to September but occasional fruits may be found on the tree at almost any time of the year.

Keeping Quality

Investigators in Hawaii studied carbon dioxide and ethylene production of mature green and 5% red-colored mabolos. Mature-green fruits reached the climacteric peak stage in 9 days; the slightly ripe fruits, in 5 days.

Food Uses

The surface fuzz adheres tightly even when the fruit is ripe. Also, the skin, though thin and pliable, is tough and papery when chewed. Therefore, the fruits should be peeled before eating, and then kept in the refrigerator for a few hours before serving. Then the odor, which is mainly in the skin, will have largely dissipated.

Some people slice or quarter the flesh, season with lime or lemon juice or Grenadine sirup and serve fresh as dessert. The flesh is also diced and combined with that of other fruits in salads. If stewed in sirup, the flesh becomes fibrous and tough. Cut into strips and fried in butter, it is crisp and fairly agreeable as a vegetable of the dasheen or taro type appropriate for serving with ham, sausage or other spicy meat.

Food Value Per 100 g of Edible Portion*

	Ordinary type	*Seedless type*
Calories		504

Moisture	77.80 g	71.95-86.04 g
Protein	0.75 g	0.82-2.79 g
Fat		0.22-0.38 g
Carbohydrates		(other) 5.49-6.12 g
Sugar	11.47 g	(reducing) 6.25-18.52 g
Fiber		0.74-1.76 g
Ash	0.83 g	0.43-1.08 g
Sulphuric Acid	0.11 g	
Malic Acid	0.16 g	
Phytin	-	3.26% (on dry basis)

*Analyses made in the Philippines and India.

The fruit is considered a fairly good source of iron and calcium and a good source of vitamin B.

Toxicity

The hairs may be somewhat irritating to sensitive skin.

Other Uses

Mabolo seedlings: Useful as rootstock on which to graft the Japanese persimmon.

Wood: The sapwood is pinkish or reddish; may have gray markings. The heartwood is streaked and mottled with gray and is sometimes all-black. In the Philippines, it is carved into highly prized hair combs.

Morton, J. 1987. Carissa. p. 420–422. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Carissa

Carissa macrocarpa A. DC.

Carissa grandiflora A. DC.

Two species of the notorious family Apocynaceae are noteworthy because of their edible fruits and innocuous milky latex. The more attractive of these is the carissa, *Carissa macrocarpa* A. DC. (syn. *C. grandiflora* A. DC.), also called Natal plum and *amantungula*.

Description

A vigorous, spreading, woody shrub with abundant white, gummy sap, the carissa may reach a height of 15 to 18 ft (4.5-5.5 m) and an equal breadth. The branches are armed with formidable stout, double-pronged thorns to 2 in (5 cm) long. The handsome, evergreen, opposite leaves are broad-ovate, 1 to 2 in (2.5-5 cm) long, dark-green, glossy, leathery. Sweetly fragrant, white, 5-lobed, tubular flowers to 2 in (5 cm) broad are borne singly or a few together at the tips of branchlets all year. Some plants bear flowers that are functionally male, larger than normal and with larger anthers, and stamens much longer than the style. Functionally female flowers have stamens the same length as the style and small anthers without pollen.

The round, oval or oblong fruit, to 2 1/2 in (6.25 cm) long and up to 1 1/2 in (4 cm) across, is green and rich in latex when unripe. As it ripens, the tender, smooth skin turns to a bright magenta-red coated with a thin, whitish bloom, and finally dark-crimson. The flesh is tender, very juicy, strawberry-colored and -flavored, with flecks of milky sap. Massed in the center are 6 to 16 small, thin, flat, brown seeds, not objectionable when eaten.

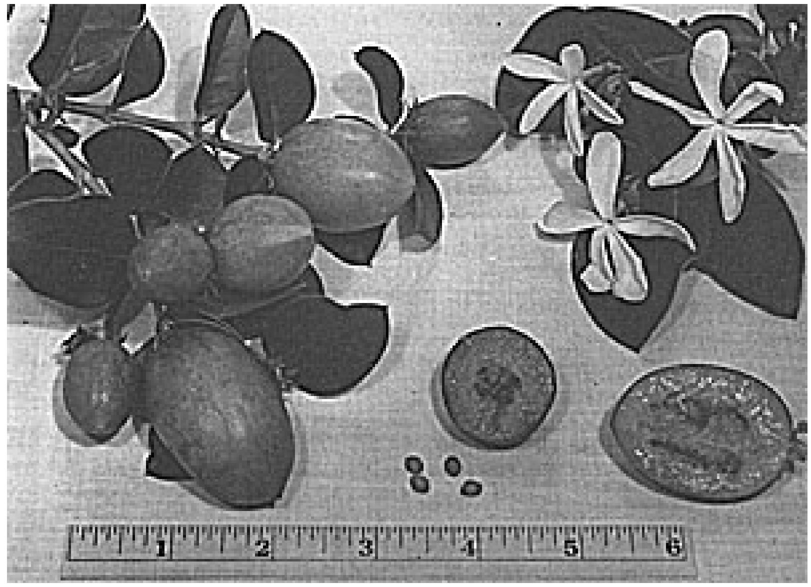

Fig. 110: Beautiful of foliage, flower and fruit, the thorny carissa (*Carissa grandiflora)* is primarily an ornamental but the fruits are edible and enjoyable.

Origin and Distribution

The carissa is native to the coastal region of Natal, South Africa, and is cultivated far inland in the Transvaal. It was first introduced into the United States in 1886 by the horticulturist Theodore L. Meade. Then, in 1903, Dr. David Fairchild, heading the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture, brought in from the Botanical Garden at Durban, a large quantity of seeds. Several thousand seedlings were raised at the then Plant Introduction Garden at Miami and distributed for testing in Florida, the Gulf States and California, and much effort was devoted to following up on the fate of the plants in different climatic zones. The carissa was introduced into Hawaii in 1905 and over the next few years was extensively distributed throughout the islands. It was planted in the Bahamas in 1913. It first fruited in the Philippines in 1924; is grown to a limited extent in India and East Africa. It was widely planted in Israel, flourished and flowered freely but rarely set fruit. Elsewhere, it is valued mainly as a protective hedge and the fruit is a more-or-less-welcomed by-product.

Varieties

Horticulturists in South Africa, California and Florida have selected and named some types that tend to bear more reliably than others:

'Fancy', selected in California in the 1950's, was an erect form bearing an abundance of large fruits with few seeds.

'Torrey Pines' produces good crops of fruit and pollen.

'Gifford' is one of the best fruit bearers in Florida.

'Extra Sweet' was advertised in Florida in the early 1960's.

'Alles' ('Chesley') produces few fruits in California.

'Frank' is a light bearer though it has a good supply of pollen.

As space for massive barrier hedges has diminished and interest in the fruits declined, efforts have been directed to the development of dwarf, compact, less spiny types for landscape use. Some of the popular ornamental cultivars include: **'Bonsai', 'Boxwood Beauty', 'Dainty Princess',**

'Grandiflora', 'Green Carpet', 'Horizontalis', 'Linkii', 'Low Boy', 'Minima', 'Nana', 'Nana Compacta', 'Prostrata' and 'Tuttlei'.

Pollination

In its homeland, the carissa is pollinated by small beetles and hawk-moths and other night-flying insects. Various degrees of unfruitfulness in America has been attributed to inadequate pollination. Some seedlings are light-croppers, but others never bear at all. It has been found that unproductive plants, apparently self-infertile, will bear fruits after cross-pollination by hand.

Climate

The carissa is subtropical to near-tropical, thriving throughout the state of Florida and enduring temperatures as low as 25º F (-3.89º C) when well-established. Young plants need protection when the temperature drops below 29º F (-1.67º C). Best growth is obtained in full sun.

Soil

The shrub thrives in dry, rocky terrain in Hawaii; in red clay or sandy loam in California, and in sandy or alkaline soils in Florida, though the latter may induce deficiencies in trace elements. The plant has moderate drought tolerance and high resistance to soil salinity and salt spray. It cannot stand water-logging.

Propagation

Seeds germinate in 2 weeks but the seedlings grow very slowly at first and are highly variable. Vegetative propagation is preferred and can be done easily by air-layering, ground-layering, or shield-budding. Cuttings root poorly unless the tip of a young branchlet is cut half-way through and left attached to the plant for 2 months. After removal and planting in sand, it will root in about 30 days. Grafting onto seedlings of the karanda (q.v.) has considerably increased fruit yield.

Culture

Seedlings may begin to produce fruit in 2 years; cuttings earlier. A standard, well-balanced fertilizer suffices except on limestone where trace elements must be added. Dwarf cultivars must be kept under control, otherwise they are apt to revert to the ordinary type. Vigorous shoots will develop and outgrow the compact form.

Season

While the carissa flowers and fruits all year, the peak period for blooming and fruiting is May through September. The 5-pointed calyx remains attached to the plant when the fruit is picked.

Pests and Diseases

Spider mites, thrips and whiteflies, and occasionally scale insects, attack young plants, especially in nurseries and in the shade.

A number of fungus diseases have been recorded in Florida; algal leaf spot and green scurf caused by *Cephaleuros virescens;* leaf spot from *Alternaria* sp., *Botryosphaeria querquum, Fusarium* sp., *Gloeosporium* sp., *Phyllosticta* sp. and *Colletotrichum gloeosporioides* which also is responsible for anthracnose; stem gall from *Macrophoma* sp., *Nectria* sp., *Phoma* sp., *Phomopsis* sp., and both galls and cankers from *Sphaeropsis tumefaciens;* dieback caused by *Diplodia natalensis* and *Rhizoctonia solani;* thread blight from *Rhizoctonia ramicola;* root rot resulting from infection by *Phytophthora parasitica* and *Pythium* sp.

Food Uses

The carissa must be fully ripe, dark-red and slightly soft to the touch to be eaten raw. It is enjoyed whole, without peeling or seeding, out-of-hand. Halved or quartered and seeded it is suitable for fruit salads, adding to gelatins and using as topping for cakes, puddings and ice cream. Carissas can be cooked to a sauce or used in pies and tarts. Stewing or boiling causes the latex to leave the fruit and adhere to the pot (which must not be aluminum), but this can be easily removed by rubbing with cooking oil.

Carissas are preserved whole by pricking, cooking briefly in a sugar sirup and sterilizing in jars. Peeled or unpeeled, they are made into jam, other preserves, sirup or sweet pickles. Jelly is made from slightly underripe fruits, or a combination of ripe and unripe to enhance the color.

Food Value

Analyses made in the Philippines show the following values: calories, 270/lb (594/kg); moisture, 78.45%; protein, 0.56%; fat, 1.03%; sugar, 12.00%; fiber, 0.91%; ash, 0.43%. Ascorbic acid content has been calculated as 10 mg/100 g in India.

Morton, J. 1987. Karanda. p. 422–424. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Karanda

Carissa congesta Wight

Carissa carandas Auct.

Less showy than the carissa, q.v., the karanda has attracted more interest as a source of fruit and as a medicinal plant than as an ornamental. Its botanical name was in recent years changed to *Carissa congesta* Wight (syn. *C. carandas* Auct., formerly widely shown as *C. carandas* L.). It is called *kerenda* in Malaya, *karaunda* in Malaya and India; Bengal currant or Christ's thorn in South India; *nam phrom*, or *namdaeng in* Thailand; *caramba, caranda*, *caraunda and perunkila* in the Philippines.

Description

This species is a rank-growing, straggly, woody, climbing shrub, usually growing to 10 or 15 ft (3-5 m) high, sometimes ascending to the tops of tall trees; and rich in white, gummy latex. The branches, numerous and spreading, forming dense masses, are set with sharp thorns, simple or forked, up to 2 in (5 cm) long, in pairs in the axils of the leaves. The leaves are evergreen, opposite, oval or elliptic, 1 to 3 in (2.5-7.5 cm) long; dark-green, leathery, glossy on the upper surface, lighter green and dull on the underside. The fragrant flowers are tubular with 5 hairy lobes which are twisted to the left in the bud instead of to the right as in other species. They are white, often tinged with pink, and borne in terminal clusters of 2 to 12. The fruit, in clusters of 3 to 10, is oblong, broad-ovoid or round, 1/2 to 1 in (1.25-2.5 cm) long; has fairly thin but tough, purplish-red skin turning dark-purple or nearly black when ripe; smooth, glossy; enclosing very acid to fairly sweet, often bitter, juicy, red or pink, juicy pulp, exuding flecks of latex. There may be 2 to 8 small, flat, brown seeds.

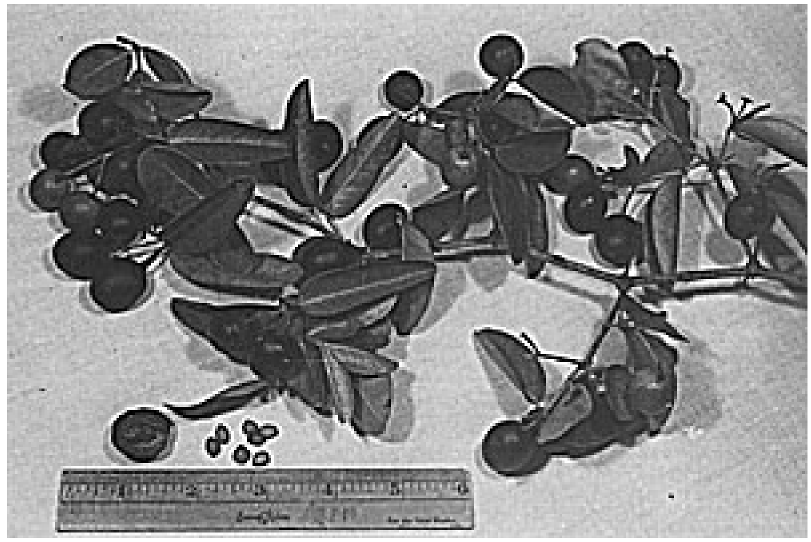

Fig. 111: The karanda *(Carissa carandas) is* small and gummy but yields colorful, tart juice.

Varieties

Formerly there were believed to be 2 distinct varieties: *C. carandas* var. amara–with oval, dark-purple, red-fleshed fruits, of acid flavor; and var. dulcis–round, maroon, with pink flesh and sweet-subacid flavor. However, David Sturrock, a Florida horticulturist who took a special interest in the karanda, observed these and other variations throughout seedling populations.

Origin and Distribution

The karanda is native and common throughout much of India, Burma and Malacca and dry areas of Ceylon; is rather commonly cultivated in these areas as a hedge and for its fruit and the fruit is marketed in villages. It is rare in Malaya except as a potted plant in the north; often grown in Thailand, Cambodia, South Vietnam and in East Africa. It was introduced into Java long ago as a hedge and has run wild around Djakarta. The karanda first fruited in the Philippines in 1915 and P.J. Wester described it in 1918 as "one of the best small fruits introduced into the Philippines within recent years."

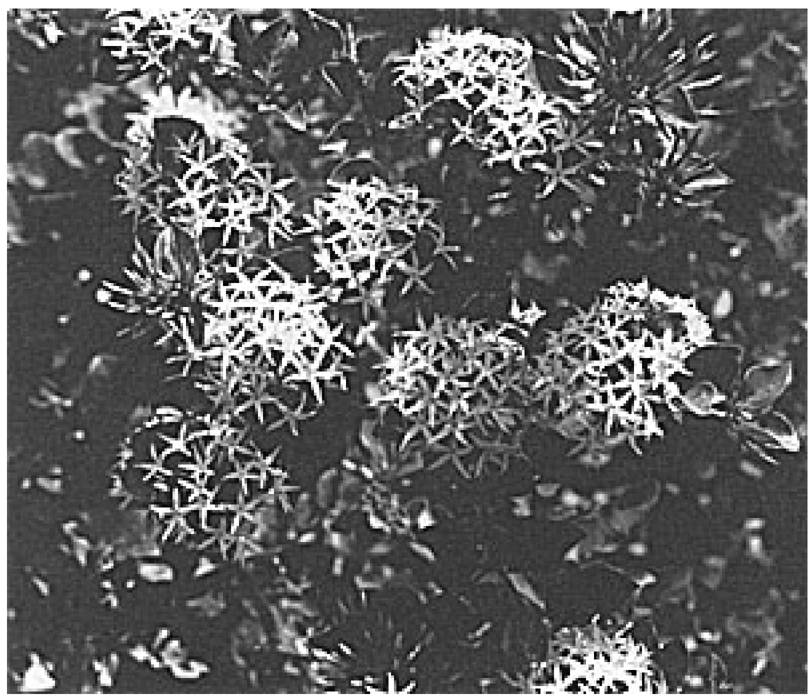

Fig. 112: The karanda, shrubby or climbing, is conspicuous when in starry bloom.

The United States Department of Agriculture received seeds from the Middle Egypt Botanic Garden in 1912 (S.P.I. #34364); from P.J. Wester in the Philippines in 1918 (S.P.I. #46636) and again in 1920 (S.P.I. #51005); and a third time in 1925 (S.P.I. #65334). The shrub has been cultivated in a limited way in Florida and California and in some experimental gardens in Trinidad and Puerto Rico.

Climate

The karanda is more cold-tolerant than the carissa. It grows from sea-level to 2,000 ft (600 m) in the Philippines; but up to an altitude of 6,000 ft (1,800 m) in the Himalayas. Burkill says it is not really suited to the humid climate of Malaya. Like the carissa, its chief requirement is full exposure to sun.

Soil

The plant grows vigorously in Florida on sand or limestone. In India, it grows wild on the poorest and rockiest soils and is grown as a hedge plant in dry, sandy or rocky soils. It is most fruitful on deep, fertile, well-drained soil but if the soil is too wet, there will be excessive vegetative growth and lower fruit production.

Propagation

Propagation is usually by seed because cuttings have never rooted readily. Experimental work in India has shown that cuttings from mature plants may not root at all; 20% of hardwood cuttings from trimmed hedges have rooted in November but not when planted earlier. Cuttings from nursery stock gave best results: 10% rooted in late September; 20% in early October; 30% in late October; and 50% in early November. In all cases, cuttings were pre-treated with indolebutyric acid at 500 ppm in 50% alcohol. Sturrock found that tender tip cuttings could be rooted under constant mist; also that the karanda can be grafted onto self-seedlings. It has proved to be a good rootstock for carissa.

Culture

The plant grows slowly when young. Once well-established, it grows more vigorously and becomes difficult to control. If kept trimmed to encourage new shoots, it will bloom and fruit profusely.

Season

The karanda may bloom and fruit off and on throughout the year. For use unripe, the fruits are harvested from mid-May to mid-July. The main ripening season is August and September. The 5-pointed calyx remains attached to the plant when the fruit is picked, leaving a gummy aperture at the base.

Keeping Quality

Freshly-picked ripe fruits can be kept at room temperature only 3 or 4 days before they begin to shrivel.

Pests and Diseases

Nursery plants are probably prone to the same pests that attack young carissas.

Fungus diseases recorded on the karanda in Florida are algal leaf spot and green scurf caused by *Cephaleuros virescens;* twig dieback from *Diplodia natalensis;* and stem canker induced by *Dithiorella* sp.

Food Uses

The sweeter types may be eaten raw out-of-hand but the more acid ones are best stewed with plenty of sugar. Even so, the skin may be found tough and slightly bitter. The fruit exudes much gummy latex when being cooked but the rich-red juice becomes clear and is much used in cold beverages. The sirup has been successfully utilized on a small scale by at least one soda-fountain operator in Florida. In Asia, the ripe fruits are utilized in curries, tarts, puddings and chutney. When only slightly underripe, they are made into jelly. Green, sour fruits are made into pickles in India. With skin and seeds removed and seasoned with sugar and cloves, they have been popular as a substitute for apple in tarts. British residents in India undoubtedly favored the karanda as being reminiscent of gooseberries.

Food Value

Analyses made in India and the Philippines show the following values for the ripe karanda: calories, 338 to 342/lb (745-753/kg); moisture, 83.17-83.24%; protein, 0.39-0.66%; fat, 2.57-4.63%; carbohydrate, 0.51-0.94%; sugar, 7.35-11.58%; fiber, 0.62-1.81%; ash, 0.66-0.78 %. Ascorbic acid content has been reported as 9 to 11 mg per 100 g.

Other Uses

Fruit: The fruits have been employed as agents in tanning and dyeing.

Leaves: Karanda leaves have furnished fodder for the tussar silkworm.

Root: A paste of the pounded roots serves as a fly repellent.

Wood: The white or yellow wood is hard, smooth and useful for fashioning spoons, combs, household utensils and miscellaneous products of turnery. It is sometimes burned as fuel.

Medicinal Uses: The unripe fruit is used medicinally as an astringent. The ripe fruit is taken as an antiscorbutic and remedy for biliousness. The leaf decoction is valued in cases of intermittent fever, diarrhea, oral inflammation and earache. The root is employed as a bitter stomachic and vermifuge and it is an ingredient in a remedy for itches. The roots contain salycylic acid and cardiac glycosides causing a slight decrease in blood pressure. Also reported are carissone; the D-glycoside of *B*-sitosterol; glucosides of odoroside H; carindone, a terpenoid; lupeol; ursolic acid and its methyl ester; also carinol, a phenolic lignan. Bark, leaves and fruit contain an unnamed alkaloid.

Morton, J. 1987. Naranjilla. p. 425–428. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Naranjilla

Solanum quitoense Lam.

Solanum angulatum Lam.

An intriguing and highly appealing member of the nightshade family, Solanaceae, the naranjilla, *Solanum quitoense* Lam. (syn. S. *angulatum* Lam.), acquired its Spanish name, meaning "little orange" because it is round, and is bright-orange when fully ripe. In Ecuador it is called *naranjilla de Quito,* or *nuqui;* in Peru, *naranjita de Quito.* The Incas called it *lulum.* In Mexico, it is *lulun;* in Colombia, *lulo, naranjilla* or *toronja.* Variety *septentrionale* Schultes & Cuatr. is called *lulo de castilla, lulo de perro,* or *lulo morado.*

Description

The naranjilla plant is a spreading, herbaceous shrub to 8 ft (2.5 m) high with thick stems that become somewhat woody with age; spiny in the wild, spineless in cultivated plants. The alternate leaves are oblong-ovate, to 2 ft (60 cm) long and 18 in (45 cm) wide, soft and woolly. There may be few or many spines on petioles, midrib and lateral veins, above and below, or the leaves may be


Plate LXIII: NARANJILLA, *Solanum quitoense*

completely spineless. Young leaves, young stems and petioles are coated with richly purple stellate hairs. Hairs on other parts may appear simple. Borne in short axillary clusters of as many as 10, the fragrant flowers, about 1 1/5 in (3 cm) wide, have 5 petals, white on the upper surface, purple hairy beneath, and 5 prominent yellow stamens. The unopened buds are likewise covered with purple hairs. A brown, hairy coat protects the fruit until it is fully ripe, when the hairs can be easily rubbed off, showing the bright-orange, smooth, leathery, fairly thick peel. The fruit, crowned with the persistent, 5-pointed calyx, is round or round-ovate, to 2 1/2 in (6.25 cm) across and contains 4 compartments separated by membranous partitions and filled with translucent green or yellowish, very juicy, slightly acid to acid, pulp of delicious flavor which has been likened to pineapple-and-lemon. There are numerous pale-buff seeds, thin, flat, hard and 1/8 in (3 mm) in diameter.

Origin and Distribution

The usually spineless naranjilla is believed to be indigenous and most abundant in Peru, Ecuador and southern Colombia. The forms found in the rest of Colombia and in the central and northern Andes of Venezuela and interior mountain ranges of Costa Rica may vary from partly to very spiny. Some botanists have suggested that these spiny forms belong to the botanical variety *septentrionale.* In Ecuador, 90% of commercial naranjilla cultivation is in a 15-mile area in the valley and adjacent hillsides of the Pastaza River, a tributary of the Amazon.

Seeds were first sent to the United States Department of Agriculture from Colombia in 1913; from Ecuador in 1914 and 1916. Many other introductions were made but the resulting plantings in California, Florida and northern greenhouses flourished only briefly, some set fruit, and all died. Trial plantings were made in the Philippines about 1922. The exhibition of fruits and 1,500 gallons of freshly made juice of Ecuadorian naranjillas at the New York World's Fair in 1939 roused a great deal of interest. In February, 1948, 20 naranjilla plants were set out in a field at the University of Florida's Agricultural Research and Education Center in Homestead, Florida. They flourished and were beginning to fruit when nearly all were destroyed by hurricanes. Dr. Milton Cobin tried grafting the naranjilla on the so-called "potato tree", *Solanum macranthum* Dunal of Brazil, hoping to give it wind-resistance. The grafted plants were set out in 1949 and fruited well. Seeds of acid and sweet strains were obtained from the United States Department of Agriculture in 1950. Some of the resulting plants were grafted onto S. *macranthum* and did well; others, set out on their own roots, became severely infested with rootknot nematodes and died. In 1951, the naranjilla was grafted onto *S. erianthum* D. Don but the plants were dwarfed by this rootstock and short-lived. A number of fruit fanciers took up the growing of grafted naranjilla plants in home gardens. Interest was aroused in Caribbean horticulturists and other visitors to the Homestead station. In the early 1950's, plantings were made in Puerto Rico, Jamaica, Panama, Hawaii and Queensland, and in the Meseta Central of Costa Rica where one of several growers set out 70,000 plants of the local wild variety which bears a larger fruit than the non-spiny South American type.

In 1962, a commercial plantation owned by Frederic Zeuner, proprietor of Cia Procesadora de Naranjilla Ltda, of San José, covered 1,200 acres (511 ha) and a $55,000 factory was built to process the fruits. The pulp was being shipped to the United States in No. 10 cans. It was blended with apple or pineapple juice, put up in small cans and frozen for retail sale. In 1966, I was advised by the U.S. Agricultural Attaché in San José that this pilot effort failed because the canned product was not properly processed and had a metallic taste, also because of the collapse of the canners' contracts with farmers. Production of a better product with proper cooling and storage continued on a local scale. In 1963, the naranjilla was a relatively new crop in Guatemala and there was an experimental plantation and others that were semi-commercial.

The naranjilla is much admired as an ornamental foliage plant in northern conservatories but it will not fruit in temperate latitudes.

Varieties

The botanical variety *septentrionale* already referred to is found in Valle, Cundinamarca, Magdalena, Santanderes and Tolima, in central and northern Colombia, and also in Ecuador and Venezuela. It is said to differ from the typical form, var. *quitoense*, of Ecuador, Peru and southern Colombia, only in having spines on the stem, branches, petioles, and principal veins of the leaves.

There is a sweet, but not very juicy strain around the Andean town of Baza, about 50 miles (80 km) east of Quito, Ecuador.

A wild, spiny form in Costa Rica, called *berenjena de olor* ("fragrant eggplant"), has woodier stem and branches and unusually large fruits to 2 1/2 in (6.25 cm) in diameter.

The fruit of seedling plants shows much variation. However, there seems to be little or no effort to select and name superior cultivars.

Climate

In Colombia, the naranjilla flourishes in humid regions at elevations between 3,600 and 7,900 ft (1,600 and 2,400 m) where the annual rainfall is about 60 in (150 cm). Precipitation up to 120 in (250 cm) is tolerable if well distributed throughout the year. In Panama, the naranjilla has made good growth at altitudes from 4,000 to 6,000 ft (1,200-1,800 m). It is grown in southern Florida at near sea-level. The best plantations in Ecuador are between 5,000 and 6,000 ft (1,500-1,800 m), where the mean temperature is 62.6º to 66.2º F (17º-19º C). The naranjilla cannot tolerate temperatures over 85º F (29.4º C). It is not adapted to full sun but favors semi-shade.

Soil

The plant does best in a rich, organic soil; also grows well on poor, stony ground, and on scarified limestone. It must have good drainage. In Latin America, naranjillas are planted on virgin soil in tracts where the large trees have been felled and the undergrowth burned off. The remaining trees provide semi-shade and wind protection.

Propagation

The naranjilla can be propagated by air-layering or by cuttings of mature wood. In Latin America, it is commonly grown from seeds which must first be spread out in the shade to ferment slightly to eliminate the mucilage, then washed, air-dried, and dusted with fungicide. There are about 140,000 seeds to the pound (.5 kg); 9,000 to the ounce (28 g). Seedlings are raised in nurseries by the same methods appropriate for tomato seedlings, and are ready for transplanting in 2 to 3 months.

In Florida, the naranjilla is easily cleft-grafted onto *S. macranthum* seedlings that have grown 2 ft (60 cm) tall and have been cut back to 1 ft (30 cm) from the ground, then split down the center for a distance of 1 to 2 in (2.5-5 cm). Selected scions 2 to 3 in (5-7.5 cm) long are inserted in the slit and tightly bound in place. It takes 2 to 3 weeks for the scion to fully unite with the stock. The plants are not set out until the scion has grown about 2 ft (30 cm). Other grafting methods–saddle, side, and whip–have also been successful.

Trials on tree tomato *(Cyphomandra betacea* Sendt.) seemed promising in 1952. In tropical Africa, the naranjilla has done well on the nematode-resistant relative, *S. torvum* Sw.

Culture

Naranjilla plants should be set 6 to 8 ft (1.8-2.4 m) apart each way, which provides 1,250 plants per acre (3,000/ha). Colombians transplant young seedlings from the nursery bed into polyethylene bags containing 5 1/2 lbs. (2.5 kg) of soil, keep them in semi-shade, give them ;4 oz (14 g) of super-phosphate and frequent irrigation. When 14 in (35 cm) high, they are set out in holes enriched with 8.8 lbs (4 kg) of organic compost, breaking the plastic bag as they place the plant in the hole. In Latin America, generally, the naranjilla is planted out in the afternoon of a cloudy day at the beginning of the rainy season. The planting hole is 12 x 12 x 12 in (30 x 30 x 30 cm) and a circle at least 3 ft (1 m) in diameter is kept free of weeds. The plant is a heavy feeder and growth is rapid if fertilizer is given once a month, though most plantations are given no such nutritional care. A 12-12-20 mixture of NPK at the rate of 3 oz (85 g) per plant every 2 months has been recommended. In the coffee zone of Caldas, Colombia, where the soil is organically rich but low in phosphorus, the addition of urea, superphosphate and potassium sulphate, has been found to double productivity.

Seedlings flower 4 to 5 months after transplanting. Fruiting begins 10 to 12 months from seed and is continuous for 3 years in Panama. When the plants reach 4 years of age, productivity declines and they begin to die. In Costa Rica, they are said to bear until 4 to 7 years old. Grafted plants begin to bear about 1 year from planting in the field. In Florida, they continue fruiting for 2 years, then they die back and are replaced by young ones. Watering is essential in dry periods.

Harvesting and Yield

Though everbearing in its natural habitat, the naranjilla fruits mainly in the winter in Florida; rarely, or very lightly, in the summer. For eating out-of-hand, the fruits are picked fully ripe, at which stage the calyx naturally separates from the fruit, leaving a circular depression. In the field, workers remove the hairs by stooping down and rubbing the fruit in dry grass. For marketing, the fruits must be picked when half-colored to avoid falling and bruising and to assure they are firm enough to withstand handling and packing. They are individually cleaned with a dry cloth and then packed in wooden boxes holding 400 fruits–about 70 lbs (32 kg).

In large-scale processing operations, there are mechanized devices for inspection and grading of fruits, washing off the hairy coat, drying, and removing the peduncle and calyx. For underripe fruits with firmly adhering hairs, the machine must be equipped with brushes. Because of the continuous bearing, fruits must be collected every 7 to 10 days. In Ecuador, long trains of mules and burros make weekly trips with sacks and boxes of naranjillas down the trails to central market places.

A healthy plant bears 100 to 150 fruits a year. A good annual yield is 135 fruits–20 lbs (9 kg)–per plant. This results in 25,000 lbs (10,417 kg) per acre, 60,000 lbs (27,273 kg) per hectare.

Keeping Quality

Fully ripe naranjillas soften and ferment very quickly. Fruit picked when half colored will remain in good condition at ordinary temperatures for 8 days. They can be stored for 1 or 2 months at 45º-50º F (7.22º-10º C) and relative humidity of 70 to 80%.

Pests and Diseases

The chief enemies of the naranjilla are the rootknot nematodes (*Meloidogyne* sp.) and grafting on nematode-resistant rootstock is essential to fruit production in southern Florida. In the Chinchiná coffee-growing region of Caldas, Colombia, nematicide-treatment of the soil each time it is invaded is considered too expensive, and the plants can therefore be kept in production only one year before they succumb to nematode damage. Nematodes are causing a drop in naranjilla production in various parts of the country and Dr. Charles Heiser of Indiana University is studying the possibility of hybridization with nematode-resistant wild relatives in order to save the industry. Measures to reduce nematode populations in Guatemalan fields include discarding nursery seedlings and adult plants that show typical symptoms (chlorosis, dwarfing, rachitic appearance), mulching, or frequent plowing during hot, dry spells. In Panama, the main stem and branches, and sometimes even the fruits, of mature plants are attacked by the *cochinilla blanca* (white, or West Indian, peach scale, *Pseudaulacaspis pentagona*).

A number of other pests and diseases affect naranjilla plants in Colombia. Bacterial wilt is a serious problem in Puerto Rico.

Food Uses

Ripe naranjillas, freed of hairs, may be casually consumed out-of-hand by cutting in half and squeezing the contents of each half into the mouth. The empty shells are discarded. The flesh, complete with seeds, may be squeezed out and added to ice cream mix, made into sauce for native dishes, or utilized in making pie and various other cooked desserts. The shells may be stuffed with a mixture of banana and other ingredients and baked. But the most popular use of the naranjilla is in the form of juice. For home preparation, the fruits are washed, the hairs are rubbed off, the fruits cut in half, the pulp squeezed into an electric blender and processed briefly; then the green juice is strained, sweetened, and served with ice cubes as a cool, foamy drink. A dozen fruits will yield 8 oz (227 g) of juice. Commercially, the juice is extracted mechanically from the cleaned and chopped fruits, strained, concentrated and canned or put into plastic bags and frozen.

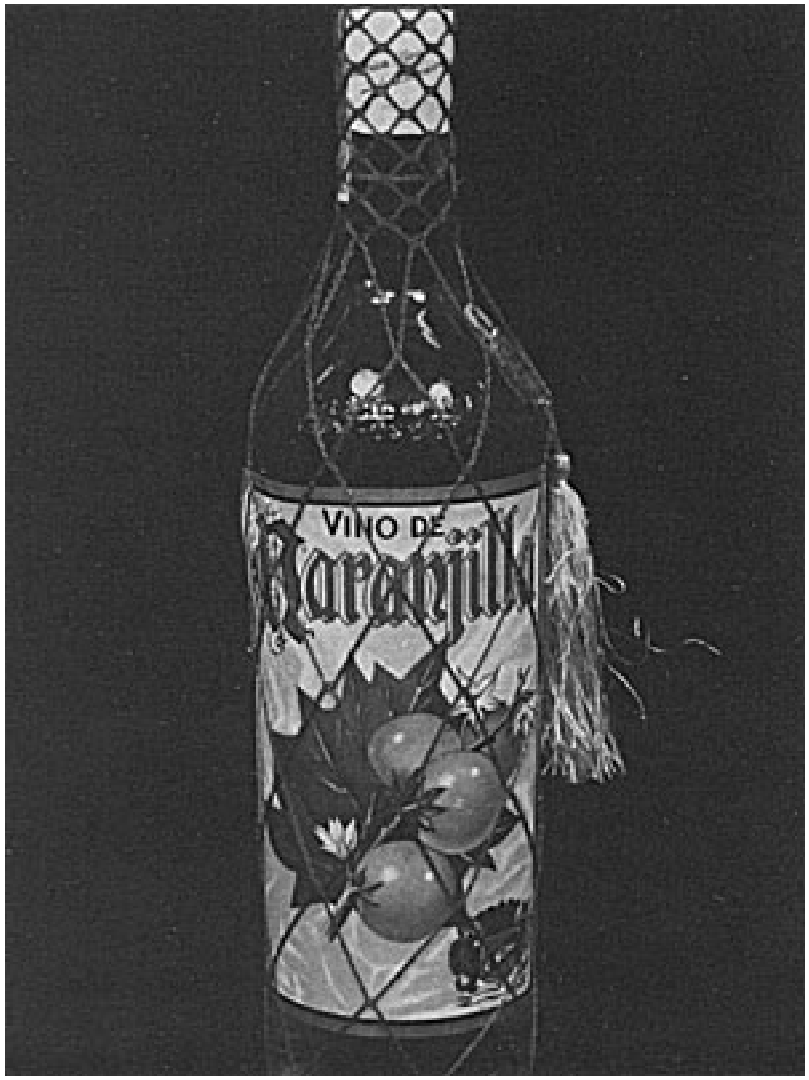

Fig. 113: Naranjilla (*Solanum quitoense*) juice is most prized fresh or preserved, but some is made into wine in Colombia.

Sherbet is made in the home by mixing naranjilla juice with corn sirup, sugar, water, and a little lime juice, partially freezing, then beating to a froth and freezing. Naranjilla jelly and marmalade are produced on a small scale in Cali, Colombia.

Food Value Per 100 g of Edible Portion*	
Calories	23
Moisture	85.8-92.5 g
Protein	0.107-0.6 g
Carbohydrates	5.7 g
Fat	0.1-0.24g
Fiber	0.3-4.6 g
Ash	0.61-0.8g
Calcium	5.9-12.4 mg
Phosphorus	12.0-43.7 mg
Iron	0.34-0.64 mg
Carotene	0.071-0.232 mg (600 I.U.)
Thiamine	0.04-0.094 mg
Riboflavin	0.03-0.047 mg
Niacin	1.19-1.76 mg
Ascorbic Acid	31.2-83.7 mg

*According to analyses of fresh fruits in Colombia and Ecuador.

Toxicity

People with very sensitive skin may find the hairs on the fruits irritating and should protect the hands when rubbing off the fuzz.

Closely Related Species

Dr. Charles Heiser has made a survey of wild relatives of the naranjilla in the hope that one or more of them may be used in cross-breeding to incorporate nematode-resistance without adversely affecting the fruit quality, productivity and other desirable characteristics. He found *S. tequileme* A. Gray most like *S. quitoense.* It is native from central Mexico to central Ecuador, usually between 3,200 and 6,200 ft (1,000-1,900 m) of elevation, and its fruit is sometimes eaten though its hairy coat is more persistent than that of the naranjilla. Fertile hybrids of the two species have been achieved.

Among other wild species reported by Heiser as having edible, naranjilla-like fruits: *S. pseudolulo* Heiser, of Colombia, with cream-colored flesh and short hairs which are readily shed. The fruits are gathered and sold by local vendors. This species, also, has made fertile hybrids with *S. quitoense.*

S. candidum occurring in lowland areas from Mexico to northern Peru and called *huevo de gato.* The juice is less flavorful than that of the naranjilla and the hairs do not detach readily.

S. pectinatum Dunal (syn. *S. hirsutissimum* Standl.), often a small tree, ranges from Mexico to Venezuela and Peru, is known variously as *lulita, lulo de la tierra fria, toronja*, or *tumo.* It has juice of fine flavor but is handicapped by persistent hairs and the fruit reportedly contains alkaloids which may hinder its exploitation. The spiny plant is a local folk-remedy for hypertension.

The inedible *S. hirtum* Vahl., *huevo de gato,* found wild in Trinidad and Tobago, Yucatan, Central America, Colombia and Venezuela, is nematode-resistant and hybrids of this species and *S. quitoense* retain this character and have moderately good fruits. Dr. Heiser is encouraging further efforts at cross-breeding in Colombia and Costa Rica.

Morton, J. 1987. Cocona. p. 428–430. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Cocona

Solanum sessiliflorum Dunal.

Closely allied to the naranjilla, and similar vegetatively but with a quite different fruit, the cocona is much less known outside its natural range. At one time it was erroneously identified as *Solanum hyporhodium* A. Br. & Bouché. This binomial was dropped in favor of *S. topiro* HBK., which is now replaced by *S. sessiliflorum* Dunal. The Amazonian Indian name, *cubiyú, is* a term applied to several species of *Solanum,* but around Manaus, Brazil, *cubiu* pertains specifically to *S. sessiliflorum.* The Indians of the Upper Orinoco call it *tupiro* or *topiro.* Some Colombians refer to it as *coconilla,* or as *lulo,* a name more often given to the naranjilla. It has been casually dubbed "turkey berry", "peach tomato", or "Orinoco apple".

Description

The cocona plant is a much-branched, herbaceous shrub 6 1/2 ft (2 m) high, with downy stem, densely white-hairy twigs, and ovate leaves, oblique at the base, scalloped on the margins, downy on the upper surface, prominently veined beneath; 18 in (45 cm) long and 15 in (38 cm) wide. New shoots are rusty-hairy on the underside. The wild variety *georgicum* has spines on stem, branches and leaves. The flowers, in clusters of 2 or more in the leaf axils, are 1 in (2.5 cm) wide, with 5 pale greenish-yellow petals, 5 yellow stamens, and a dark-green, 5-pointed calyx. Borne


Plate LXIV: COCONA, *Solanum sessiliflorum*

singly or in compact clusters on very short peduncles, and capped with the persistent calyx, the fruit may be round, oblate, oblong or conical-oval, with bluntly rounded apex; 1 in (2.5 cm) to 4 in (10 cm) long, and up to 2 1/3 in (6 cm) wide at the base. The thin, tough skin is coated with a slightly prickly, peach-like fuzz until the fruit is fully ripe, then it is smooth, golden- to orange-yellow, burnt-orange, red, red-brown or deep purple-red, and has a bitter taste. Within is a 1/4 to 3/8 in (6-10 mm) layer of cream-colored, firm flesh enclosing the yellow, jelly-like central pulp. The cut-open fruit has a faint, tomato-like aroma. The flesh has a mild flavor faintly suggestive of tomato, while the pulp has a pleasant, lime-like acidity. Abundant throughout the central pulp are the thin, flat, oval, cream-colored seeds, 3/32 to 3/16 in (2-4 mm) in length and unnoticeable in eating.

Origin and Distribution

The spineless cocona is apparently unknown in the wild, having been observed by botanists only in cultivation from Peru and Colombia to Venezuela and bordering regions of Brazil. In 1760, a Spanish surveyor, Apolinar Diez de la Fuente, found the cocona with maize and beans in an Indian garden between Guaharibos Falls and the juncture of the Casiquiare and Orinoco rivers. In 1800, Humboldt and Bonpland, traveling up the Orinoco, observed that the cocona was one of the common plants in the region between the Javita and Pimichin rivers, and they collected specimens on which the first technical description was based. In the mid-1940's, seeds from the upper Amazon were planted at the Experiment Station in Tingo Maria, Peru, and, later on, the plant was grown at the Instituto Interamericano de Agricultura at Turrialba, Costa Rica. Seeds sent from Natal, South Africa, were planted at the University of Florida's Agricultural Research and Education Center, Homestead, Florida, in 1948. By 1950, all the resulting plants had succumbed to nematode damage. The seeds sent to Medellin, Colombia, in 1948 could have been from these plants. Dr. J.J. Ochse grew specimens in a plot outside the then Botany Building at the University of Miami, Coral Gables, Florida, in 1953.

Dr. Niilo Virkki of Cupey, Puerto Rico, bought one fruit from a street vendor in Manaus, Brazil, in June 1964 and planted the seeds when he returned home. The seedlings grew vigorously and began fruiting in March 1965. Plant breeders studied the plant and fruits in view of its possible potential for hybridizing with the naranjilla. They determined the chromosome number of the cocona to be 2n = 24.

The fruits are much eaten by the Indians and commonly marketed throughout the producing areas of Latin America. In Colombia and Brazil, the cocona is a domestic product, in Peru it is the basis of an industry. Cultivation is being encouraged by Gerber's Baby Foods and farmers are guaranteed a good price. Canned juice is being exported to Europe.

Varieties

The wild variety, *S. topiro* var. *georgicum* Heiser, of the lowlands of eastern Ecuador and Colombia, is a smaller plant with smaller fruits and with spines on the stem, branches and leaves. It spontaneously hybridizes with the typical var. *topiro,* and Dr. Charles Heiser of Indiana University views it as the ancestor of the cultivated cocona.

In Peru, 4 types are distinguished: a) small, purple-red; b) medium, yellow; c) round, resembling an apple, yellow; d) pear-shaped. The medium-sized cocona is in greatest demand in Peru and especially for juice.

The Divisão de Ciencias Agronomicas of INPA in Amazonia, made a collection of 35 strains of cocona from Belem do Pará, Brazil, and Iquitos, Peru, and established an experimental block of 149 plants in pure sand for evaluation. The range of variation indicated that seedling coconas represent a great reservoir of characters to be utilized in improvement of the crop, to enhance nematode resistance, reduce seed count, and increase sweetness.

Climate

In Florida and Trinidad, the cocona is grown at near sea-level. In Colombia, it is grown from sea-level to an elevation of 2,000 ft (610 m), while elsewhere in South America it thrives at altitudes up to 3,000 or 4,000 ft (910-1,200 m). Unlike the naranjilla, the plant needs full sun.

Soil

The cocona grows in soil of medium fertility on Peruvian mountain slopes; in Amazonian Brazil, on latisols or pure sand. In Puerto Rico, it has done well on clay; in southern Florida on scarified limestone. Good drainage is essential.

Pollination

The cocona is self-fertile. Bees are always visiting the flowers and carrying pollen, and natural crosses are common. Fruits mature about 8 weeks after pollination.

Propagation

There are from 800 to 2,000 seeds in each fruit. New plants spring up voluntarily from seeds clinging to discarded rinds in full sun on disturbed ground in northern South America. For planting, seeds extracted from the ripe fruits are placed in the shade for 2 days to ferment a little and break down the mucilage. Then they are washed and dried briefly out of the direct sun, and finally dusted with fungicide –2 1/4 g per lb (5 g per kg) of seeds. The seeds are planted 3/8 in (1 cm) deep in nursery beds in rows 8 in (20 cm) apart; or in polyethylene bags containing a 50-50 mixture of potting soil and sand. In each bag, or each hole, one puts 4 to 5 seeds expecting the emergence of 1 or 2 sturdy seedlings. Germination time varies from 15 to 40 days.

Vegetative propagation is possible, in order to perpetuate a particular cultivar. Air-layers and cuttings of mature wood have been rooted successfully.

Culture

Seedlings are transplanted to the field when 8 to 12 in (20-30 cm) high and they are spaced 5 to 7 ft (1.5-2.5 m) apart each way, depending on the fertility of the soil. Flowering commences 2 to 3 months after transplanting. The plants usually begin fruiting in 6 to 7 months from seed and will continue fruiting for several months.

A fertilizer formula of 10-8-10 NPK is applied 6 times during the year at the rate of 1.8 to 2.5 oz (50-70 g) per plant. If the soil is low in phosphorus, the formula should be 10-20-10. Productivity has been greatly enhanced in field trials at Manaus on pure sand, by applying organic fertilizer–104 tons per acre (250 tons/ha), with the addition of appropriate amounts of triple super-phosphate, urea and chlorate of potassium.

Yield

Average annual yield in Colombia is 22 to 44 lbs (10-20 kg) per plant. In Costa Rica, cocona plants have yielded 40 to 60 lbs (18-27 kg) of fruit. In variety trials at Manaus, productivity per plant varied from 5 1/2 to 30 lbs (2.5-14 kg). An unfertilized plantation may provide 20 to 30 fruits per plant–12 tons per acre (29 tons/ha). With a high-yielding selection and a well-fertilized field, one can realize up to 136 fruits per plant–61 tons per acre (146 tons/ha). The fresh fruit keeps well for 5 to 10 days at normal temperature.

Processing studies have shown that 22 lbs (10 kg) of fruit will yield about 6 1/2 pints (3 liters) of preserved flesh and 3 1/4 lbs (1 1/2 liters) of jelly, or 2 gallons (7 1/2 liters) of juice. A plantation providing 30 tons fruit per acre (70 tons/ha) will yield 5,548 gallons preserved flesh and 2,774 gallons of jelly, or 13,738 gallons (52,000 liters) of juice.

Pests and Diseases

The cocona is prone to attack by rootknot nematodes *(Meloidogyne* sp.*)*. In 1973, it was decided, after test plantings at the Universidad Central de Venezuela, that it was impossible to cultivate the cocona commercially in that country because of its susceptibility to nematodes, but the experimenters at Manaus believe that they have demonstrated that selection for nematode-resistance and soil-enrichment can give the farmer good returns.

In Puerto Rico, a mealybug, *Pseudococcus* sp., infests the new growth but causes little harm. However, *Psara periosalis* has been very damaging in the fall. Cutworms and leaf-eating insects require control. In Brazil, a hemipterous bug of the family Tingidae colonizes the underside of the leaves, causing them to discolor and fall. A fungal disease *(Sclerotium* sp.*)* has been identified with wilting.

Food Uses

The ripe fruit is peeled and eaten out-of-hand by South American Indians. More sophisticated people use the fruit in salads, cook it with fish and also in meat stews. Sweetened, it is used to make sauce and pie-filling. It is prized for making jam, marmalade, paste, and jelly, and is sometimes pickled or candied. It is often processed as a nectar or juice which, sweetened with sugar, is a popular cold beverage. Dr. Victor Patiño of Cali, Colombia, states that a 50-50 cocona-naranjilla juice mixture is superior to naranjilla alone.

In Brazil, the leaves are cooked and eaten as well.

Food Value Per 100 g of Edible Portion*	

Protein	0.6 g
Fiber	0.4g
Carbohydrates	5.7 g
Calcium	12 mg
Phosphorus	14 mg
Iron	0.6 mg
Carotene	140 mcg
Thiamine	25 mcg
Riboflavin	
Niacin	500 mcg

*Analyses made in Brazil.

The fruit has a high level of citric acid, about 0.8%. Venezuelan studies reveal 142 mg tannin.

Toxicity

The cocona is utilized by Indians of eastern Peru to rid the head of lice.

Morton, J. 1987. Cape Gooseberry. p. 430–434. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Cape Gooseberry

Physalis peruviana L.

Physalis edulis Sims

The genus *Physalis*, of the family Solanaceae, includes annual and perennial herbs bearing globular fruits, each enclosed in a bladderlike husk which becomes papery on maturity. Of the more than 70 species, only a very few are of economic value. One is the strawberry tomato, husk tomato or ground cherry, *P. Pruinosa* L., grown for its small yellow fruits used for sauce, pies and preserves in mild-temperate climates. Though more popular with former generations than at present, it is still offered by seedsmen. Various species of *Physalis* have been subject to much confusion in literature and in the trade. A species which bears a superior fruit and has become widely known is the cape gooseberry, *P. Peruviana* L. (*P. edulis* Sims). It has many colloquial names in Latin America: *capuli, aguaymanto, tomate sylvestre,* or *uchuba*, in Peru; *capuli* or *motojobobo embolsado* in Bolivia; *uvilla* in Ecuador; *uvilla, uchuva, vejigón* or *guchavo* in Colombia; *topotopo,* or *chuchuva* in Venezuela; *capuli, amor en bolsa,* or *bolsa de amor,* in Chile; *cereza del Peru* in Mexico. It is called cape gooseberry, golden berry, *pompelmoes* or *apelliefie* in South Africa; *alkekengi* or *coqueret* in Gabon; *lobolobohan* in the Philippines; *teparee, tiparee, makowi,* etc., in India; cape gooseberry or *poha* in Hawaii.

Description

This herbaceous or soft-wooded, perennial plant usually reaches 2 to 3 ft (1.6-0.9 m) in height but occasionally may attain 6 ft (1.8) m. It has ribbed, often purplish, spreading branches, and nearly opposite, velvety, heart-shaped, pointed, randomly-toothed leaves 2 3/8 to 6 in (6-15 cm) long and 1 1/2 to 4 in (4-10 cm) wide, and, in the leaf axils, bell-shaped, nodding flowers to 3/4 in (2 cm) wide, yellow with 5 dark purple-brown spots in the throat, and cupped by a purplish-green, hairy, 5-pointed calyx. After the flower falls, the calyx expands, ultimately forming a straw-colored husk much larger than the fruit it encloses. The berry is globose, 1/2 to 3/4 in (1.25-2 cm) wide, with smooth, glossy, orange-yellow skin and juicy pulp containing numerous very small yellowish seeds. When fully ripe, the fruit is sweet but with a pleasing grape-like tang. The husk is bitter and inedible.

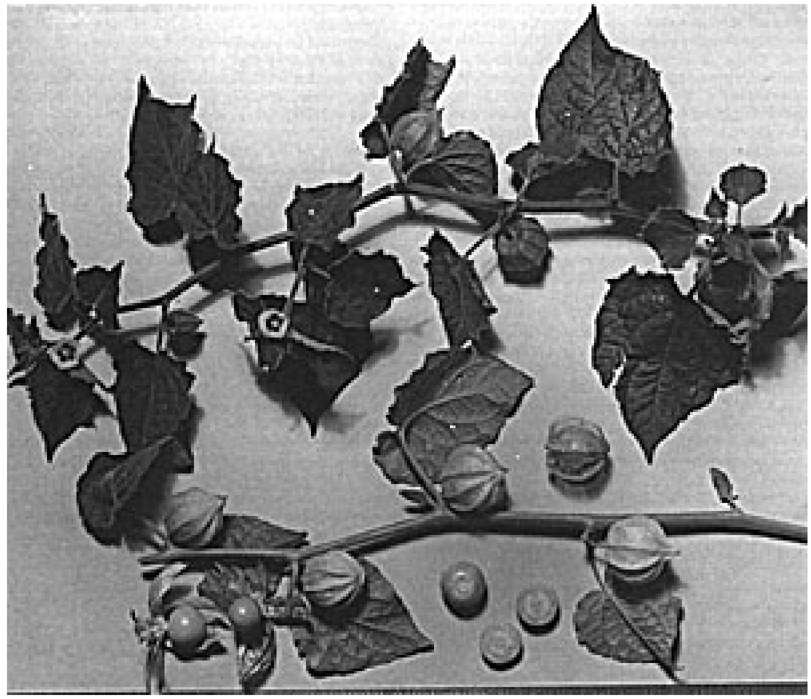

Fig. 114: The golden cape gooseberry (*Physalis peruviana)* keeps well and makes excellent preserves. The canned fruits have been exported from South Africa and the jam from England.

Origin and Distribution

Reportedly native to Peru and Chile, where the fruits are casually eaten and occasionally sold in markets but the plant is still not an important crop, it has been widely introduced into cultivation in other tropical, subtropical and even temperate areas. It is said to succeed wherever tomatoes can be grown. The plant was grown by early settlers at the Cape of Good Hope before 1807. In South Africa it is commercially cultivated and common as an escape and the jam and canned whole fruits are staple commodities, often exported. It is cultivated and naturalized on a small scale in Gabon and other parts of Central Africa.

Soon after its adoption in the Cape of Good Hope it was carried to Australia and there acquired its common English name. It was one of the few fresh fruits of the early settlers in New South Wales. There it has long been grown on a large scale and is abundantly naturalized, as it is also in Queensland, Victoria, South Australia, Western Australia and Northern Tasmania. It was welcomed in New Zealand where it is said that "the housewife is sometimes embarrassed by the quantity of berries [cape gooseberries] in the garden," and government agencies actively promote increased culinary use.

In China, India and Malaya, the cape gooseberry is commonly grown but on a lesser scale. In India, it is often interplanted with vegetables. It is naturalized on the island of Luzon in the

Fig. 115: The cape gooseberry is a useful small fruit crop for the home garden; is labor-intensive in commercial plantings.

Philippines. Seeds were taken to Hawaii before 1825 and the plant is naturalized on all the islands at medium and somewhat higher elevations. It was at one time extensively cultivated in Hawaii. By 1966, commercial culture had nearly disappeared and processors had to buy the fruit from backyard growers at high prices. It is widespread as an exotic weed in the South Sea Islands but not seriously cultivated. The first seeds were planted in Israel in 1933. The plants grew and bore very well in cultivation and soon spread as escapes, but the fruit did not appeal to consumers, either fresh or preserved, and promotional efforts ceased.

In England, the cape gooseberry was first reported in 1774. Since that time, it has been grown there in a small way in home gardens, and after World War II was canned commercially to a limited extent. Despite this background, early in 1952, the Stanford Nursery, of Sussex, announced the "Cape Gooseberry, the wonderful new fruit, especially developed in Britain by Richard I. Cahn." Concurrently, jars of cape goosebery jam from England appeared in South Florida markets and the product was found to be attractive and delicious. It is surprising that this useful little fruit has received so little attention in the United States in view of its having been reported on with enthusiasm by the late Dr. David Fairchild in his well-loved book, *The World Was My Garden.* He there tells of its fruiting "enormously" in the garden of his home, "In The Woods", in Maryland, and of the cook's putting up over a hundred jars of what he called "Inca Conserve" which "met with universal favor." It is also remarkable that it is so little known in the Caribbean islands, though naturalized plants were growing profusely along roadsides in the Blue Mountains of Jamaica before 1913.

With a view to encouraging cape gooseberry culture in Florida, the Bahamas, and the West Indies, seeds have been repeatedly purchased from the Stanford Nursery and distributed for trial. Good crops have been obtained. Nevertheless there was no incentive to make further plantings.

Pollination

In England, growers shake the flowers gently in summer to improve distribution of the pollen, or they will give the plants a very light spraying with water.

Climate

The cape gooseberry is an annual in temperate regions and a perennial in the tropics. In Venezuela, it grows wild in the Andes and the coastal range between 2,500 and 10,000 ft (800-3,000 m). It grows wild in Hawaii at 1,000 to 8,000 ft (300-2,400 m). In northern India, it is not possible to cultivate it above 4,000 ft (1,200 m), but in South India it thrives up to 6,000 ft (1,800 m).

In England, the plants have been undamaged by 3 degrees of frost. In South Africa, plants have been killed to the ground and failed to recover after a temperature drop to 30.5º F (-0.75º C).

The plant needs full sun but protection from strong winds; plenty of rain throughout its growing season, very little when the fruits are maturing.

Soil

The cape gooseberry will grow in any well-drained soil but does best on sandy to gravelly loam. On highly fertile alluvial soil, there is much vegetative growth and the fruits fail to color properly. Very good crops are obtained on rather poor sandy ground. Where drainage is a problem, the plantings should be on gentle slopes or the rows should be mounded. The plants become dormant in drought.

Propagation

The plant is widely grown from seed. There are 5,000 to 8,000 seeds to the ounce (28 g) and, since germination rate is low, this amount is needed to raise enough plants for an acre–2 1/2 oz (70 g) for a hectare. In India, the seeds are mixed with wood ash or pulverized soil for uniform sowing.

Sometimes propagation is done by means of 1-year-old stem cuttings treated with hormones to promote rooting, and 37.7% success has been achieved. The plants thus grown flower early and yield well but are less vigorous than seedlings. Air-layering is also successful but not often practiced.

Culture

It is necessary to determine the time of planting for each area. In India, seeds are broadcast from March through May. In Hong Kong, planting in seedbeds is done in September/October and again in March/April. In the Bahamas the first seeds planted in late summer of 1952 produced healthy plants and a continuous crop of fruits for 3 months during the following winter. Additional seeds procured from England were planted in April of 1953. The plants started to blossom in mid-July and from September on continued to flower and set fruit, although no fruits remained on the plants to maturity until the cooler months of winter when a good yield was obtained. Seeds were again planted the following November. Thirteen weeks later, the first fruits were ripening, and by mid-May of the following year a heavy crop was harvested. In late June, the plants were still growing and flowering profusely but only a few fruits were being set and these failed to develop to maturity. This condition continued into September, by which time some of the more robust plants had reached 6 ft (1.8 in) in height with much lateral growth.

In Jamaica, the initial planting of cape gooseberries in late January of 1954 made slow growth until June when development accelerated. By mid-August the plants had reached 15 in (37.5 cm) in height with much lateral growth, and were flowering and setting fruit. It would appear that the heat of summer is unfavorable for fruit development and, therefore, the best time to plant the cape gooseberry is in the fall so that fruit can be set during the cooler weather and harvested in late spring or early summer. In California, the plants do not fruit heavily until the second year unless started early in greenhouses.

Some growers have kept plants in production for as long as 4 years by cutting back after each harvest, but these plants have been found more susceptible to pests and diseases.

In India, plants 6 to 8 in (15-20 cm) high are set out 18 in (45 cm) apart in rows 3 ft (0.9 m) apart. Farmers in South Africa space the plants 2 to 3 ft (0.6-0.9 m) apart in rows 4 to 6 ft (1.2-1.8 m) or even 8 ft (2.4 m) apart in very rich soil. They apply 200 to 400 lbs (90-180 kg) of complete fertilizer per acre (approx. = kg/ha) on sandy loam. Foliar spraying of 1% potassium chloride solution before and just after blooming enhances fruit quality.

In dry seasons, irrigation is necessary to keep the cape gooseberry plant in production.

Season

In parts of India, the fruits ripen in February, but, in the South, the main crop extends from January to May. In Central and southern Africa, the crop extends from the beginning of April to the end of June. In England, plants from seeds sown in spring begin to fruit in August and continue until there is a strong frost.

Harvesting and Yield

In rainy or dewy weather, the fruit is not picked until the plants are dry. Berries that are already wet need to be lightly dried in the sun. The fruits are usually picked from the plants by hand every 2 to 3 weeks, although some growers prefer to shake the plants and gather the fallen fruits from the ground in order to obtain those of more uniform maturity. At the peak of the season, a worker can pick 2 1/2 bushels (90 liters) a day, but at the beginning and end of the season, when the crop is light, only 1/2 bushel (18 liters).

A single plant may yield 300 fruits. Seedlings set 1,800 to 2,150 to the acre (228-900/ha) yield approximately 3,000 lbs of fruit per acre (approx. = kg/ha). The fruits are usually dehusked before delivery to markets or processors. Manual workers can produce only 10 to 12 lbs. (4.5-5.5 kg) of husked fruits per hour. Therefore, a mechanical husker, 4 to 5 times more efficient, has been designed at the University of Hawaii.

Keeping Quality

Cape gooseberries are long-lasting. The fresh fruits can be stored in a scaled container and kept in a dry atmosphere for several months. They will still be in good condition. If the fresh fruits are to be shipped, it is best to leave the husk on for protection.

Pests and Diseases

In South Africa, the most important of the many insect pests that attack the cape gooseberry are cutworms, in seedbeds; red spider after plants have been established in the field; the potato tuber moth if the cape gooseberry is in the vicinity of potato fields. Hares damage young plants and birds (francolins) devour the fruits if not repelled. In India, mites may cause defoliation. In Jamaica, the leaves were suddenly riddled by what were apparently flea beetles of the family Chrysomelidae. In the Bahamas, whitefly attacks on the very young plants and flea beetles on the flowering plants required control.

In South Africa, the most troublesome diseases are powdery mildew and soft brown scale. The plants are prone to root rots and viruses if on poorly-drained soil or if carried over to a second year. Therefore, farmers favor biennial plantings. Bacterial leaf spot *(Xanthomonas* spp.) occurs in Queensland. A strain of tobacco mosaic may affect plants in India.

Food Uses

In addition to being canned whole and preserved as jam, the cape gooseberry is made into sauce, used in pies, puddings, chutneys and ice cream, and eaten fresh in fruit salads and fruit cocktails. In Colombia, the fruits are stewed with honey and eaten as dessert. The British use the husk as a handle for dipping the fruit in icing.

Food Value Per 100 g of Edible Portion*

Moisture	78.9 g
Protein	0.054 g
Fat	0.16 g
Fiber	4.9 g
Ash	1.01 g
Calcium	8.0 mg
Phosphorus	55.3 mg
Iron	1.23 mg
Carotene	1.613 mg
Thiamine	0.101 mg
Riboflavin	0.032 mg
Niacin	1.73 mg
Ascorbic Acid	43.0 mg

*According to analyses of husked fruits made in Ecuador.

The ripe fruits are considered a good source of Vitamin P and are rich in pectin.

Toxicity

Unripe fruits are poisonous. The plant is believed to have caused illness and death in cattle in Australia.

Other Uses

Fruits: In the 18th Century, the fruits were perfumed and worn for adornment by native women in Peru.

Medicinal Uses: In Colombia, the leaf decoction is taken as a diuretic and antiasthmatic. In South Africa, the heated leaves are applied as poultices on inflammations and the Zulus administer the leaf infusion as an enema to relieve abdominal ailments in children.

Indian chemists have isolated from the leaves a minor steroidal constituent, *physalolactone C.*

Morton, J. 1987. Mexican Husk Tomato. p. 434–437. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Mexican Husk Tomato

Physalis ixocarpa Brot.

Physalis aequata Jacq.

Somewhat suggesting a miniature tomato, the Mexican, or Mayan, husk tomato, *Physalis ixocarpa* Brot. (syn. *P. aequata* Jacq.), is also called tomate *de cáscara, tomate verde*, *tomate Mexicano, tomate de fresadilla, tomate de culebra, tomatillo, miltomate* and *farolito*.

Description

The plant, which is a semi-woody annual, may attain a height of 4 to 5 ft (1.2-1.5 m), but is often prostrate and spreading. Its branches and leaves are smooth, not downy. The leaves are ovate, pointed at apex, wedge-shaped at base, sometimes wavy-margined; 2 1/2 in (6.25 cm) long, 1 1/4 in (3.2 cm) wide. Borne singly in the leaf axils, the flowers, clasped halfway by a 5-toothed, green calyx, are 1/2 to 3/4 in (1.25-2 cm) long and wide; yellow with dark-brown spots in the throat. As the fruit develops, the calyx enlarges to more or less enclose it and finally becomes straw-colored and papery. It is so tight-fitting that it often bursts. The berry is slightly oblate, 1 to 2 1/2 in (2.5-6.25 cm) wide. When ripe, its thin skin may be yellow, purple, or, more rarely reddish, or still green. The flesh is pale-yellow, crisp or soft, and acid, subacid, sweet, or insipid, and contains many tiny seeds.

Fig. 116: The Mexican husk tomato, (*Physalis ixocarpa*), page-green, yellow, purple or reddish when ripe, is a staple food in Mexico and Guatemala and commonly marketed.

Origin and Distribution

The Mexican husk tomato was a prominent staple in Aztec and Mayan economy. The plant abounds in Mexico and the highlands of Guatemala and the fruits are commonly seen in native markets. Nevertheless, this species has not been as widely distributed abroad as the Cape gooseberry. It was introduced into India in the 1950's and is cultivated in the northwest desert region of Rajasthan. In Queensland, Australia, and in South Africa it has fruited prolifically. There is some commercial cultivation in Pietersburg, South Africa, for processing. It was too-successfully introduced into East Africa, for, in 1967, it was reported to be the most important weed of agricultural fields in the highlands of Kenya.

Before 1863, it was thoroughly naturalized and commonly growing in abundance in the far west of the United States. Mr. Sun Jue cultivated some 20 acres (8 ha) of Mexican husk tomatoes near Los Angeles, California, from 1930 to about 1939, supplying the fruits to Mexican and Italian markets. In 1945, the American Fruit Grower publicized this species under the concocted name "Jamberry", as a new fruit introduced by scientists at Iowa State College. Dr. I.E. Melhus, Director of the Iowa State College Guatemala Tropical Research Center reported in 1953 that, as a result of 6 years' testing of hundreds of selections, only a few were found suitable for the American Midwest. They were then sending out a strain to which they had given the name "Mayan husk tomato"; 4,000 packets of seed were distributed in Iowa and adjoining states. Sampling data from 200 people that grew the plant showed that over 60% were successful and liked the fruit. Later, that strain was offered by the Earl May Seed Company of Shenandoah, Iowa. An apparently independent introduction was made by Glecklers, Seedsmen, of Metamora, Ohio, and first offered by them as "Jumbo husk tomato" in 1952. Seeds obtained from these sources and from fruits purchased in the Mexican markets were given by the writer to experimenters in the Bahamas, Puerto Rico, Jamaica and Florida.

Plantings were successful in the Bahamas and Puerto Rico but did not arouse enough interest to cause further cultivation. Florida and Jamaica trials were failures. In recent years, test plantings have been made in Trinidad and Taiwan, and plants have fruited well in greenhouse culture in

England. The principal areas of production in Mexico are the States of Morelos and Hidalgo. The former has about 32,000 acres (13,000 ha) with a total production of 101,366 tons.

Varieties

There is great variation, not only in color and flavor of the numerous strains of Mexican husk tomato. Some require long days and others short days. Some mature early, others late. The husk may be long or short. The flesh may be soft and spongy or firm and crisp. A large number of selections has been made at the Campo Agricola Experimental de Zacatepec, in the State of Morelos, Mexico. The most promising, **'Rendidora',** is more erect than the common type, the fruit is large, green, ripens 15 days earlier than others and gives 80% greater yield. Horticulturists at the Universidad de San Simón in Bolivia have long maintained a collection of various types received from Mexico.

The "Mayan husk tomato" selection at Iowa is semi-prostrate, vigorous, branching at a height of 4 to 6 in (10-15 cm); the stems are pale-green, smooth and succulent when young. The fruit is round, yellow, with light-yellow, firm flesh and mild-acid flavor. According to Dr. Margaret Menzel, an authority on the genus, the so-called *Physalis macrocarpa*, or "Golden Nugget Cape Gooseberry", offered by seedsmen in Australia, is really a yellow-fruited form of the Mexican husk tomato, *P. ixocarpa.*

Pollination

The Mexican husk tomato is highly self-incompatible. When the flowering plants are bagged, no fruits are set. K.K. Pandey, while at the University of Ohio, studied this problem. He reported that only a few seedlings in a group produce rare fruits by natural-selfing and such fruits usually contain no seeds or only a small number. An occasional fruit may have 100 or more.

Climate and Soil

This species is not ultra-tropical but tropical and, like the tomato, is grown in summer in temperate regions. The plant needs full sun. It will grow in any soil suitable for tomatoes but not in wet situations.

Propagation

The Mexican husk tomato is usually raised from seed and it takes about 2 1/4 oz (60 g) to plant an acre; 5 1/4 oz (150 g) to plant a hectare. In Puerto Rico, seeds saved from the first crop and kept for 6 months without refrigeration were planted and 80% germinated.

Cuttings should root easily. Heavy rains cause the plants to bend down to the ground and it has been observed that tips that touch the soil take root and the new shoots grow vigorously.

Culture

Ideal spacing for cv. 'Rendidora' is 16 in (40 cm) between plants and 4 ft (1.25 m) between rows.

From 4 to 6 seeds are planted 1/2 in (1.25 cm) deep in hills 2 ft (60 cm) apart in rows 5 ft (1.5 m) apart. When 4 to 5 in (10-12.5 cm) high, the seedlings are thinned to 1 plant per hill. In the midwestern United States, seedlings are raised in greenhouses and are transplanted when about 3 weeks old as soon as all likelihood of spring frosts is past. They will begin to bear 6 to 18 weeks later and continue for about 1 1/2 months.

In Bahamian trials, seeds were planted in mid-April. By mid-September, the plants were fruiting heavily. They reseeded themselves and a healthy clump of "volunteers" sprang up on the site. In Puerto Rico, seeds planted at Mayaguez produced an abundant crop in the winter of 1953-54. The plot was fertilized at the rate of 2 oz (56 g) per plant, side dressing, of 9-8-8 fertilizer. The plants were staked and tied twice and grew to a height of 5 ft (1.5 m).

Season

Wild plants in Mexico flower from June to October. In the midwestern United States, flowering takes place in mid-June and fruits start to ripen in late July and fruiting continues until fall frosts. The plants bear during the summer months in South Africa; in northern India, both summer and winter.

Harvesting

With the Mexican husk tomato, falling of fruits before ripening is not uncommon, and, according to Dr. Melhus, they may be allowed to remain on the ground until fully colored. Collecting must be done every day. The green-skinned variety grown commercially by Mr. Jue was harvested as soon as it burst its husk, and the crop was then kept on hand 2 to 4 weeks for the husk to dry before the fruit was considered acceptable to the consumer. If left too long on the plant, there is much loss of flavor.

Yield

Individual plants may produce 64 to 200 fruits in a season. In test plantings at Ames, Iowa, the fruit yield averaged 2 12 lbs (1.1 kg) per plant; equal to approximately 9 tons per acre (20.2 MT/ha). In Mexico and India, yields of 7.5 to 10 tons per acre (17-22.5 MT/ha) have been reported.

Keeping Quality

The unhusked fresh fruits can be stored in single layers in a cool, dry atmosphere for several months. Mexican and Central American people may pull up the entire plant with fruits attached and hang it upside-down in a dry place until the fruits are needed.

Pests and Diseases

The Mexican husk tomato is subject to few pests and diseases. In Mexico, the main pest is the so-called *mosquita blanca* (see below). The larvae of *Heliothis virescens* attack the fruits. It has been found that various species of *Trichogramma* parasitize the eggs, found mainly on the underside of the leaves, though only in certain localities at certain seasons. In India, fruit and stem borers are troublesome during the rainy season but not in the winter. No insects attacked the plant in Puerto Rico. The two trials in Florida were at first promising, the plants flowering and setting fruit satisfactorily. However, as the fruits began to mature, they were attacked within the husk by a species of cutworm and only a few mature fruits were harvested. In Jamaica, seeds planted in late January produced vigorous and precocious plants which flowered when only 4 in (10 cm) high. Fruit-setting began in May and a high yield was expected but nearly all of the fruits were damaged by caterpillars before reaching maturity.

In Puerto Rico, no diseases were evident. In the Bahamas, only a slight incidence of leaf spot was observed. In Mexico, the husk tomato and the common tomato are both subject to a disease called *chino* or *chahuixtle* which occurs in irrigated plantings in Morelos. It is transmitted by the *mosquita blanca, Trialeurodes vaporariorum.*

Food Uses

This species, in contrast with the cape gooseberry, is used more largely as a vegetable than as a dessert fruit, though it is often consumed ripe, raw, out-of-hand. In Mexico, it is generally made into a sauce, *salsa verde*, for meats, alone or together with green chili peppers. Suggestions for use distributed by Iowa State College include recipes for stewing, frying, baking, cooking with chopped meat, making into soup, marmalade and dessert sauce. The fruit is an excellent addition to salads and curries. It has been utilized commercially for jam in Australia but the product is there considered inferior to that made from the cape gooseberry. The fruits, canned whole in Mexico, are sold domestically and in the western United States.

Food Value Per 100 g of Edible Portion*

Moisture	90.4-91.7 g
Protein	0.171-0.7 g
Fat	0.6 g
Carbohydrates	5.8 g
Fiber	0.6-1.7 g
Ash	0.6-0.69 g
Calcium	6.3-10.9 mg
Magnesium	23 mg
Phosphorus	21.9-40 mg
Phytin Phosphorus	7 mg
Iron	0.57-1.4 mg
Ionisable Iron	1.0 mg
Sodium	0.4 mg
Potassium	243 mg
Copper	0.09 mg
Sulfur	27 mg
Chloride	14 mg
Carotene (Vitamin A)	80 I.U. or 0.061-0.074 mg
Thiamine	0.054-0.106 mg
Riboflavin	0.023-0.057 mg
Niacin	2.1-2.7 mg

Ascorbic Acid	2-4.8 mg

*According to analyses of the husked fruit made in Guatemala and India.

Medicinal Uses

It is said in Mexico that a decoction of the calyces will cure diabetes.

Morton, J. 1987. Tree Tomato. p. 437–440. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Tree Tomato

Cyphomandra betacea Sendt.

Cyphomandra hartwegi Sendt.

Solanum betaceum Cav.

The tree tomato, *Cyphomandra betacea* Sendt. (*C. hartwegi* Sendt.; *Solanum betaceum* Cav.) is the best-known of about 30 species of *Cyphomandra* (family Solanaceae). Among its various regional names are: *tomate, tomate extranjero, tomate de arbol, tomate granadilla, granadilla, pix*, and *caxlan pix* (Guatemala); *tomate de palo* (Honduras); *arvore do tomate, tomate de arvore* (Brazil); *lima tomate, tomate de monte*, *sima* (Bolivia); *pepino de arbol* (Colombia); *tomate dulce* (Ecuador); *tomate cimarron* (Costa Rica); and *tomate francés* (Venezuela, Brazil). In 1970, or shortly before, the construed name "tamarillo" was adopted in New Zealand and has become the standard commercial designation for the fruit.

Description

The plant is a small, half-woody, attractive, fast-growing, brittle tree; shallow-rooted; reaching 10

Plate LXV: TREE TOMATO, *Cyphomandra betacea*

to 18 ft (3-5.5 m) in height; rarely as much as 25 ft (7.5 m). The leaves are muskily odorous, evergreen, alternate, more or less heart-shaped at the base, ovate, pointed at the apex, 4 to 13 1/2 in (10-35 cm) long and 1 1/2 to 4 3/4 in (4-12 cm) broad, thin, softly hairy, with conspicuous coarse veins. Borne in small, loose clusters near the branch tips, the fragrant flowers, 1/2 to 3/4 in (1.25-2 cm) wide, have 5 pale-pink or lavender, pointed lobes, 5 prominent yellow stamens, and green-purple calyx. The long-stalked, pendent fruit, borne singly, or in clusters of 3 to 12, is smooth, egg-shaped but pointed at both ends and capped with the persistent conical calyx. In size it ranges from 2 to 4 in (5-10 cm) long and l 1/2 to 2 in (4-5 cm) in width. Skin color may be solid deep-purple, blood-red, orange or yellow, or red-and-yellow, and may have faint dark, longitudinal stripes. Flesh color varies accordingly from orange-red or orange to yellow or cream-yellow. While the skin is somewhat tough and unpleasant in flavor, the outer layer of flesh is slightly firm, succulent and bland, and the pulp surrounding the seeds in the two lengthwise compartments is soft, juicy, subacid to sweet; it is black in dark-purple and red fruits, yellow in yellow and orange fruits. The seeds are thin, nearly flat, circular, larger and harder than those of the true tomato and distinctly bitter. The fruit has a slightly resinous aroma and the flavor suggests a mild or underripe tomato with a faintly resinous aftertaste.

Origin and Distribution

Although its place of origin is not certain, the tree tomato is generally believed to be native to the Andes of Peru and probably also Chile, Ecuador and Bolivia where it is extensively grown, as it is also in Argentina, Brazil and Colombia. It is cultivated and naturalized in Venezuela and grown in the highlands of Costa Rica, Guatemala, Jamaica, Puerto Rico and Haiti.

It must have been carried at an early date to East Africa, Asia and the East Indies, as it is well established in the Nilgiri heights and the hills of Assam in southern India, and in the mountains of Malaya, and was popular in Ceylon and the Dutch East Indies before 1903. It has been grown in Queensland, Australia, in home gardens, for many years and is a practical crop in the highlands of the Australian part of New Guinea.

D. Hay & Sons, nurserymen, introduced the tree tomato into New Zealand in 1891 and commercial growing on a small scale began about 1920. Shortages of tropical fruits in World War II justified an increased level of production. A promotional campaign was launched in 1961; window banners and 100,000 recipe leaflets were distributed. This small industry prospered until 1967 when annual production reached a peak of 2,000 tons. There was a heavy loss of trees at

Kerikeri in 1968. Replanting took place there and at the Bay of Plenty and cultivation of this crop continues to expand. In 1970, there were 209,110 trees on 476 acres (130 ha) in New Zealand. Shipment of the fresh fruits to Australia has not been very successful and the surplus crop is being delivered to processors for the making of preserves.

The United States Department of Agriculture received seeds from Argentina in 1913; from Sumatra and Ceylon in 1926. The plant was fruiting at the United States Department of Agriculture's Plant Introduction Station at Chico, California, in 1915. It is still grown casually in California and occasionally in Florida. It is frequently advertised and sold throughout the United States for growing indoors in pots as a curiosity. It fruits satisfactorily in northern greenhouses.

Varieties

There are apparently no named cultivars, but there are local preferences according to fruit color. Red fruits are chosen for the fresh fruit markets because of their appealing color. The dark-red strain (called "black") now leading in commercial plantings in New Zealand was obtained by selection around 1920 as a variation from the yellow and purple types grown up to that time. It was propagated and reselection thereafter resulted in this large, higher quality, red variety.

Plate LXVI: TREE TOMATO, *Cyphomandra betacea*

Yellow fruits are considered best for preserving because of their superior flavor.

Climate

The tree tomato is not tropical but subtropical. It flourishes between 5,000 and 10,000 ft (1,525-3,050 m) in Ecuador; between 1,000 and 3,000 ft (305-915 m) in Puerto Rico; 1,000 to 7,500 ft (305-2,288 m) in India. In Haiti it grows and fruits to perfection at 6,000 ft (1,830 m). In cooler climates, it succeeds at lower elevations. It does best where the temperature remains above 50º F (10º C). Frost at 28º F (-2.2º C) kills the small branches and foliage of mature trees but not the largest branches and main stem. The tree will recover if such frosts are not prolonged or frequent. However, seedlings and cuttings are readily killed by frost during their first year.

Protection from wind is necessary as the tree is shallow-rooted and easily blown over. It is also brittle and its branches are easily broken by gusts, especially when laden with fruit. It is suggested that windbreaks be established for each 1/2 acre (1/5 ha) before setting out the plantation in order to protect the young plants. Hedges of *Albizia lophantha* Benth. and of *Hakea saligna* R. Br., kept trimmed and narrow, are popular in the North Auckland area of New Zealand.

Soil

The tree tomato cannot tolerate tightly compacted soil with low oxygen content. It requires fertile, light soil. It grows well on deep lateritic soil in Haiti. Perfect drainage is necessary. Water standing for even a few days may kill the tree.

Propagation

Seeds or cuttings may be used for propagation. Seeds produce a high-branched, erect tree, ideal for sheltered locations. Cuttings develop into a shorter, bushy plant with low-lying branches, suitable for exposed, windy sites. The tree does not always come true from seed, but is most likely to if one is careful to take seed from red fruits with black seed pulp or yellow fruits with yellow seed pulp.

In Brazil, seeds for planting are first washed, dried in the shade, and then placed in a freezer for 24 hours to accelerate germination. They are then planted in boxes of rich soil–12 in (30 cm) between plants and 24 in (60 cm) between rows–and virtually 100% will germinate in 4 to 6 days.

Culture

The seedlings are set out in the field when 2 to 2 3/4 in (5-7 cm) high, spaced 32 in (80 cm) apart in rows 6 1/2 ft (2 m) apart. In New Zealand, the trees are set 8 to 10 ft (2.5-3 m) apart in paired rows 8 ft (2.5 m) apart with 14 ft (4.25 m) between each pair. If the soil is very rich, 9 ft (2.75 m) is allowed between the rows and 16 ft (5 m) between the pairs. Closer planting is recommended in windy, unprotected locations–5 to 6 ft (1.5-1.8 m) between the plants and 8 to 10 ft (2.5-3 m) between the rows, and the trees may be staked to prevent swaying and disturbing the roots. In India, the trees are set out in pits 4 to 5 ft (1.2-1.5 m) apart.

Cuttings should be of 1- to 2-year-old wood 3/8 to 1 in (10-25 mm) thick and 18 to 30 in (45-75 cm) long; the leaves are removed and the base cut square below a node. They can be planted directly in the field and, while precocious, should not be permitted to fruit in the first year.

Recommended fertilizer application is 0.5 to 2.2 lbs (0.25-1.0 kg) per tree of NPK 5:6:6, half in early spring and half in midsummer. In the 5th or 6th year, the grower is advised to give a special feeding of 2 parts superphosphate, 1 1/2 parts nitrate of soda, 1 part sulphite of potash, in late winter or early spring, at the rate of 2 to 3 lbs (1-1.5 kg) per plant–approximately 10 to 16 cwt per acre, or 100 kg per hectare.

Because of the shallow root system, deep cultivation is not possible, but light cultivation is desirable to eliminate weeds until there is sufficient vegetative growth to shade them out.

Seedling trees are pruned back the first year after planting to a height of 3 or 4 ft (0.9-1.2 m) to encourage branching. Annual pruning thereafter is advisable to eliminate branches that have already fruited and induce ample new shoots close to the main branches, inasmuch as fruit is produced on new growth. Otherwise, the tree will develop a broad top with fruits only on the outer fringe. And wide-spreading branches are subject to wind damage. Pruning facilitates harvesting and, if timed appropriately, can extend the total fruiting period. Early spring pruning of some of the owners' trees brings about early maturity; fall pruning of other trees delays fruit maturity to the following fall.

Irrigation

The tree tomato cannot tolerate prolonged drought and must have an ample water supply during extremely dry periods. A mulch is very beneficial in conserving moisture at such times.

Pollination

Tree tomato flowers are normally self-pollinating. If wind is completely cut off so as not to stir the branches, this may adversely affect pollination unless there are bees to transfer the pollen. Unpollinated flowers will drop prematurely.

Cropping and Yield

The tree usually begins to bear when 1 1/2 to 2 years old and continues to be productive for 5 or 6 years. If then adequately nourished, it may keep on fruiting for 11 to 12 years. In Brazil, each tree is expected to yield 44 to 66 lbs (20-30 kg) of fruit annually.

The crop does not ripen simultaneously and several pickings are necessary. The fruits are clipped, leaving about 1/2 in (12.5 cm) of stem attached. They are collected in bags worn by the harvesters.

In New Zealand, the fruits are sorted by size–small, medium and large–and packed in paper-lined wooden boxes for marketing. Because of its firm flesh and tough skin, the fruit can be shipped long distances without bruising. However, it deteriorates rather rapidly under ordinary storage conditions.

Pests and Diseases

The tree tomato is generally regarded as fairly pest-resistant. A looper caterpillar makes large holes in the leaves of young plants in the nursery but causes little damage to trees in the field. Occasionally the plants are attacked by the green aphis.

In South America and the Caribbean, the fruits are subject to attack by fruit flies–*Anastrepha* sp. and *Carpolonchaea pendula* (syn. *Silba pendula).* In Colombia, the tree tomato has been found to be the preferred host of the tree tomato worm *(Neoleucinodes* sp.) which infests also the tomato and the eggplant. The larvae feed on the fruits and cause heavy losses. Rigorous spraying and sanitary measures are required to reduce losses and means of biological control are being sought.

The principal disease is powdery mildew (both *Erysiphe* sp. and *Oidium* sp.), which may cause serious defoliation if not controlled. Minor problems include Sclerotinia disease *(Sclerotinia sclerotiorum)*, the black lesions of which girdle stems and cause terminal wilting; and Ascochyta disease *(Ascochyta* sp.) which is evidenced by small, round, black, dead areas on leaves, especially mature leaves. Tree tomato mosaic virus causes pale mottling on leaves and sometimes on the fruits which has not been considered a serious disadvantage. Another virus disorder, called "bootlace virus", distorts the leaf, especially on young plants, reducing it to little more than the midrib. Affected plants are pulled up and destroyed.

The tree tomato is noted for its resistance to tobacco mosaic virus, though it is susceptible to cucumber mosaic virus and potato virus. Die-back, of unknown origin, at times is lethal to the flowers, fruit cluster, twigs and new shoots. A strain of Arabis mosaic virus (which, in combination with two other unidentified viruses, causes sunken necrotic rings on the fruit surface) was reported in two plantations in the TePuke-Tauranga area of New Zealand in 1971, together with the identification of its vector, the nematode *Xiphinema diversicaudatum.*

Abnormality: In Haiti and New Zealand, small, hard, irregular, semi-transparent "stones" occur in the flesh of tree tomatoes and must be strained out in the process of jam-making. It is not known if these are similar to the "two gritty lumps in the wall of the fruit (on opposite sides)" mentioned by

E.J.H. Corner as observed in Malaya. Samples of the stones were examined at the Division of Plant Industry, Florida State Department of Agriculture, and were found to contain "large amounts of sodium and calcium, probably as silicates, borates, aluminum-magnesium-oxygen complexes, or aluminates or magnesium oxides. In addition, small amounts of tin, copper, chromium, iron and phosphorus were found. " It is well known that plants may accumulate minerals from mineral-rich soils, but such stony accretions are found in the leaves, not in the fruits. At Tela, Honduras, concretions occur in mangosteens, often rendering the fruit inedible. The cause has not been determined.

Food Uses

Ripe tree tomatoes may be merely cut in half lengthwise, sprinkled with sugar and served for eating by scooping out the flesh and pulp. Or the halves may be seasoned and grilled or baked for 15 minutes for service as a vegetable. The fruit should not be cut on a wooden or other permeable surface, as the juice will make an indelible stain. For other purposes, the skin must be removed and this is easily done by pouring boiling water over the fruit and letting it stand for 4 minutes, then peeling is begun at the stem end. The peeled fruit can then be sliced and the slices added to stews or soups, or served with a sprinkling of sugar and perhaps with a scoop of vanilla ice cream. Seasoned with salt and pepper, the slices can serve as sandwich-filling or may be used in salads. Chopped slices are blended with cream cheese and used as sandwich spread.

Peeled, diced fruits, with diced onion, breadcrumbs, butter and appropriate seasonings are employed as stuffing for roast lamb. Tree tomato slices, alone, or combined with sliced apple, are cooked in pies. They may be packed in preserving jars with water or sugar sirup and cooked for 55 minutes, or may be put into plastic containers with a 50% sirup and quick-frozen for future use in pies or puddings. The peeled fruits can be pureed in a blender or by cooking, strained to remove the seeds and then packed in plastic containers and frozen. Lemon juice may be added to the puree' to enhance flavor. The peeled, stewed fruits are combined with gelatin, milk, sugar and lemon juice to make a dessert which is then garnished with fresh tree tomato slices. Peeled, sliced and seeded tree tomatoes, with lemon rind, lemon juice and sugar, are cooked to a jam; or, with onions and apples, are made into chutney. Chutney is prepared commercially in a factory in Auckland, New Zealand. Being high in pectin, the fruit is easily made into jelly but the fruit oxidizes and discolors without special treatment during processing. Whole, peeled fruits, with sugar, are cooked to a sauce for use on ice cream. The peeled fruits may be pickled whole, or may be substituted for tomatoes in a hot chili sauce.

Food Value Per 100 g of Edible Portion*

Moisture	82.7-87.8
Protein	1.5 g
Carbohydrates	10.3 g
Fat (ether extract)	0.06-1.28 g
Fiber	1.4-4.2 g
Nitrogen	0.223-0.445 g
Ash	0.61-0.84 g

Calcium	3.9-11.3 mg
Phosphorus (with seeds)	52.5-65.5 mg
(without seeds)	13.1 mg
Iron	0.66-0.94 mg
Carotene	0.371-0.653 mg
(or calculated as Vitamin A)	540 I.U.
Thiamine	0.038-0.137 mg
Riboflavin	0.035-0.048 mg
Niacin (with seeds)	1.10-1.38 mg
(without seeds)	1.011 mg
Ascorbic Acid**	23.3-33.9 mg

*Analyses made in Ecuador, Guatemala and India.

**Most of the ascorbic acid is lost in cooking.

Morton, J. 1987. Genipap. p. 441–443. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Genipap

Genipa americana L.

Rating low as an edible fruit but popular as a source of beverages, the genipap, *Genipa americana* L. (syns. *G. americana* var. *caruto* Schum.; *G. caruto* HBK.), of the family Rubiaceae, has a number of colloquial names: marmalade box in former British West Indies; *genipa, jagua* or *caruto* in Puerto Rico and several other Spanish-speaking countries; *genipapo* or *jenipapo* in parts of Colombia and Brazil; *chipara* or *chibara* or *guanapay* among Colombian Indians; *carcarutoto, caruto rebalsero*, or *guaricha* in Venezuela; *tapoeripa* in Surinam; *lana* in Guyana; *bi, bicito* or *totumillo* in Bolivia; *huitoc, vito, vitu* or *palo colorado* in Peru; *maluco* in Mexico; *crayo, irayol de montaña*, or *guali* in Guatemala; *guaitil* or *tapaculo* in Costa Rica; *irayol, tambor* or *tiñe-dientes* in El Salvador; *guayatil colorado* or *jagua blanca* in Panama.

Description

The tree is erect, to 60 or even 110 ft (18-33 m), with a tall, slender trunk and spreading branches. One form with a dense coating of soft hairs on the young branchlets and underside of the leaves has been separated by some botanists as a distinct species, *G. caruto* or *G. americana* var. *caruto*, though most botanists now view this as just a variation of *G. americana.* The leaves are abundant, deciduous, short-petioled, opposite but mostly clustered at the branch tips; oblong-obovate, 4 to 13 in (10-33 cm) long, 1 1/2 to 5 1/4 in (4-13 cm) wide; sometimes faintly toothed, and with prominent whitish midrib. The faintly fragrant pale-yellow or white, tubular, 5-petalled flowers, to 1 1/2 in (4 cm) wide, are borne in short, branched, terminal clusters.

The fruit, 3 1/2 to 6 in (9-15 cm) long, 2 3/4 to 3 1/2 in (7-9 cm) wide, weighing 7 to 14 oz (200-400 g), is elliptic or rounded-oval tapering briefly at the stem end, and having a short hollow tube at the apex. It has a thin leathery, yellow-brown, scurfy skin adherent to a 1/4 to 1/2 in (6-12.5 mm) layer of muskily odorous, rubbery, whitish flesh (turning yellowish on exposure). The central cavity is filled with flat, circular, yellowish or brown seeds 3/8 to 1/2 in (1-1.25 cm) long, enclosed in grayish-yellow, mucilaginous membranes arranged in rows around a central fleshy core. The fruit, like the European medlar (*Mespilus germanica* L.) is edible only when overripe and soft to the touch, when the flavor, acid to subacid, resembles that of dried apples or quinces.

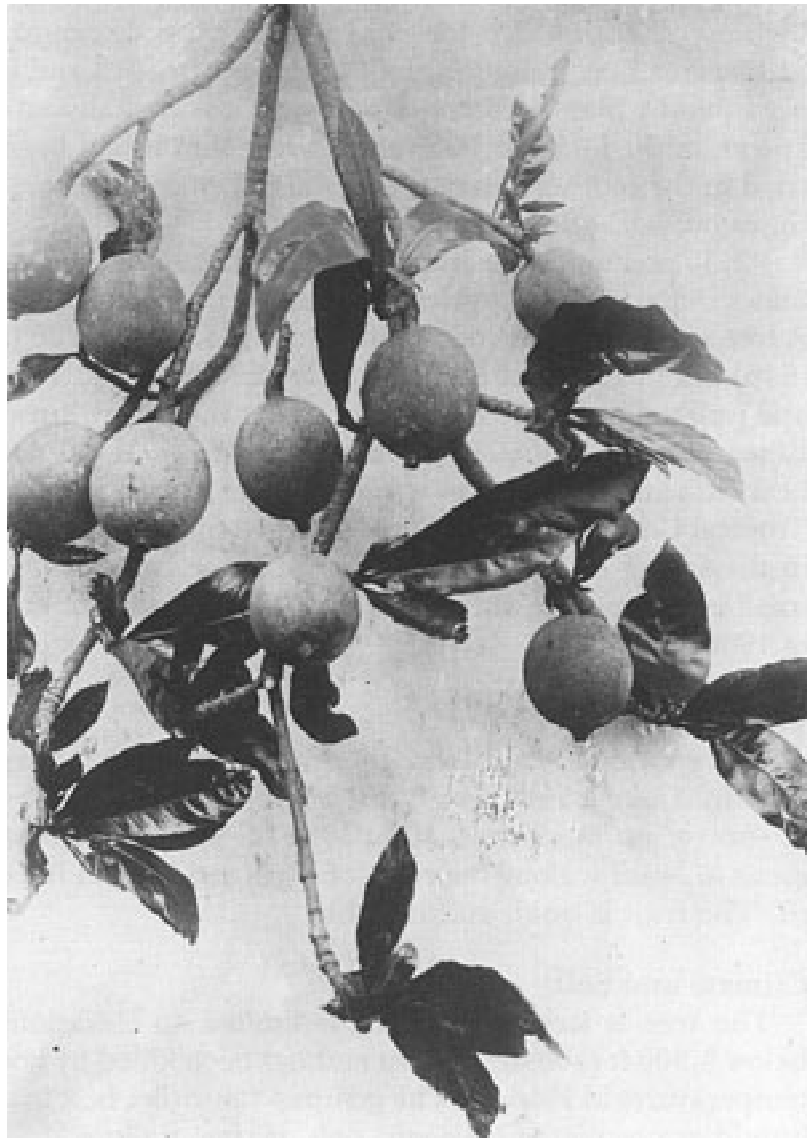
Fig. 117: The genipap (*Genipa americana* L.) photographed by P.H. Dorsett, plant explorer for the U.S. Department of Agriculture, Bureau of Plant Industry, in Bahia, Brazil, November 12, 1913.

Origin and Distribution

The genipap is native to wet or moist areas of Cuba, Hispaniola, Puerto Rico, the Virgin Islands, and from Guadeloupe to Trinidad; also from southern Mexico to Panama, and from Colombia and Venezuela to Peru, Bolivia and Argentina. Its usefulness to the Indians was reported by several European writers in Brazil in the 16th Century. It is widely cultivated in dooryards as an ornamental tree and for its fruits, but Patiño stated in 1967 that it was no longer as commonly grown in the Cauca Valley of Colombia as it had been in the past. In Trinidad, the tree is occasionally planted as a living fencepost for pasture fences. In 1965, a program was launched to utilize the genipap for reforestation in northeastern Brazil and plantations were established with a view to the exploitation of the fruit for liquor manufacture and the timber and other products for local use and possible export.

The tree first fruited in the Philippines in 1913 and is occasionally planted there. Otherwise, it is virtually unknown in the Old World. Burkill wrote that it had been tried in the southern part of the Malay Peninsula several times but without success.

P.J. Wester sent seeds from the Philippines to the United States Department of Agriculture in 1917 (S.P.I. #44090). A tree at the Plant Introduction Station, Miami, was 20 ft (6 m) tall in 1951 but had never bloomed. It is still alive and well today. There was a large tree at the Agricultural Research and Education Center, Homestead. It did not bear fruit and was killed by a freeze. A tree at the Fairchild Tropical Garden, Coral Gables, bloomed for the first time in the spring of 1980 but did not produce fruit. A few small seedlings were distributed by the Rare Fruit Council in 1980.

Varieties

It is reported in Brazil that there are varieties that bear all year. There is a shrubby form, *jenipaporana*, or *jenipapo-bravo*, no more than 10 to 13 ft (3-4 m) high, that grows in swamps along the edges of rivers and lakes in Brazil. The fruit is small and inedible.

Plate LXVII: GENIPAP, *Genipa americana*

Climate and Soil

The tree is strictly tropical; is limited to elevations below 3,300 ft (100 m) in Peru and has been killed by low temperatures in Florida. The genipap flourishes best in a humid atmosphere and deep, rich, loamy, moist soil.

Propagation

The genipap is mostly grown from seed but P.J. Wester determined that it can be propagated by shield-budding, using mature, non-petioled scions.

Culture

Seeds germinate in 25 to 30 days. The seedlings reach 4 3/4 in (12 cm) in 3 to 4 months and are transplanted when 6 to 12 months old at a height of 8 in (20 cm). The tree requires little cultural attention and thrives even in and situations. For fruit production, the trees are spaced 33 to 50 ft (10-15 m) apart. Temporary crops such as cassava or cotton are interplanted to provide shade for the young trees and income for the farmer. For purposes of reforestation, the spacing may be 5 x 10 ft (1.5 x 3 m) or up to 10 x 10 ft (3 x 3 m). The heavy leaf fall of the genipap is important in improving the soil of the plantation.

Season

Flowers and fruits appear continuously from spring to fall in Puerto Rico. In Brazil, the tree flowers in November and the fruits appear in the markets in February and March.

Food Uses

In Puerto Rico, the fruit is cut up and put in a pitcher of water with sugar added to make a summer drink like lemonade. Sometimes it is allowed to ferment slightly. A bottled concentrate is served with shaved ice by street vendors. In the Philippines, also, the fruit is used to make cool drinks, as well as jelly, sherbet and ice cream. The flesh is sometimes added as a substitute for commercial pectin to aid the jelling of low-pectin fruit juices. Rural Brazilians prepare sweet preserves, sirup, a soft drink, *genipapada*, wine, and a potent liqueur from the fruits.

Food Value

Analyses made in the Philippines many years ago show the following values for the edible portion (70%) of the fruit: protein, 0.51%; carbohydrates, 11.21%; sugar, 4.30%; ash, 0.20%; malic acid, 0.63%.

Recent analyses made at the Fundacion Instituto Brasileiro de Geografia e Estatistica show:

Food Value per 100 g of Edible Portion	
Calories	113
Moisture	67.6 g
Protein	5.2 g
Lipids	0.3 g
Glycerides	25.7 g
Fiber	9.4 g
Ash	1.2 g
Calcium	40.0 mg
Phosphorus	58.0 mg
Iron	3.6 mg
Vitamin B,	0.04 mg
Vitamin B2	0.04 mg
Niacin	0.50 mg
Ascorbic Acid	33.0 mg
Amino Acids	
(per g of nitrogen [N 6.25])	
Lysine	316 mg
Methionine	178 mg
Threonine	219 mg
Tryptophan	57 mg

The fruit contains too much-tannin to be a desirable article of diet.

Other Uses

Fruit: In Guyana, the ripe fruit is used mainly as fish bait. The fallen, astringent fruits are much eaten by wild and domestic animals. The juice of the unripe fruit is colorless but oxidizes on exposure to the air and gradually turns light brown, then blue-black, and finally jet black. It has been commonly employed by South American Indians to paint their faces and bodies for adornment and to repel insects; and to dye clothing, hammocks, utensils and basket materials a bluish-purple. The dye is indelible on the skin for 15 to 20 days. Oviedo wrote that the Indian men sometimes playfully sprinkled the women with the fresh juice mixed with perfume so that mysterious spots would appear on their bodies and alarm them. Cardenas tells of seeing the robe of a Franciscan monk which was dyed a very dark purple with this juice.

Leaves: The foliage is readily eaten by cattle.

Bark: The bark, rich in tannin, has been used for treating leather. It also yields a fiber employed in making rough clothing.

Wood: When 5 or 6 years old, saplings can be harvested for firewood, poles or fenceposts. Ten-year-old trees can be cut for timber. The wood is yellowish-white or sometimes slightly pinkish or lavender, with light, reddish-brown streaks. It is fibrous, compact, hard, elastic, strong but not durable, being subject to attack by termites, borers and fungi. It has been used for spears, rifle stocks, shoe lasts, frames for sieves, barrel hoops, ammunition chests and other boxes, packing cases, plows, tool handles, boards for flooring, door frames and cabinetwork.

Flowers: The flowers yield nectar for honeybees.

Medicinal Uses: The fruit is eaten as a remedy for jaundice in El Salvador. Ingested in quantity, it is said to act as a vermifuge. The fruit juice is given as a diuretic. It is a common practice in Puerto Rico to cut up the fruits, steep them in water until there is a little fermentation, then add flavoring and drink the infusion as a cold remedy.

Because the fruit and its infusion have unusually good keeping quality, Puerto Rican scientists investigated the possible presence of antibiotic principles and proved the existence of antibiotic activity in all parts of the fruit. In 1964, Dr. W.H. Tallent of G.D. Searle & Company in Chicago, isolated and identified 2 new antibiotic cyclopentoid monoterpenes, primarily genipic acid and secondarily genipinic acid, its carbomethoxyl derivative.

The crushed green fruit and the bark decoction are applied on venereal sores and pharyngitis. The root decoction is a strong purgative.

The bark exudes when cut a whitish, sweetish gum which is diluted and used as an eyewash and is claimed to alleviate corneal opacities. The juice expressed from the leaves is commonly given as a febrifuge in Central America. The pulverized seeds are emetic and caustic. The flower decoction is taken as a tonic and febrifuge.

Superstitious Uses: Guatemalan Indians carry the fruits in their hands in the belief that this will provide protection from disease and ill-fortune.

Morton, J. 1987. Cassabanana. p. 444–445. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Cassabanana

Sicana odorifera Naud.

Cucurbita odorifera Vell.

A handsome and interesting member of the Cucurbitaceae, the cassabanana, *Sicana odorifera* Naud. (syn. *Cucurbita odorifera* Vell.), is also called sikana or musk cucumber. It is known as *melocotonero, calabaza de olor, calabaza melón, pérsico* or *alberchigo* in Mexico; *melocotón* or *melón de olor* in El Salvador and Guatemala; *calabaza de chila* in Costa Rica; *cojombro* in Nicaragua; *chila* in Panama; *pavi* in Bolivia; *padea, olerero, secana* or *upe* in Peru; *calabaza de Paraguay, curuba,* or *pepino melocoton* in Colombia; *cura, coróa, curua, curuba, cruatina, melão caboclo* or *melão macã* in Brazil; *cajú cajuba, cajua, cagua, calabaza de Guinea* in Venezuela; *pepino, pepino angolo* or *pepino socato* in Puerto Rico; *cohombro* in Cuba.

Description

The vine is perennial, herbaceous, fast-growing, heavy, requiring a strong trellis; climbing trees to 50 ft (15 m) or more by means of 4-parted tendrils equipped with adhesive discs that can adhere tightly to the smoothest surface. Young stems are hairy. The leaves are gray-hairy, rounded-cordate or rounded kidney-shaped, to 1 ft (30 cm) wide, deeply indented at the base, 3-lobed, with wavy or toothed margins, on petioles 1 1/2 to 4 3/4 in (4-12 cm) long. Flowers are white or yellow, urn-shaped, 5-lobed, solitary, the male 3/4 in (2 cm) long, the female about 2 in (5 cm) long. Renowned for its strong, sweet, agreeable, melon-like odor, the striking fruit is ellipsoid or nearly cylindrical, sometimes slightly curved; 12 to 24 in (30-60 cm) in length, 2 3/4 to 4 1/2 in (7-11.25 cm) thick, hard-shelled, orange-red, maroon, dark-purple with tinges of violet, or entirely jet-black; smooth and glossy when ripe, with firm, orange-yellow or yellow, cantaloupe-like, tough, juicy flesh, 3/4 in (2 cm) thick. In the central cavity, there is softer pulp, a soft, fleshy core, and numerous flat, oval seeds, 5/8 in (16 mm) long and 1/4 in (6 mm) wide, light-brown bordered with a dark-brown stripe, in tightly-packed rows extending the entire length of the fruit.

Fig. 118: The cassabanana (*Sicana odorifera* Naud.), photographed by Wilson Popenoe, plant explorer for the U.S.D.A. Bureau of Plant Industry, in Guatemala on September 23, 1916.

Origin and Distribution

The cassabanana is believed native to Brazil but it has been spread throughout tropical America. Historians have evidence that it was cultivated in Ecuador in pre-Hispanic times. It was first mentioned by European writers in 1658 as cultivated and popular in Peru. It is grown near sea-level in Central America but the fruit is carried to markets even up in the highlands. Venezuelans and Brazilians are partial to the vine as an ornamental, but in Cuba, Puerto Rico and Mexico it is grown for the usefulness of the fruit.

In 1903, O.F. Cook saw one fruit in a market in Washington, D.C. The United States Department of Agriculture received seeds from C.A. Miller, the American Consul in Tampico, Mexico, in 1913 (S.P.I. #35136). H.M. Curran collected seeds in Brazil in 1915 (S.P.I. #41665). Wilson Popenoe introduced seeds from Guatemala in 1916 (S.P.I. #43427). The author brought seeds from Rio Piedras, Puerto Rico, to the Agricultural Research and Education Center, Homestead, in 1951. A resulting vine grew to large size but produced a single 2 ft (60 cm) fruit. Dr. John Thieret, formerly Professor of Botany at Southwestern Louisiana University, says that the Cajuns in the southern part of that state grow the cassabanana for making preserves. Verrill stated in 1937, "The fruit is now on sale in New York markets."

According to Burkill, the vine was tried in the Botanic Gardens in Singapore but lived for only a short time. Wester wrote that it fruited at Lamao in the Philippines in 1916 and became heavily attacked by a destructive fly (*Dacus* sp.).

Culture

Fenzi says that the cassabanana is grown from seeds or cuttings. A high temperature during the fruiting season is needed to assure perfect ripening. Brazilians train the vine to grow over arbors or they may plant it close to a tree. However, if it is allowed to climb too high up the tree there is the risk that it may smother and kill it.

Plate LXVIII: CASSABANANA, *Sicana odorifera*

Keeping Quality and Marketing

The cassabanana remains in good condition for several months if kept dry and out of the sun.

The fruit has high market value in Puerto Rico. It is cut up and sold by the piece, the price being determined by weight.

Food Uses

The ripe flesh, sliced thin, is eaten raw, especially in the summer when it is appreciated as cooling and refreshing. However, it is mainly used in the kitchen for making jam or other preserves. The immature fruit is cooked as a vegetable or in soup and stews.

Food Value Per 100 g of Edible Portion

	Analyses of ripe fruit made in Guatemala (without peel, seeds, or soft central pulp)	*Analyses of peeled green fruit made in Nicaragua* (including seeds)
Moisture	85.1 g	92.7 g
Protein	0.145 g	0.093 g
Fat	0.02 g	0.21 g
Fiber	1.1 g	0.6 g
Ash	0.70 g	0.38 g
Calcium	21.1 mg	8.2 mg
Phosphorus	24.5 mg	24.2 mg
Iron	0.33 mg	0.87 mg
Carotene	0.11 mg	0.003 mg
Thiamine	0.058 mg	0.038 mg
Riboflavin	0.035 mg	
Niacin	0.767 mg	0.647 mg
Ascorbic Acid	13.9 mg	10.0 mg

Other Uses

Fruit: People like to keep the fruit around the house, and especially in linen- and clothes-closets, because of its long-lasting fragrance, and they believe that it repels moths. It is also placed on church altars during Holy Week.

Medicinal Uses: In Puerto Rico, the flesh is cut up and steeped in water, with added sugar, overnight at room temperature so that it will ferment slightly. The resultant liquor is sipped frequently and strips of the flesh are eaten, too, to relieve sore throat. It is believed beneficial also to, at the same time, wear a necklace of the seeds around the neck.

The seed infusion is taken in Brazil as a febrifuge, vermifuge, purgative and emmenagogue. The leaves are employed in treating uterine hemorrhages and venereal diseases. In Yucatan, a decoction of leaves and flowers (2 g in 180cc water) is prescribed as a laxative, emmenagogue and vermifuge, with a warning not to make a stronger preparation inasmuch as the seeds and flowers yield a certain amount of hydrocyanic acid.

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Macadamia integrifolia Maiden & Betche

Smooth Shelled Macadamia

and

M. tetraphylla L.A.S. Johnson

Rough Shelled Macadamia

and their natural & artificial hybrids.

Proteaceae

The NewCROP server has Macadamia information at:

Macadamia Production in Southern California—Lawrence T. McHargue

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness J.R. et al. 1971. Food and feed crops of the United States.

Outside links:

Macadamia Crop Information from University of California Davis

MACADAMIA "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Macadamia Library articles from the California Macadamia Society yearbooks as well as other sources provided by Thompson Cooper.

Australian Macadamia Breeding Unit

Macadamia nut—from Mark Reiger, Dept of Horticulture, University of Georgia.

Current Comments

"Macadamias are easier to grow in South Florida than lychees, they are less delicate and grow faster, besides they bear regularly year after year. But they are very susceptible to soil conditions. I've tried growing them in alkaline soils in Dade county, and found that a very difficult task. On mucky soil however, they truly thrive. I have four different varieties, two Integrifolias (pink flowers, bumpy skin) and two ternifolias (white flowers, smooth skin). They all grow and fruit well here. As with lychees they grow better in the acid soils".- *Mario Lozano*, April 1998

Collards

Cruciferae *Brassica oleracea* L. (Acephala group)

Source: Magness et al. 1971

Collards are closely related to kale and cabbage, and might be described as a non-heading cabbage. They are grown for the smooth, rather thick, tender leaves which are used as greens or pot herbs. Plants may be started in beds, or direct seeded in the field. They produce a rosette of leaves. The whole rosette may be cut off and marketed, the usual commercial practice, or leaves may be stripped off and the central axis will continue to grow and produce. Leaf surface is generally exposed, as in spinach.

Season, seeding to harvest: 21/2 to 3 months.

Production in U.S.: 10,050 acres, 1959 census.

Use: Mainly as greens or pot herbs.

Part of plant consumed: Leaves.

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Theobroma cacao L.

Sterculiaceae

Chocolate, Cacao, Cocoa

We have information from several sources:

New Products from *Theobroma cacao*: Seed Pulp and Pod Gum—Antonio Figueira, Jules Janick, and James N. BeMiller

Article from:
Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links

Cacao—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 20—Link to the publication on the International Plant Genetic Resources Institute web site

Cacao butter

Stericuliaceae *Theobroma cacao* L.

Source: Magness et al. 1971

Cacao butter is obtained fromcacao seeds, which contain 50 percent or more of a non-drying fat. The butter is a byproduct from the manufacture of beverage cacao. The butter may be extracted by pressing or with solvents. The chief use of the butter is in confections. It is also used in pharmaceutical preparations.

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Opuntia sp.

Cactaceae

Cactus pear, tuna, Barbary fig, Indian fig, Nopalitos

We have information from several sources:

Native Cultivars of Cactus Pear in México—C. Mondragon-Jacobo and S. Perez-Gonzalez

Mediterranean Fruits—Joan Tous and Louise Ferguson

Commercializing Mesquite, Leucaena, and Cactus in Texas—Peter Felker

Low Input Agricultural Systems Based on Cactus Pear for Subtropical Semiarid Environments—Candelario Mondragon Jacobo

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Cajanus cajan (L.) Millsp.

Syn.: *Cajanus indicus* Spreng.

Fabaceae

Alverja, Bengal bean, Congo pea, Dhal, Gandul, Goongoo pea, Gray pea, Gungo pea, Indian dhal, Indian pea, No-eye pea, Pigeon pea, Pois cajun, Pois d'Angole, Red gram, Yellow dhal

We have information from several sources:

Pigeonpeas: Potential New Crop for the Southeastern United States—Sharad C. Phatak, Ram G. Nadimpalli, Suresh C. Tiwari, and Harbans L. Bhardwaj

New Crops and the International Agricultural Research Centers—Robert B. Bertram

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

New Forage, Grain, and Energy Crops for Humid Lower South, US—Gordon M. Prine and Edwin C. French

Chickpea, Faba Bean, Lupin, Mungbean, and Pigeonpea: Potential New Crops for the Mid-Atlantic Region of the United States—Harbans L. Bhardwaj, Muddappa Rangappa, and Anwar A. Hamama

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Melaleuca quinquenervia (Cav.) S.T.Blake

Syn.: *M. cajuputi* Auct.
M. leucadendron Auct.
Myrtaceae
Cajeput

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Source of oil of Cajeput or Tea Tree Oil, used as a mosquito repellent, effective also against lice and fleas. The tea-tree oil serves as a solvent and cleaning agent. Dissolving caoutchouc, it creates a good varnish. In dentistry, it is used to relieve the pain of dry sockets. The oil is used as a flavor component in foods (baked goods, candy, condiments, dairy desserts, meat and meat products, nonalcoholic beverages, relishes) and in creams, detergents, lotions, perfumes, and soaps (Leung, 1980). Bark serves in lieu of cork as an insulating material, also used in floats, life belts, and stuffing cushions, mattresses, and pillows (Duke, 1984b). Years ago, the tree was recommended for salt swamps to subdue "malarial vapors." In India, sheets of cajeput bark were historically employed for sacred writing. The bark is useful in packing tropical fruits. The leaf infusion has been used as a tea. Steeping the flower in water is said to impart an agreeable sweetness to the water. The wood, durable under ground and water, is valued for boats, cabinetry, carving, crossties, fencerails, flooring, gunstocks, mine braces, pilings, posts, rafters, railway sleepers, ships and wharves.

Folk Medicine

Reported to be antiseptic, astringent, carminative, diaphoretic, emollient, rubefacient, sedative, stimulant, sudorific, and vermifuge, cajeput is a folk remedy for acne, bronchitis, bruise, cholera, cold, colic, cough, diarrhea, earache, eczema, gout, headache, hiccup, inflammation, laryngitis, malaria, myalgia, neuralgia, paralysis, pharyngitis, pityriasis, pleuritis, pneumonia, psoriasis, rheumatism, rhinitts, scabies, scurvy, skin ailments, sore throat, spasms, sprains, toothache, and tumors (Duke and Wain, 1981). Burmese mix cajeput oil with camphor for gout. Indochinese use the oil for arthritis and rheumatism, inhaling the oil for colds and rhinitis. Cambodians use the leaves for dropsy. Indonesians apply the oil externally for burns, cramps, colic, earache, headache, pain, skin disease, and toothache. Softened bark is applied to boils as a suppurative. New Guinea natives rub the oil on the body for malaria. Filipinos use the leaves for asthma. Indonesians use the fruit for stomach disorders. Malayans use the oil as pain killer and stomachic, dropping a bit onto sugar lumps for cholera and colic (Duke, 1984b). In India, the oil is used internally as an expectorant in chronic bronchitis and laryngitis. Overdoses cause gastrointestinal irritation. Acts as an anthelmintic, especially against roundworms.

Chemistry

Leaves contain ca 1.3% essential oil with 14–65% cineole (or eucalyptol), 1-pinene, and terpineol and aldehydes. Besides these, the oil contains 1-limonene, 3,5,-dimethyl-4-6-di-0-methylphloroacetophenone, dipentene, nerolidiol, sesquiterpenes, azulene, sesquiterpene alcohols, valeraldehyde, and benzaldehyde. The bark contains betulinic acid (melaleucin) (Duke, 1984b). Oleanolic- and ursolic-acids, quercimeritrin, isoquercitrin, kaempferol-3-glucoside, kaemp-ferols-7-glucoside, and gallic acid derivatives are also reported (List and Horhammer, 1969–1979). Silica content of the wood varies from 0.2–0.95%.

Toxicity

Overdoses of the oil may induce gastroenteritis, kidney inflammation, and disturbance of the nervous system. Even small amounts may cause skin eruptions in sensitive persons (Morton, 1966). Although the vapors emanating from the tree may repel insects and the trees may serve as a "super Air-Wick", Morton (1966) adduces evidence to show that the volatile properties may also irritate the human respiratory system. Morton even suggests that eating cajeput honey may build up immunity in cajeput-sensitive individuals. Mitchell and Rook (1979) say that contact with branches, fruits, and roots, even the volatile emanations, can produce dermatitis. The oil can produce dermatitis and folliculitis when used for massage. According to Leung (1980), "Available data indicate it to be nontoxic ... Has been approved for food use ([[section]]172.510)."

Description

Resiniferous evergreen tree to 30 m tall, 1 m diameter, with whitish papery bark, often exfoliating. Leaves alternate, dull green, narrowly lanceolate, oblanceolate, or lance-elliptic, 5–20 cm long, 5–35 mm wide, apically and basally acute, entire, pli-nerved, aromatic, the petiole 2–4 mm long. Flowers ramiflorous, between or below groups of leaves in "bottlebrush spikes" 4–15 cm long, often producing apical foliaceous shoots following flowering. Calyx with 5 rounded lobes <2 mm long, and 5 somewhat longer whitish petals, ca 30 filiform stamens and inferior 2–4 celled ovary with many ovules. Capsules sessile, crowded along the branches, with many minute narrow brown seeds <2 m long.

Germplasm

Reported from the Australian, Hindustani, and Indonesia-Indochina Centers of Diversity, cajeput, or cvs thereof, is reported to tolerate acid sulphate soils, brackish sites, drought, fire, heavy soils, light frost, limestone, low pH, poor soil, salt spray, sand, tin tailings, waterlogging, weeds, and wind. Morton (1966) discusses several of the confusing variations in this species and genus. ($2n = 22$)

Distribution

Native from eastern Australia through Malaysia and Burma, now widely introduced, e.g. in Africa, Central America, Florida, Hawaii, India, Philippines, Puerto Rico, South America, and the West Indies.

Ecology

Ranging from Subtropical Dry to Wet through Tropical Dry Forest Life Zones, cajeput is reported to tolerate annual precipitation of 6.4 to 40.3 dm (mean of 4 cases = 22.2), annual temperature of 21.3 to 25.°4C (mean of 4 cases = 24.0), and pH of 5 to 7.7 (mean of 3 cases = 6.6) (Duke, 1978, 1979). Commonly forms forest communities on swampy ground; in Java, Sumatra, and Borneo, forms brackish swamp forests immediately behind the mangroves and great savannas in Buru and Ceram. Its thick flaky bark makes it fire resistant. In Burma it sometimes occurs as shrub or small tree on edge of tidal forests. In Annam and Queensland, it is found on sand dunes as shrub up to 1 m tall, or shrubs of 1–2 m tall in amphibious scrub. Common in gray podsolic depressions in sandstone outcropping areas with *Eucalyptus* species. Occasionally on calcareous gravelly soils near waterholes.

Cultivation

Propagated by seed, but cuttings of immature wood root easily in sand, laid horizontally. Seeds are scattered on damp seedbed, placed in shade or covered with damp burlap or sphagnum moss. Stratification has been reported to retard germination. Seedlings may attain 1–2 m height a year. Once established, trees are extremely vigorous and tough, crowding out other plants and difficult to exterminate by cutting or burning. It is rarely cultivated for essential oil because of the enormous quantity of leaf material available from wild-growing trees.

Harvesting

Leaves, harvested throughout the year, are cut from shrubs or low trees which are not more than 6 months old. Fresh leaves and terminal branchlets yield, on steam-distillation, the volatile oil. The commercial product is usually green due to its being distilled in copper containers. Distillation often takes place in field stills similar to those used for producing American eucalyptus oils (Reed, 1976). Seven year rotations have been suggested in Malaysia. Coppices readily.

Yields and Economics

Leaves and branchlets yield 1–1.5%, sometimes up to 1.8%, of essential oil. Of five trees studied in Florida, this one was projected to lead the others by far in dry matter yields, at 28.5 MT/ha of 9.4 for slash pine, 9.0 for sand pine, 8.3 for casuarina, and only 5.6 MT/ha for Eucalyptus (Smith and Dowd, 1981). At spacings of 1 x 2 m, *M. leucadendron* yields 5,500 kg leaves/yr, at 1 x 2.5 m, 3,500 kg. Webb et al. (1980) put the annual wood production at 10–16 m^3/ha. During this century, oil of cajeput is imported into India mainly from France and Netherlands, up to 10 MT/yr. Main producers of the oil are in the East Indies. Much of the crude oil is shipped to other countries where it is refined and resold. When Morton (1966) published her paper, tea-tree oil was twice as costly as Eucalyptus oil. It takes ca 1 man-hour to harvest 8.5 kg leaves, and 405 man-hours/ha (Fenton et al., 1977).

Energy

According to the phytomass files (Duke, 1981b), standing biomass of Melaleuca in Cambodia, LAI 7.1, was ca 172 MT/ha. Fenton et al. (1977) however put the stem biomass of natural stands at only 7.4 MT/ha. Moderately heavy (740–785 kg/m^3 air dry, 410 kg/m^3 oven dried), the wood is said to be an excellent fuel, the chief firewood of Malacca, exuding resin as it burns. The average heat values (kj/kg) of melaleuca wood, bark, terminal branches, and foliage were 18,422, 25,791, 19,301, and 20,139, respectively. The heat of combustion of melaleuca bark is unique because it is comparable with that of some coals at 25,000 kj/kg, the highest figure yet determined for tree material. This unique characteristic is due to the presence of a great amount of fatty substances in the bark. The densities (g/cm^3) of stemwood and stembark are approximately 0.51 and 0.19, respectively. The green moisture contents averaged 114% for stemwood and 131% for stembark. The average ash contents of stemwood and stembark are 0.7 and 2.7%, respectively. The fuel quality of melaleuca stemwood and stembark varies significantly among trees (Wang et al., 1982).

Biotic Factors

Browne (1968) lists the following as affecting *M. leucadendron*: (Fungi) *Fomes lignosus*. (Angiospermae) *Loranthus* sp. (?). (Crustacea) *Sesarma* spp. (Lepidoptera) *Bathrotoma constrictana*, *Metara elongata*. (Mammalia) *Lepus crawshayi*. Fenton et al (1977) list the following fungi: *Cylindrocladium macrosporum, C. pteriolis, Phellinus senex* (causing heart rot), *Phytophthora cinnamomi*, *Pleomassaria melaleucac*, and *Rigidiporus lignosis* on this or closely related species. In Hawaii, the black twig borer *Xylosandrus compactus*, has been associated with plantation mortality. The foliage is unattractive to browsing livestock.

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Complete list of references for Duke, Handbook of Energy Crops

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Cucurbits

(*Cucurbita* spp.)

The authors of this chapter are R. Lira Saade (National Herbarium of Mexico, Mexico City) and S. Montes Hernández (CIFAP, SARH, Celaya, Guanajuato, Mexico).

One plant group with the most species used as human food is the Cucurbitaceae family. Within this family, the genus *Cucurbita* stands out as one of the most important. Five of its species *Cucurbita argyrosperma* Huber, *C. ficifolia* Bouché, *C. moschata* (Duchesne ex Lam.) Duchesne ex Poiret, *C. maxima* Duchesne ex Poiret, and *C. pepo* L.—have been domesticated in the New World and for thousands of years they have been cultivated or at least handled by American societies.

In spite of the current marginalization of some of these species, from very remote times all have contributed essential food products to the diet of rural and some urban communities on the American continent and in many other parts of the world. With the exception of *C. maxima*, whose centre of origin is in South America, it is assumed that the other four cultivated species were domesticated in Mesoamerica. although this has not been confirmed in all cases.

During the second half of the 1980s, a great quantity of information was collected on the origin and evolution of the four species. The taxonomic and genetic limits of *Cucurbita argyrosperma* and *C. pepo* have been redefined and their closest-related wild species have been classified into intraspecific categories within these limits. The results of this research have raised some doubts about the Mesoamerican origin of *C. ficifolia* and *C. moschata,* suggested so often in many publications.

Cucurbita argyrosperma

Botanical name: *Cucurbita argyrosperma* Huber

Family: Cucurbitaceae

Common names. English: cushaw (United States); Spanish: calabaza, calabaza pinta, calabaza pipiana (Mexico), pipián (Mexico, El Salvador, Nicaragua, Costa Rica), saquil, pipitoria (Guatemala)

Origin, domestication and expansion

Cucurbita argyrosperma is one of the cultivated species of the genus which has undergone the most profound study in recent years. There are two subspecies:

i) *argyrosperma*, comprising four varieties—*argyrosperma, callicarpa, stenosperma* and *palmieri*—three of which include all the cultivated types, while the fourth corresponds to spontaneous populations of northeastern Mexico that are generally known as *Cucurbita palmieri* L. Bailey;

ii) *sororia*, which includes wild populations with a wide distribution from Mexico to Nicaragua, originally described under the name *C. sororia* L. Bailey. This subspecies has been designated as the wild ancestor of the group.

According to the age of the archaeological remains discovered thus far, it has been suggested that domestication of *C. argyrosperma* must have occurred in southern Mexico more than 7000 years ago.

The characteristics that were most transformed in the process of domestication of the ssp. *argyrosperma* were, as in other crops, mainly those connected with handling and preferred uses. For example, relatively uniform germination; a reduction in size and abundance of trichomes; an increase in the size of parts and organs used, such as fruits and seeds; and a reduction in the bitter taste of the flesh. It is considered that var. *argyrosperma* is the least specialized or most primitive of the group and that var. *callicarpa,* on the other hand, is the most recent or specialized.

The different degrees of variation in the nutritionally important parts of the three cultivated varieties of the complex *argyrosperma* suggest a strong association with human interests. The relatively large seed size of the var. *argyrosperma* indicates that it was mainly selected to obtain seeds. while the great diversity of shapes, colours and size of the fruits and seeds of var. *stenosperma* and *callicarpa* indicate that selection had a double aim: to obtain flesh as well as seeds.

Unlike with the rest of the cultivated species of *Cucurbita*, data on the distribution of cultivated *Cucurbita argyrosperma* varieties outside America are very scarce and there is no certainty that this species was cultivated at any time in the Old World or even outside its general area of domestication.

In South America, it is grown in Peru and Argentina, although it appears to involve very recent introductions of certain cultivars which can be class)fled within the var. *callicarpa*. In the United States, some cultivars of var. *callicarpa* are cultivated on a very low scale for nutritional purposes, and one cultivar of var. *argyrosperma*, Silver Seed Gourd, is occasionally grown as a horticultural curiosity.

The reasons for the sparse world distribution of this species are not known; although the situation is not surprising, given the low quality of the fruit's flesh compared with that of *C. moschata* or *C. pepo* and the size of the seeds of all the cultivated varieties that may have been attractive to the first Europeans who learned of them.

Uses and nutritional value

Throughout its distribution area, the flowers, young stems, young fruit and ripe fruit of *C. argyrosperma* are eaten as vegetables. The ripe fruit is occasionally used to prepare sweets although it is used most frequently as feed for livestock and poultry. The seeds are eaten whole, roasted, toasted or ground and are the main ingredient of sauces used to prepare various stews (for example, *pipián*—meat cooked in thick chili sauce, *mole verde*—a stew prepared with chili and green tomatoes). The seeds are the most important product, chiefly because of their oil (39 percent) and protein content (44 percent), and their consumption in urban areas of Mexico and other countries of Central America is fairly common.

In some regions of Mexico, the seeds and also the unripe fruit of wild taxa are used as food. The latter are eaten after being washed and boiled several times to rid them of the bitter taste deriving from the cucurbitins present in the flesh and placentae, while the seeds are simply washed, seasoned with salt and roasted or toasted. On the Yucatán peninsula, peasants use the flesh of the cultivated varieties' fruit to treat burns, sores and skin eruptions, while the seeds are prepared with water and used as an anaesthetic and to stimulate women's milk production for breastfeeding.

Botanical description

C. argyrosperma is a creeping or climbing monoecious plant, ranging from villous to pubescent and which may be hirsute, with short, rigid and rather enlarged and sharp trichomes. It has fibrous roots and slightly angular stems. Its ovate-cordate leaves have petioles of up to 30 cm and measure 10 to 30 x 15 to 40 cm. They have white spots, number three to five and are lobulate with triangular or elliptical lobules. The margins are denticulate to serrate-denticulate. There are two to four ramified tendrils and pentamerous, solitary, axillary flowers. The male flowers are on pedicels of 10 to 20 cm and have a campanulate calyx of 5 to 20 x 8 to 25 mm. Their sepals are linear-lanceolate or (rarely) foliaceous and are 10 to 35 mm long. They have a tubular-campanulate corolla that is yellow to orange, 6 to 12 cm long, with five lobules for up to one-third of its total length and they have three stamens. The female flowers grow on sturdy peduncles of 2 to 3.5 cm; have a globose, ovoid-elliptical, botuliform or piriform, multilocular ovary, a small calyx and a corolla that is somewhat bigger than that of the male flowers. They have three stigmas. The fruit is short or long and piriform, straight or curved in the thinnest part and 11 to 50 cm long. It has a hard rind which is smooth to slightly ribbed, and is white with longitudinal green reticulate stripes or completely white. The flesh is white, yellow or orange, the seeds elliptical and slightly inflated, measuring 15 to 30 x 8 to 16 mm, with a white, smooth and even testa.

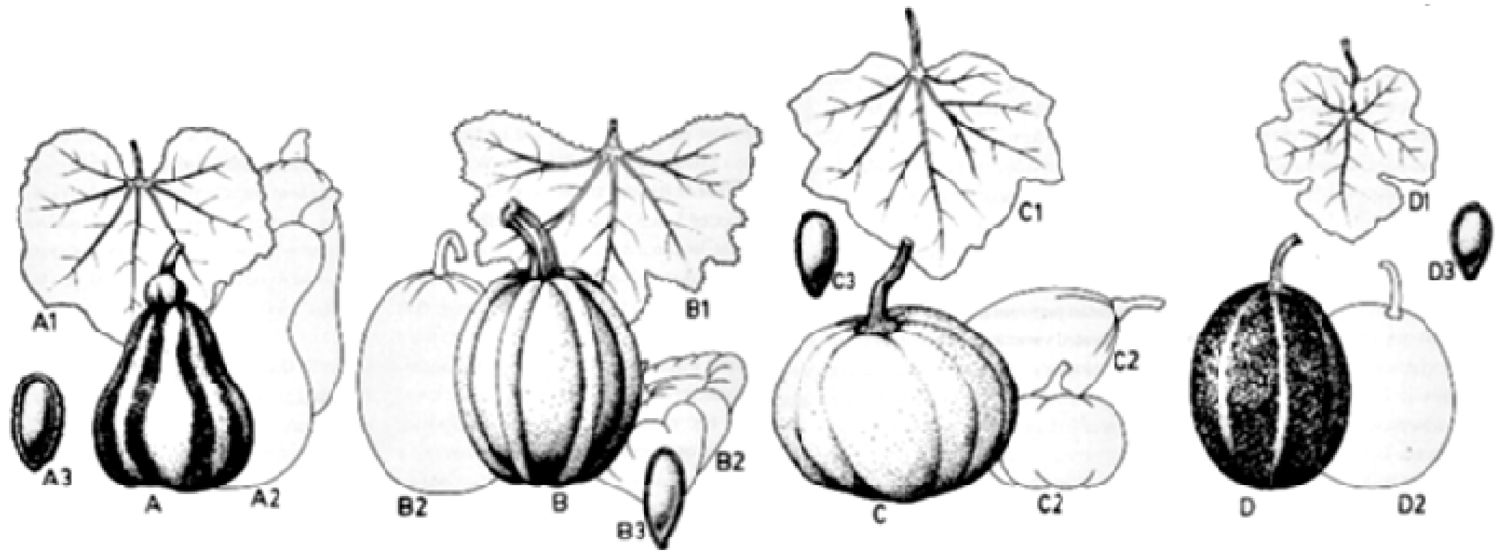

Figure 5 Mesoamerican cucurbits: A) *Cucurbita argyrosperma;* A1) leaf; A2) fruit; A3) seed; B) *C. pepo;* B1) leaf; B2) fruit; B3) seed; C) *C. moschata;* C1) leaf; C2) fruit; C3) seed; D) *C. ficifolia;* D1) leaf; D2) fruit; D3) seed

Ecology and phytogeography

The three cultivated varieties of *C. argyrosperma* are found in a relatively wide range of altitudes (0 to 1800 m), generally in areas with a hot, fairly dry climate or a well-defined rainy season. The species does not tolerate very low temperatures, which limits its cultivation to the altitudes mentioned. Each cultivated variety has a fairly defined distribution model, although there are some areas where two varieties can be found cultivated simultaneously.

In Mexico, the var. *argyrosperma* is grown on the slope of the gulf (Tamaulipas, San Luis Potosí, Puebla, Veracruz, Tabasco, Chiapas and Yucatán). In Central America it has been recorded in Belize, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama. The var. *callicarpa is* found mainly on the Pacific slope, from the southeastern United States to central Mexico (Sonora, Sinaloa, Chihuahua. Zacatecas, Guanajuato, Nayarit and Jalisco). The var. *stenosperma* is endemic to Mexico and is grown in the central and southeastern states (Guerrero, Morelos, Michoacán and Oaxaca) as well as in some areas of the gulf slope (Veracruz and Yucatán).

Genetic diversity

Limits of genetic stock. Knowledge of the genetic relations of C. *argyrosperma* Huber and the consequent inclusion and definition of wild and cultivated taxa within its taxonomic limits have considerably widened the species' genetic stock. This includes: the local races of the cultivated varieties in the southeastern United States. Mexico and Central America; the two wild taxa of the complex (var. *palmieri* and ssp. *sororia*): and, in the United States, Green Striped Cushaw, White Cushaw, Magdalena Striped, Papago, Silver Seed Gourd, Japanese Pie, Hopi, Taos, Parral Cushaw and Veracruz Pepita.

Hybridization experiments of the taxa belonging to *C. argyrosperma* with other wild and cultivated taxa of the genus and some field observations have revealed that, with the cultivated species, *C. moschata* has the highest degree of compatibility. A second level of compatibility consists of the wild and cultivated taxa of *C. pepo,* some cultivars of *C. maxima* and the wild perennial species of *C. foetidissima* H.B.K. A third group is formed by *C. lundelliana* L. Bailey, and *C. martinezii* L. Bailey, with which crossings only produced fruit without viable seeds. The fourth and last group includes the perennial species *C. pedatifolia* L. Bailey, *C. digitata* A. Gray, in the broad sense and *C. radicans* Naudin, with which only a few fruits were able to be obtained but generally without viable seeds.

The wild species that have shown some degree of compatibility with the taxa of the complex *C. argyrosperma* possess genes resistant to some viral diseases that have a high incidence in the cultivated species.

However, because of two factors relating to interspecific crossings, some obstacles will have to be overcome before a successful plant improvement programme including all the taxa is carried out:

- hybrids with viable seeds were not always produced;
- when some success was achieved, the plant receiving the pollen was always from the complex *C. argyrosperma* and, in the case of the species of the last two groups, it always involved var. *palmieri* or ssp. *sororia*.

Germplasm collections. Germplasm collections are not so scarce for the cultivated taxa but they are in very short supply in the case of the wild ones. Most of the accessions come from Mexico and are deposited in the CIFAP's gene bank in Mexico and in the USDA's in the United States.

Cultivation practices

The cultivated varieties of *Cucurbita argyrosperma* are worked in the traditional heavy rain agricultural systems and are sown at the start of the rainy period (May-June). Development of these varieties lasts five to seven months; the young fruit for vegetables is harvested approximately three months after being sown, while the ripe fruit for seed is harvested between October and December.

In the Mixe region of the state of Oaxaca, var. *stenosperma is* also grown in the dry season on so-called humid ground. This practice is also recorded in some parts of the state of Sonora in northeastern Mexico, where some cultivars of var. *callicarpa* can be grown in the dry season, but always with the help of irrigation to ensure production throughout the year.

The only form of propagation is the sowing of seed which is done along with some of the traditional crops of this agricultural model (maize, beans and other species of *Cucurbita*). In some regions of Yucatán, Quintana Roo and Oaxaca the seeds of *C. argyrosperma* are often the first to be planted in the maize fields. Sowing begins shortly before the start of the rain and before the other associated crops are sown.

In some localities of Yucatán, sowing is done very quickly the day after the traditional burning of the stubble of the previous crop and long before the first rain and the sowing of other associated crops. The aim is to prevent the development of weeds which would affect production of the other species cultivated in the maize field, utilizing the rapidity of growth and cover attained by this species. Practices of this type show that the seeds of *C. argyrosperma* are completely suited to these regions and germinate even in conditions of low humidity.

Unlike other cultivated species of the genus, it is less frequent for varieties of the *argyrosperma* complex to be found in vegetable gardens or plots or in small agricultural holdings or to be associated with other species.

Cucurbita pepo

Botanical name: *Cucurbita pepo* L.

Family: Cucurbitaceae

Common names. English: pumpkin, vegetable marrow, summer pumpkin, autumn pumpkin; Spanish: calabaza (Mexico), hüicoy (Guatemala)

Origin, domestication and expansion

According to archaeological recordings, *C. pepo* appears to be one of the first domesticated species. The oldest remains have been found in Mexico, in the Oaxaca valley (8750 BC to AD 700) and in the caves of Ocampo, Tamaulipas (7000 to 500 BC). Its presence in the United States also dates back a long time, as the recordings in Missouri (4000 BC) and Mississippi (1400 BC) indicate. This species may have been domesticated at least on two occasions and in two different regions: in Mexico and in the eastern United States, in each case having *C. fraterna* and *C. texana*, respectively, as possible progenitors.

Eight groups of edible cultivars of *C. pepo* are known:

- Pumpkin (*C. pepo* L. var. *pepo* L. Bailey) includes cultivars of creeping plants which produce spherical, oval or oblate fruit that is rounded or flat at the ends. The fruit of this group is grown to be eaten when ripe and sometimes is used as fodder.
- Scallop (*C. pepo* L. var. *clypeata* Alefield) has a semi-shrubby habit, the fruit ranges from flat to almost discoidal, with undulations or equatorial margins, and it is eaten before maturity.
- Acorn (*C. pepo* L. var. *turbinata* Paris) is both a shrubby and creeping plant with fruit which is obovoid or conical, pointed at the apex and longitudinally costate-grooved. The rind is soft, hence the fruit can be eaten in the ripe state.
- Crookneck (*C. pepo* L. var. *torticollia* Alefield) is a shrubby type, with yellow, golden or white fruit which is claviform and curved at the distal or apical end and generally has a verrucose rind. It is eaten unripe since the rind and the flesh harden when ripe.
- Straightneck (*C. pepo* L. var. *recticollis* Pans) is a shrubby plant with yellow or golden fruit and a verrucose rind

similar to that of var. *torticollia*.

- Vegetable marrow (*C. pepo* L. var. *fastigata* Paris) has creeper characteristics as a semi-shrub and has short cylindrical fruit that is slightly broader at the apex, with a smooth rind which hardens and thickens on ripening and which varies in colour from cream to dark green.
- Cocozzelle (*C. pepo* L. var. *Ionga* Paris) has cylindrical, long fruit that is slender and slightly bulbous at the apex; it is eaten in the unripe state and one of the most common names is Cocozzelle.
- Zucchini (*C. pepo* L. var. *cylindrica* Paris) is the most common group of cultivars at present. Like the previous group, the zucchini group has a strong affinity with the vegetable marrow and its origin is also recent (nineteenth century). Its plants are generally semi-shrubby and its cylindrical fruit does not broaden or else broadens only slightly. It is eaten as a vegetable in the unripe state.

With regard to traditional cultivars, it is common to see a fair representation of cultivars with characteristics similar to those of each of the commercial groups in one single field cultivated by Mesoamerican peasants. The question of the origin of the cultivars native to the Mayan area in the middle and low areas of Chiapas and the Yucatán peninsula still has to be resolved. These cultivars, whose fruits are either without or with unpronounced ribs and have rather rounded and oval seeds, are grown from a little above sea level to nearly 1800 m.

The distribution of *C. pepo* outside America is possibly the best documented of this genus: it is known that some cultivars reached Europe approximately half a century after 1492 and it is even said that others originated on that continent. In contrast to *C. pepo's* long-established presence in the Old World, it seems that its arrival in South America was very recent. At present, the fruit of some cultivars (for example, Zucchini and Cocozzelle) has a nutritional and commercial role in several regions of the world.

Uses and nutritional value

Like the other cultivated species of the genus, the mature or young fruit and the seeds of *C. pepo*, as well as to a lesser extent the flowers and young tips of the stems, are eaten in many parts of its native distribution area and in other regions of the world. *C. pepo's* nutrient content is similar to that described for the other cultivated species.

Botanical description

C. pepo has: creeping plants which are compact or semi-shrubby, annual, monoecious and pubescent-scabrous; broadly ovate-cordate to triangular-cordate leaves, 20 to 30 x 20 to 35 cm, with or without white spots, often with three to five deep lobules, and with denticulate to serrate-denticulate margins. Tendrils have two to six branchlets, or are simple and little developed tendrils in the semi-shrubby types. It has pentamerous, solitary, axillary flowers, the males of which have pedicels 7 to 20 cm in length, a campanulate calyx of 9 to 12 mm, linear sepals of 12 to 25 x 1 to 2 mm, a tubular/campanulate corolla, 5 to 10 cm long, which is divided into five for up to one-third or more of its length; and three stamens. The female flowers have sturdy, sulcated pedicels of 2 to 5 cm; the ovary is globose, oblate, ovoid, cylindrical, rarely piriform, smooth, ribbed or verrucose and multilocular; and the calyx is very small. The fruit is very variable in size and shape: smooth to heavily ebbed, often verrucose and rarely smooth, with a rigid skin varying in colour from light to dark green, plain to minutely speckled with cream or green contrasting with yellow, orange or two-coloured. The flesh is cream to yellowish or pale orange; it ranges from soft and not bitter to fibrous and bitter, has numerous seeds which are narrowly or broadly elliptical or rarely orbicular, slightly flattened and 3 to 20 x 4 to 12 mm.

Ecology and phytogeography

Traditionally, *C. pepo* is cultivated from North America to Central America and in some parts of South America, although it is generally said to be a crop of high areas. Like *C. moschata*, this species covers a fairly wide range of altitudes. In Mexico, there are native varieties which grow from very close to sea level and in semi-dry climates, such as the variety called tsol in Yucatán, to others which are cultivated at altitudes greater than 2000 m, such as those called güiches in Oaxaca. In Guatemala, the native cultivars, commonly called güicoy, are grown above 1000 m, while tsols are sown in the low, hot humid parts of the Petén below 500 m.

Genetic diversity

Limits of genetic stock. The primary genetic stock of *C. pepo* is formed by the groups of edible cultivars (ssp. *pepo*) and ornamental cultivars (ssp. *ovifera*) as well as wild taxa (*C. fraterna* and *C. texana*).

There are a great number of commercial cultivars with particular characteristics which, together with the local varieties referred to which are grown mainly in Mexico, constitute an extraordinary genetic stock. However, in contrast to other species, this diversity does not represent an important source of genes resistant to pests and diseases, since *C. pepo* (including *C. texana*) is probably the species with the greatest susceptibility to the most important viral diseases that attack cultivated species of *Cucurbita*.

Species that might represent a secondary genetic stock are scarce, as most of the attempts at hybridizing *C. pepo* with other wild or cultivated species have required special techniques such as embryo culture; however, good results with hybridization have been achieved in Mexico and the United States.

Germplasm collections. Data obtained from the gene banks show that *C. pepo* is the species of the genus with the second highest number of accessions (1135). However, this refers only to cultivated and edible forms, since those corresponding to the two closest wild relatives are very scarce and, in fact, those of *C. fraterna* were completed only very recently. The gene banks with the greatest representation of *C. pepo* cultivars are in the United States, Mexico and Costa Rica.

Cultivation practices

In its native area of distribution, *C. pepo* is grown both in maize fields and vegetable gardens as well as in other more intensive systems. In the former case, it is combined with maize, beans and/or with one to three of the other cultivated species of *Cucurbita*, while in the latter system it may be found growing on plots or in small groups. generally combined with other vegetables. Where it is grown commercially, it is generally found as the sole crop, occupying areas of varying size.

In the region of Mixteca Alta, Mexico, and particularly in San Andres Lagunas, some local variants have been found which are grown under two different sets of conditions and at two different times. One of these is known as heavy rain gourd (calabaza de temporal); it is grown on rocky ground, generally with abundant outcrops of limestone and commonly with little soil—that is, on dry ground. Sowing takes place in April and May, depending on the appearance of the first rains, and the ripe fruit is harvested in October and November. Another variant is known as the bowl gourd (calabaza de cajete); it is grown on ground called *cajete* (bowl), which is very flat and humid and situated in small valleys which are said to have once been occupied by lakes. In this form, it is sown at the start of the driest period of the year (February or March) and the ripe fruit is harvested between July and September.

In Yucatán, the tsol or "mensejo" variety is grown, generally in vegetable gardens or intensive husbandry systems such as those called *conucos* (small farms) and *pachpakal*, and very rarely in maize fields. It is a short-cycle variety; sowing takes place approximately 15 to 20 days after the start of the heavy rainstorms (from May to June); the unripe fruit for use as vegetables is harvested from August onwards, while the ripe fruit is available between September and October.

Prospects for improvement

The three species *Cucurbita argyrosperma*, *C. moschata* and *C. pepo* complement one another in their natural areas of production, which range from 0 to 2 000 m in their region of origin. In the latter, evaluation of the primitive cultivars needs to be stepped up and their germplasm used to develop new cultivars that are more productive and of greater food value, or that are resistant to diseases, especially viruses. As has already been shown in the case of some species, there are also local varieties which differ in their production period. The direct use of these, or of the genes that determine this characteristic, would allow their period of availability at markets to be extended.

The germplasm of the four species of *Cucurbita* should be urgently collected in their area of natural distribution. Introducing varieties present in other areas, such as *C. moschata* varieties which are found in Africa and have a high carotene content, and incorporating them in genetic improvement programmes is also a matter of urgency.

Boosting consumption, whether local or in the form of exports, requires the fruit to possess characteristics adapted to consignment and storage. There is a wide diversity of such characteristics which can be used to produce superior varieties.

Cucurbita spp. offer possible new uses or more intensive uses, which can be widely promoted. One is the preparation of purees or similar foods, for which there would be a very extensive genetic stock for determining organoleptic or nutritional characteristics, resulting in a product superior to the one existing on the markets and which is derived from other products. We ought also to explore the possibility of increasing the use of young stems, which are the part of the plant with the greatest food value because of the amino acid and vitamin content. Varieties which produce more foliage could even be bred for this purpose.

The use of seeds as dried fruit is common in some areas of Mesoamerica and almost unknown in others. The seeds are a good source of protein and oil, and their industrial preparation and marketing should be investigated.

There is still much to be done in terms of the collection, conservation, evaluation and use of regional or local varieties. These tasks are feasible. as the range of these crops is still to be found in the rural communities of the New World. We should not pass up the opportunity of utilizing this material to produce superior varieties and conserve their germplasm for future use.

Cucurbita moschata

Botanical name: *Cucurbita moschata* (Duchesne ex Lam.) Duchesne ex Poiret

Family: Cucurbitaceae

Common names. English: pumpkin, winter squash. musky squash, cushaw; Nahuatl: tamalayota (Mexico, Colombia [Guerrerol); Spanish calabaza (Mexico), ayote (Guatemala to Costa Rica), auyama (Panama to Venezuela), zapallo (Ecuador, Peru), joko (Bolivia)

Origin, domestication and distribution

It was thought that *C. moschata,* like *Cucurbita ficifolia,* was of Asiatic origin. However, it is now evident that it was domesticated in Latin America, although it is still unclear what the precise area of domestication of either species was. On numerous occasions, it has been reported to be in Mesoamerica and on other occasions in South America, more specifically with its centre of origin in Colombia. The vestiges available are undoubtedly difficult to interpret. The oldest archaeological remains of this species were found in northwestern Mexico (the caves of Ocampo, Tamaulipas) and date from 4900 to 3500 BC. Remains are also known in northern Belize, in Tikal, Guatemala (2000 BC to AD 850), and in Huaca Prieta, Peru (3000 BC).

Electrophoretic analysis of isoenzymes has not provided any substantial evidence. However, it has enabled us to reaffirm the strong relationship between this species and taxa of the *C. argyrosperma* group. Nor is the linguistic evidence very clear: *C. moschata* is known by native names both in the Mesoamerican region (mainly in Mexico) and in South America; this, on the other hand, supports the observation that both regions correspond to two centres of the crop's diversification.

Furthermore, the variation in *C. moschata* does not suggest any region in particular as the centre of origin, since this species is extremely variable in the morphology of its fruit and seeds.

The geographical distribution of the known archaeological remains of *C. moschata* indicate that it has been cultivated for more than 5000 to 6000 years. Its spread to other countries, both within Latin America and outside the continent, was certainly very early. This is shown by the existence of the variety called Seminole Pumpkin, grown since pre-Columbian times by indigenous groups of Florida in the United States, and also by its appearance in seventeenth-century botanical illustrations. Such an early spread must have been very continuous and intense since, in the last decade of the nineteenth century, the species was cultivated in India, Java, Angola and Japan.

Uses and nutritional value

In the greater part of *C. moschata's* native area, its flowers. young stems and young and ripe fruits are eaten as a vegetable. The latter are also commonly used to prepare sweets and as fodder. The seeds are eaten whole, roasted or toasted and are ground into different stews. They have high oil and protein contents (similar to those noted in *C. argyrosperma*) and their consumption in urban areas is also fairly common.

Botanical description

C. moschata is a creeping and climbing plant. It is herbaceous, annual, monoecious, lightly and densely pubescent, with short and long uniseriate trichomes and caulescent vegetative apices that are fairly reflexed. It has slightly angular stems. Its leaves have petioles of 30 cm or more, are broadly ovate-cordate to suborbicular, measure 20 to 25 x 25 to 30 cm, have white spots, are slightly lobate with three to five ovate or triangular lobules. have an obtuse apex that is briefly apiculate, serrate-denticulate margins and three to five ramified tendrils. *C. moschata* has pentamerous, solitary, axillary flowers. The male flowers have 16 to 18 cm pedicels and a very short calyx, are broadly campanulate to pateriform, expanded or foliaceous towards the apex, 5 to 13.5 cm long, with five divisions for up to one-third of their length. The female flowers have thick pedicels of 3 to 8 cm in length, and a globose, ovoid, oblate, cylindrical, piriform, conical, turbinate ovary. They have a very small calyx and sepals that are more often foliaceous than in the males, measure up to 7.5 cm in length and are of thickened style. They have three lobate stigmas. The fruit varies greatly in size and shape (generally following the form of the ovary): smooth or with rounded ribs, rarely verrucose or granulose, with a rind that is both thickened and durable and soft and smooth, and of a very variable colour—light green to uniform dark green or with cream spots, light to dark, or completely white. The flesh is light or bright orange to greenish, ranges from light to very sweet, is soft and generally not fibrous. It has numerous seeds which are ovate/elliptical, measuring 8 to 21 x 5 to 11 mm and which have a yellowish-white surface.

Ecology and phytogeography

In botanical literature, *C. moschata* is reported as being grown mainly in areas of low altitude with a hot climate with high humidity. However, while it is true that this species is preferentially grown within these limits, they do not appear to be strictly adhered to, as variants have recently been found above 2200 m in Oaxaca, Mexico.

Genetic diversity

Limits of genetic stock. The wide range of altitudes at which *C. moschata is* cultivated within the American continent, the considerable morphological diversity of its seeds and fruit (colour, shape, thickness and durability of the fruit's skin), the existence of varieties with life cycles of different duration as well as the existence of numerous cultivars developed in other parts of the world and of local varieties with excellent agronomic characteristics, clearly indicate that the genetic variation of this species is very extensive.

Some interesting regional varieties for Latin America are those existing on the Yucatán peninsula (and possibly in other regions of Latin America), with two life cycles of different duration, and those cultivated in Guanajuato and Chiapas, in which resistance to some viral diseases was recently found. Among the former, the short-cycle variety commonly grown in Mayan vegetable gardens is of great interest, since it was certainly from this that the most commercially important variety in the region was derived. It should be mentioned that those cultivated in Guanajuato and Chiapas are currently being used in genetic improvement programmes.

With regard to the sources of variation of *C. moschata* cultivars developed outside its area of origin, the best example is that of a cultivar, native to Nigeria, which represents the only source of resistance to certain viral diseases. The possibilities of hybridization that *C. moschata* has shown with other cultivated species (for example, *C. maxima*) enable us to affirm that there are good prospects for the improvement of these crops.

Another part of the genetic stock of *C. moschata is* represented by the numerous commercial cultivars that have been developed, mainly in the United States and to a lesser extent in Brazil. Prominent among these are Butternut Squash, Golden Cushaw, Large Cheese, Tennessee Sweet Potato, Kentucky Field, Menina Brasileira and others. Some of these commercial cultivars also have different levels of resistance and/or susceptibility to certain diseases, which is indicative of the wide genetic variation of this species.

Germplasm collections. *C. moschata is* the best represented of *Cucurbita* in the gene banks of America. in which more than 2 000 accessions have been deposited. These come chiefly from Mexico and Central America and to a lesser degree from South America and other regions of the world. The most important accessions are those from the United States and Costa Rica. Collectively, the accessions are made up of American material, mainly from Central America. For its part, the CIFAP collection in Mexico is possibly the most representative of *C. moschata's* variation in that country.

Cultivation practices

The different variants of *C. moschata* are grown under traditional, heavy rain agricultural systems. It is possible to find varieties grown in maize fields together with maize, beans and one or two other Cucurbits, or in vegetable gardens and other more intensively managed farmland where they are grown alone or with other species. Sowing is carried out at the start of the rainy season and the development time is approximately five to seven months, although there are varieties with a very short cycle (three to four months) such as those mentioned from the Yucatán peninsula. In the long-cycle varieties, the young fruit to be used as vegetables is harvested approximately three months after sowing, while the ripe fruit for seed is harvested mainly between the sixth and seventh month.

In the Mixe region and other regions of the state of Oaxaca, *C. moschata* is also grown in the cold, dry season of the year on moisture-retaining ground. Cultivation is even carried out with the help of irrigation in some parts of the state of Sonora and some short-cycle varieties have also been observed on the Yucatán peninsula where they are grown for commercial purposes in humid soils or using unusual substrates (henequen fibre waste) and irrigation.

It is likely that varieties such as the ones described, and possibly others, are grown more commonly than is thought or known on the American continent. There are some old references to a considerable variation in Colombia, but its current situation has to be properly documented and evaluated.

Cucurbita ficifolia

Botanical name: *Cucurbita ficifolia* Bouche

Family: Cucurbitaceae

Common names. English: fig leaf squash. Malabar gourd, cidra, sidra; Nahuatl: chilacoyote (Mexico, Guatemala): Spanish: lacoyote (Peru. Bolivia, Argentina), chiverri (Honduras, Costa Rica), victoria (Colombia)

Origin, domestication and distribution

At the end of the last and the beginning of this century, some authors were suggesting an Asiatic origin for *Cucurbita ficifolia*. Since the middle of this century. the consensus has been that it is of American origin. However, its centre of origin and domestication are still unknown. Some authors have suggested Central America or southern Mexico as places of origin, while others suggest South America, and more specifically the Andes. Biosystematic studies have been unable to support the Mexican origin suggested by the distribution of common names derived from Nahuatl throughout America.

Archaeological vestiges point to a South American origin. since the oldest remains are Peruvian. but biosystematics have not been able to confirm this hypothesis either.

Attempts at obtaining hybrids beyond the first generation with the other four cultivated species have failed and the few results obtained have required the use of special techniques such as embryo cultivation. These results have been corroborated by other studies which reveal that *C. ficifolia* shows considerable isoenzymatic and chromosomic differences compared with all the taxa of the genus.

In addition to the foregoing observations, the recent discovery that *Peponapis atrata* does not appear to be a specific pollinator of *C. ficifolia* has led to the suggestion that the wild ancestor of this species might have been a still undiscovered species whose habitat could be the eastern region of the Andes. This is why the possibility of using wild (or cultivated) species in future programmes for the genetic improvement of this crop and their use in the improvement of other cultivated species of the genus is still remote. The importance of these programmes lies in the fact that collections have been identified which are resistant or completely immune to the attack of different viruses that severely affect other cultivated species.

The cultivation of *C. ficifolia* ranges from northern Mexico to Argentina and Chile. Its spread to Europe (France and Portugal, for example) and Asia (India) apparently began in the sixteenth and seventeenth centuries when its fruit reached the Old World from South America and India. Since then, its cultivation has spread to many other parts of the world (Germany, France, Japan and the Philippines).

Uses and nutritional value

The different parts of *C. ficifolia* plants are put to various food uses throughout its distribution area in America. The unripe fruit is eaten boiled as a vegetable, while the flesh of the ripe fruit is used to prepare sweets and soft or slightly alcoholic drinks. The seeds are also greatly valued and in Chiapas, Mexico, they are used with honey to prepare desserts known as *palanquetas*.

In some regions of Mexico (and perhaps other countries of the continent), the young stems (or "runner tips") and also the flowers are eaten as a cooked vegetable, while the ripe fruit is used as fodder for domestic animals. The latter is the commonest use in the Old World where this species has been introduced.

The most important nutritional value is found in the seeds which provide a considerable source of protein and oil. As indicated by its white colour, the flesh of the fruit is deficient in beta-carotene, and has a moderate quantity of carbohydrates and a low vitamin and mineral content.

Recent research in Chile has shown that some proteolytic enzymes from the flesh of *C. ficifolia* fruit can be used to treat waste water from the industrial processing of foods derived from fish. This discovery is of great interest because of the reduction in costs that these industries could achieve by using enzymes which would replace those imported at present.

In Japan and Germany, it has been used as a support or rootstock for the winter production of cucumber (*Cucumis sativus* L.) in greenhouses.

Botanical description

C. ficifolia is a creeping or climbing plant, monoecious, annual—although persistent for a certain period, giving the impression of being a short-lived perennial—without swollen reserve roots. It is resistant to low temperatures but not to severe frosts. It is villose to softly pubescent. with some short. sharp spines dispersed over the vegetative parts. It has five vigorous, slightly angular stems and leaves with 5 to 25 cm petioles that are ovate-cordate to suborbicular-cordate. with or without white spots on the surface, and have three to five rounded or obtuse, apiculate lobules, the central one bigger than the lateral ones. They have denticulate margins and three to four ramified tendrils. The flowers are pentamerous, solitary, and axillary. The male flowers are long and pedicellate, have a campanulate calyx that is 5 to 10 mm long and almost as wide, 5 to 15 x 1 to 2 mm linear sepals and a tubular-campanulate corolla that is rather broader towards the base, 6 to 12 cm long and yellow to pale orange. They have three stamens. The female flowers have sturdy peduncles, 3 to 5 cm long, an ovoid to elliptical, multilocular ovary: sepals that are occasionally foliaceous and a corolla that is somewhat larger than that of the male flowers. They are of a thickened style and have three lobate stigmas. The fruit is globose to ovoid-elliptical, with three colour patterns: i) light or dark green, with or without longitudinal white lines or stripes towards the apex; ii) minutely spotted white and green; iii) white, cream or flesh white. The flesh is sweet and the seeds are ovate-elliptical, flattened, 15 to 25 x 7 to 12 mm, and a dark brown to black or creamy white colour.

Ecology and phytogeography

C. ficifolia is grown over a wide distribution area from 1000 to almost 3000 m in practically all the mountain ranges of Latin America. The restriction of cultivation to areas of considerable altitude is a distinctive characteristic of *C. ficifolia* compared with other cultivated species of the genus, which can generally grow in a wider range of ecological conditions (in the case of *C. pepo* and *C. moschata,* from 0 to 2300 m).

Genetic diversity

Limits of genetic stock. In view of the reproductive incompatibility of *C. ficifolia* with the other species of the genus. it may be said that its genetic stock is limited to itself. However, in other respects this species is much less different than are other cultivated species of the genus. and there are no commercial cultivars. Among its most notable morphological variations are the coloration and size of its fruit and seeds. The scant morphological variation of this species is consistent with that observed in the patterns of isoenzymes studied so far.

From the agronomic point of view, it is possible to acknowledge the existence of some genetic diversity for *C. ficifolia* for two reasons:

- it is cultivated in a wide geographic range where conditions are only relatively uniform as regards altitude. but different from the point of view of other local ecological factors;

- it is grown both without distinction both under agricultural systems with high competition (for example, heavy rain maize fields) and under others with less competition or which allow a more intensive cultivation (for example, maize fields cultivated in the dry season on humid ground, vegetable gardens and plots).

However, none of these aspects has so far been evaluated.

Productivity, as regards the number of fruits and the quantity of seeds per fruit, is another aspect which possibly reflects the genetic diversity of the species and which, again, is insufficiently documented. Field observations have revealed that some medium-sized fruits contain 500 or more seeds and that each plant can produce more than 50 fruits.

Germplasm collections. Accessions of *C. ficifolia* germplasm are the least abundant of all those existing for the cultivated species of *Cucurbita*. In addition, they are not very representative of its geographical distribution. There are 338 accessions to be found in America's gene banks; these, added to another 82 deposited with institutions of countries outside the continent, make a total of 420. However, many of the accessions are duplicates. which reduces their number by about half.

Cultivation practices

C. ficifolia is a crop grown mainly in traditional heavy rain agricultural systems, which shows that the start of the rainy season corresponds to the sowing time, while harvesting takes place from the end of September (young fruit and flowers for vegetables) to December or January (ripe fruit for seed and flesh). In some regions of Mexico. such as Mixteca Alta in Oaxaca, it has been found that, in addition to being cultivated during the rainy season on heavily rain-fed terrain. this species is also grown during the dry season on more humid ground (valleys or areas where the soil drainage is slightly deficient). In these cases, sowing is carried out in the early months of the year and the crop is harvested from the dry season (April) until that corresponding to summer (May to July). This has made it possible to ensure almost uninterrupted production throughout the year.

The only form of propagation is the sowing of seed, together with one of the traditional crops of this type of agriculture (maize, bean and other species of *Cucurbita*), or else cultivation in vegetable gardens along with other species or by itself. The ripe fruit is harvested and selected for seed. It can be stored for long periods (18 to 20 months) and it is frequently seen drying on the roofs of farmers' houses.

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× *Citrofortunella mitis* J. Ingram & H. E. Moore

Rutaceae

Calamondin, calamondin orange, China orange, musk lime, Panama orange, Philippine orange, to-kumquat

We have information from several sources:

Calamondin—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Calathea allouia (Aubl.) Lindl.

Marantaceae

Guinea arrowroot, *Allouya*, Leren, *Lerenes, Llleren, Llerenes*, Sweet-corm-root, *Topee-tambu*

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Calendula officinalis L.

Compositae

Pot marigold, Scotch marigold, Calendula

We have information from several sources:

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

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New Horticultural Crops in New Zealand

Errol W. Hewett

New Zealand, a small country located in the South Pacific (latitude between 35° and 47°S and longitude 167° and 178°E) has a population of 3.3 million. Horticulture is a small but important contributor to the national economy having NZ$1.2 billion export earnings in 1991, 7.4% of total exports (NZ$1 = US$0.54, 1992). Four new fruit crops have been successfully introduced to international trade during the 20th century: avocado, blueberry, kiwifruit, and macadamia (Janick 1991). Of these, kiwifruit has arguably made the largest and most dramatic impact over the last 20 years.

The kiwifruit is a unique fruit with unusual visual (a brown, hairy skin with a spectacular green translucent flesh containing an attractive circle of black seeds around a white pith), nutritive (low calories, high fiber, high potassium, and vitamin C content), and storage (quality can be maintained for up to 12 months in air or controlled atmosphere storage) characteristics. It has successfully captured the imagination of traders and consumers who have paid high prices to purchase this new fruit. Associated profitability has seen kiwifruit planted in large numbers throughout the world during the 1980s.

ESTABLISHED FRUIT CROPS

New Zealand grows a wide range of temperate fruit crops, but only contributes significantly to world trade with kiwifruit and apples. Major efforts are currently underway to improve the existing range of cultivars to exploit consumer demand for new taste and visual sensations.

Largely as a result of the foresight, dedication, perseverance, and skill of the late D.W. McKenzie, major breeding and plant improvement programs are being undertaken by the Department of Scientific Research (DSIR) on a range of crops including kiwifruit, apples, pears, apricots, and a range of subtropical fruits.

Kiwifruit [*Actinidia deliciosa* (A. Chev.) C.F. Liang & A.R. Ferguson] var deliciosa, Actinidiaceae

Commercial plantings of kiwifruit in New Zealand are known to have derived from one seed acquisition brought from China in about 1903 by Miss Isabel Fraser, sister of Miss Katie Fraser, a missionary in Xichang. It is possible that the majority of kiwifruit grown in New Zealand (and to a large extent elsewhere especially France, Italy, and Australia) originated from seed from one fruit, certainly from only a few fruit collected from the wild by E.H. Wilson from one region in China (Ferguson 1990). Hence, the present genetic base of existing kiwifruit plantings is extremely limited.

The genus *Actinidia* is known to have more than 50 species and more than 100 taxa (Liang and Ferguson 1986, Ferguson 1990). The cultivar `Hayward', which accounts for more than 95% of the current kiwifruit plantings in New Zealand today, was selected by Hayward Wright, a nurseryman who has been called "the Luther Burbank of New Zealand horticulture." In the period from 1903 to 1946, when kiwifruit were grown mainly as an ornamental plant, many enthusiastic nurserymen were involved in the propagation, improvement and sale of these novel plants; in particular Bruno Just, Alexander Allison, James McGregor, and Hugh Gorton, made significant contributions (Ferguson and Bollard 1990).

Scientists in DSIR recognized the inherent danger of relying on such a narrow genetic base for the development and continued success of an important new crop. They were also well aware of the diverse range of species, indigenous in China, which while providing fruit for a range of products (jam, pastes, medicines) had not been subject to any concerted or deliberative screening programme for improving size or quality. Since the 1970s there has been a joint effort by DSIR and Chinese scientists to obtain seed material from a broad range of *Actinidia* species, to grow them together under uniform conditions of cultivation and training for comparison of fruiting characteristics and to obtain diverse material to be used in breeding programmes by traditional or novel molecular biology means.

The genus *Actinidia* is characterized by having a wide range of growth habits, fruit size, shape, color, and nutritive qualities. Some species are cross compatible and interspecific crosses are easily achieved, while others are incompatible, and interspecific hybrids may only be possible by using recently developed embryo transfer techniques. Three major thrusts are being adopted by scientists involved in the current breeding program:

1. to obtain improved or different selections from existing plantings or "Hayward lookalikes." Selections already made and under evaluation include: more uniform fruit shape, earlier fruit maturation, hermaphrodite as distinct from diecious plants, more productive plants than `Hayward', higher vitamin C, and reduced flats and fans.
2. to develop vigor controlling rootstocks which will also offer better flowering after mild winters, produce high export yields, enhance precocity from young vines, and reduce flats and fans.
3. to crossbreed with other *Actinidia* species, in particular from *A. chinensis* Planchon, to produce fruit with smooth skins like a peach or pear, maybe with different colored skins and/or flesh. *A. chinensis* vines are precocious and high yielding, some are early maturing with good flavor. A range of flesh colors from green through yellow to pink are available, and fruit store for 2 to 3 months. Successful hybridization between *A. deliciosa* and *A. chinensis* is likely to produce fruit combining the desirable features of both species. *A. arguta* (Seibold & Zuccarini) Planchon ex Miquel, marketed as a home garden vine in North America, produces fruit about grape-size, very sweet, with red or green flesh. A green skinned hairless fruit from a highly productive vine has already been produced.

Results from these different approaches already indicate that there is a major potential for a dramatic increase in the range of cultivars of kiwifruit of commercial potential. Even more exciting is the possibility of the emergence of "new" fruits based on the genetic diversity of the *Actinidia* species. These long term strategic plant improvement programs are financially supported by the kiwifruit industry which recognizes the commercial necessity and opportunities which accrue from successful new cultivar development.

Apples (*Malus* x *domestica* Borkh., Rosaceae)

One of the main reasons for the success of the New Zealand apple industry is the ability to provide customers with a range of 5 to 9 distinct cultivars over a 4 to 6 month marketing period. This contrasts with some other apple producing countries which tend to produce only two or three major cultivars. In addition, the New Zealand Apple and Pear Marketing Board has successfully introduced several highly acceptable new cultivars to international trade in recent years. The cultivars 'Braeburn', 'Gala', and 'Royal Gala' have had a major impact in apple markets highlighting New Zealand's reputation of being able to develop and market appealing new fruit sensations.

The late D.W. McKenzie, working for DSIR, with great perspicacity, foresaw the need for a concentrated and directed breeding program to ensure a continuous release of new apple cultivars onto major markets. With perseverance and dedication, he overcame serious opposition in New Zealand, and acting against prevailing international trends, initiated a program to produce a bright red, late maturing highly flavored apple to have a market slot after 'Granny Smith'.

While none of his original selections are likely to achieve major success, subsequent releases from his work, together with hybrids from current programs, are likely to have a substantial impact in the next decade. 'Splendour' x 'Gala' crosses are undergoing commercial evaluation and two are being focussed on by the New Zealand Apple and Pear Marketing Board for test marketing. In particular, GS2085, looks promising. It is a rosy pink cultivar which ripens late in the season with 'Granny Smith'; it has an extremely crisp and crunchy texture with a sweet flavor and a good acid balance. The trees are precocious, like a 'Golden Delicious' in openness and vigor, having good branch angles and carrying good fruit loads on young branches. GS2085 has tolerance to black spot and is less susceptible to mildew than existing cultivars.

Later crosses, including selections from a collaborative program with Japanese plant breeders, are equally, if not more exciting. It is anticipated that a portfolio of selections will be produced which will provide quite different taste and texture sensation for consumers contrasting markedly with major cultivars available today. Enhanced pest and disease tolerance/resistance is another major objective in the ongoing pome fruit breeding program in an attempt to reduce the importance of pesticides in producing high quality fruit. A pear breeding program is also underway in DSIR, but this is less advanced than the apple projects. Recognition of the strategic importance of providing new apple cultivars has resulted in considerable financial input from the New Zealand apple industry to this program.

THE SOUTH AMERICAN CONNECTION

In tropical South American countries, at altitudes between 2,000 and 3,000 m, there occur endemic fruiting plants that are really warm temperate species. Many of these appear to be well adapted to warmer parts of New Zealand. Over the past 20 years, both private and Government sponsored expeditions have visited a number of countries, including Colombia, Ecuador, Peru, Chile, and Brazil to obtain propagating material for evaluation under New Zealand conditions. The rapid destruction of natural rainforest vegetation in several of these countries is placing many precious food plants at risk of extinction; there is an urgent need to collect and preserve as many of these plants as soon as possible if they are not to be lost forever. New Zealand has been fortunate in being recipients of some most interesting fruit and vegetable crops from South America, many of which were common foods of the Incas (Veitmeyer 1991).

Tree Tomato [*Cyphomandra betacea* (Cav.) Sendtn., Solanaceae]

The tree tomato [renamed the tamarillo in New Zealand, not to be confused with the tomatillo (*Physalis ixocorpa* Brot.)] is an egg shaped/sized, bright red fruit developed in New Zealand from seed thought to have been obtained from a missionary in Ecuador early this century. In the wild, the fruit is generally small, splotchy and yellow or pale red in color (Veitmeyer 1991). Large red-fruited strains were developed by nurserymen in New Zealand, and recently large golden colored cultivars have been produced.

Tamarillos are rapidly growing trees which produce good crops after 18 months. They are frost tender which limits their distribution. Fruit is highly attractive, but some people find the skin and flesh too astringent to make it a popular fresh fruit. While the fruit has a high vitamin C content, it has a limited storage life, suffering from chilling injury and postharvest pathogens if maintained below 5°C for any sustained period of time. Fruit processes extremely well. They can be frozen or canned and can be used for a range of products including jam, pulp, puree, chutney, and juice; there is considerable potential for combining with milk products such as yogurt.

Unfortunately, tamarillo trees are easily infected with tamarillo mosaic virus, which results in production of blotchy, streaked unattractive fruit. Until disease resistant stock can be obtained, opportunities for existing tamarillo cultivars are limited. A wide range of seeds have been collected from indigenous tamarillo plants in South America and these are currently under evaluation.

Feijoa (*Feijoa sellowiana* Berg, Myrtaceae)

Originating in the plateau lands of southeast Brazil, the feijoa, known as pineapple guava in California, has been grown in New Zealand for many years. It has a shrub-like growth habit producing attractive flowers. It is more hardy than tamarillo, being able to tolerate mild winter frosts. In California, it is grown mainly as an ornamental hedge, while in southern Russia and Israel, it has been grown as a commercial fruit crop. Until recently, most plantings in New Zealand have been with seedlings, resulting in extreme variation in fruit size, shape, flavor, and keeping quality. Over the last decade, a number of improved selections have been made and the availability of grafted plants is ensuring consistency in fruiting.

The ovoid green skinned fruit with vanilla-colored flesh has a very sweet and aromatic taste when eaten fresh. Flesh has to be scooped as the skin is bitter. No satisfactory maturity index has been developed so it is difficult to determine optimum harvest maturity. Fruit catching structures are placed under trees by the serious feijoa growers in order to prevent fruit dropping to the ground when ripe; if this occurs fruit is likely to be damaged and become infected with postharvest pathogens. Recent research has produced cultivars with large fruit having thin smooth dark green skins, strong aromatic flavor, good sugar/acid balance, smooth texture with a minimum of grittiness, and a moderate storage life. Fruit may be canned to create a pleasing product.

Pepino (*Solanum muricatum* Ait., Solanaceae)

The pepino is a small, shrubby plant which produces large (up to 15 cm diameter) fruit with a sweet smell, subtle flavor, and attractive yellow/golden skin color often with purple stripes. It is grown widely in the north of South America and cultivated extensively in Chile. Seed material, introduced to New Zealand in 1973, produced extremely variable fruit with a range of shapes and flavors. It grows well in New Zealand, generally in the same climate as tomato. Early sales of seedling fruit by entrepreneur growers wanting to cash in on this new crop, created serious market problems, as fruit was often small, bitter, unattractive to both the eye and the palate.

A selection and breeding programme by DSIR scientists in conjunction with a committed and enthusiastic grower, has led to the production of several outstanding cultivars. However, best crops seem to be produced under protected cultivation and many management problems involving nutrition temperature, light, and maturity indices have still to be solved.

In spite of an apparently receptive market in Japan for high quality pepinos, this industry has virtually lapsed for want of necessary research input.

Babaco [*Carica* x *heilbornii* Badillo m. pentagona (Heilborn) Caricaceae]

The babaco is native of Ecuador and is a hybrid between two Andean papayas, producing more and larger fruit than the mountain papayas. It was introduced to New Zealand in 1973, but popularized by an ardent nurseryman who made numerous visits to Ecuador to collect this and other exotic fruit material.

Babaco is extremely productive, producing large (2 kg) green, torpedo shaped fruit hanging in clusters around the trunk. The fruit has a subtle flavor when ripe; it is very refreshing to eat and make an acceptable and healthy juice. Although difficult to propagate initially, many plants were sold to real and "would-be" horticulturists during the boom times of the early 1980s. However, this crop has not been a commercial success either locally or for export, possible because of their novelty (and lack of promotion) and their large size (they are too expensive for the consumer wanting to try something new).

Cape Gooseberry (*Physalis peruviana* L., Solanaceae)

These plants grow all over the Andes and were fruit of the Incas (Veitmeyer 1991). Cape gooseberries (which are neither gooseberries nor from the Cape; seeds were obtained from the Cape of Good Hope late last century) are grown on a few small properties in New Zealand. Production is small and fruit is supplied mainly to the local market. Removed from the paper-like husks, the attractive yellow marble-sized fruit makes an extremely tasty jam. Fruit has a high vitamin A, B, and C content, is a rich source of carotene, phosphorous, and iron, and also contains vitamin P. It may be eaten fresh, in salads or in cocktails. No research effort is being made in New Zealand to improve this crop.

Cherimoya (*Annona cherimola* Mill., Annonaceae)

Considerable interest is currently being shown for this green-skinned, softball-sized fruit sometimes called "the queen of subtropical fruits." A range of cultivars have been introduced from Ecuador, Chile, and Peru for evaluation in warmer climates in New Zealand and several commercial orchards have been planted. A reasonable market potential seems to exist for this very tasty fruit (enhanced by the recent freeze in California which destroyed a major production area). However, selection of cultivars for good production of high quality fruit in marginal New Zealand climatic conditions is still necessary; fruit with fewer seeds and extended shelf life are also required before this fruit could become a substantial export earner from New Zealand.

Oca or "Yam" (*Oxalis tuberosa* Mol., Oxalidaceae)

The oca (or yam as it is called in New Zealand) is a small, red, waxy, crinkled tuber was probably a staple food item of the Andean Indians (Veitmeyer 1991). They are grown on a very small scale in a localized area in New Zealand and sold only on the local market. The tubers have a tangy, acid nutty flavor and are eaten mainly with roast dinners. The original planting material probably came from Chile to New Zealand in the late 1800s with immigrants. Oca does not seem to be widely grown outside of South American countries and so appears to qualify as "one of the lost crops of the Incas" (Veitmeyer 1991).

Other Crops

A range of other unusual and exotic South American food crops are being grown in New Zealand, generally by enthusiastic horticulturalists. These include: naranjilla (*Solanum quitoense* Lam., Solanaceae), which produces an orange hairy fruit which makes a green frothy drink, and has a flavor reminiscent of pineapple and strawberry; capulin cherry (*Prunus capuli* Cav., Rosaceae) a red skinned, green fleshed fruit with excellent flavor; yacon (*Polymnia sonchifolia* Poepp. & Endl., Asteraceae) a root vegetable, which when eaten uncooked, is very crunchy, watery to translucent, and sweet. Any attempt to improve or develop these plants further is being undertaken by private individuals.

Another fruit vegetable that has received some interest in recent years is the kiwano or African Horned Melon (*Cucumis metuliferus* E.H. Mey. ex Schrad., Cucurbitaceae). It grows on the fringes of the Kalahari Desert in Africa and was introduced to New Zealand during the 1970s. The orange spiny fruit with intensely green flesh is extremely attractive. The fruit has many seeds, a subtle flavor, and has an excellent storage life at room temperature. However, it is more of a novelty crop and has not undergone commercial development.

NEW FLOWER CROPS

New Zealand is a very small producer of flowers by international standards. Orchids are the most important flower in terms of exports. However, there are a few new flower types that have been developed which are poised to make a contribution in the near future. Private breeders are also producing international prize winning cultivars with traditional flowers.

Calla (*Zantedeschia* spp., Araceae)

Originating in Southern Africa, several New Zealand nurserymen have specialized in developing an extensive range of new brightly colored callas. These are versatile plants and can be used as bedding plants, pot plants, and cut flowers. A considerable amount of basic research has been undertaken at Massey University to understand the factors controlling the growth cycle of these plants, including flowering, dormancy, and productivity, with a view to producing a production management blueprint for purchasers of the export tubers and plants (Funnell et al. 1988). A recent innovation has been to develop a miniature potted version of the white arum lily (*Z. aethiopica* cv. Childsiana) which holds considerable potential as a decorative or commemorative living momento.

Nerine (*Nerine* spp., Amaryllidaceae)

In recent years, New Zealand has obtained ownership of probably the most extensive collection of nerine species and cultivars in cultivation in the world. A very limited number of growers are involved in evaluating this collection in New Zealand conditions, with a view to exporting both bulbs and a range of diversely colored cultivars.

Sandersonia (*Sandersonia auriantiaca* Hook., Liliaceae)

A protected genera now in South Africa, Sandersonia stock was obtained by a New Zealand nurseryman over 70 years ago, but commercial development has been very slow. Grown from tubers, the plants produce beautiful, orange, bell-like granny's bonnet shaped flowers which have a reasonable shelf life. Both tubers and cut flowers are grown for export.

Other Flowers

New Zealand has some highly accomplished private flower breeders who are making major advances in new cultivars. Prominent among these are: Keith Hammett who has gained international awards for his outstanding new selections of dahlias, sweet peas, and carnations; Sam McGredy, originally from Ireland, who now resides in New Zealand and continues to produce world class roses with infinite shape, color, and aroma; Bill Doreen who has been producing a wide range of colorful and exciting lilies for many years.

A number of other flower crops are being grown by committed enthusiasts; these include peony, leucodendrons, limonium, and gypsophila. A recent novel development has been the production of miniature flower plants of *Leptospermum* spp. (Myrtaceae) and kowhai [*Sophora* spp., Leguminosae (subfamily Faboideae)].

NATIVE PLANTS FROM NEW ZEALAND

New Zealand has a unique flora. Many indigenous shrubs and trees are not well-known in other parts of the world. Some of these have potential for pot plants or foliage. While some have been developed by nurserymen for local sale, most of the range of foliage and flower types available have not been utilized as commercial products.

A number of *Cordyline* spp. and *Phormium* spp. (both Agavaceae) have been selected; these include dwarf species, and selections with a range of foliage from deep reds through yellow to green, as well as a range of variegated types.

One tree with considerable potential is the pohutakawa or New Zealand Christmas tree (*Meterosideros* spp., Myrtaceae). In the wild, it grows as a huge gnarled tree, often protruding precariously from high cliffs overlooking the sea. Trees have brilliant crimson red flowers which cover the whole tree in December in New Zealand. It is possible to produce trees in pots and to induce flowering within two years of planting. Further research is required to manipulate growth and flowering with more precision before a successful export industry can develop, but there is considerable potential for this spectacular specimen.

Hebe spp. (Scrophulariaceae) are common throughout New Zealand. Many have been developed as garden and potted plants, as much for their varied foliage as for their range of flower types. Increasingly, these Hebes are being developed in countries other than New Zealand, (Denmark) as successful commercial nursery plants.

CONCLUSION

Possingham (1990) identified two contrasting influences at work in horticultural industries in developed countries. On the one hand there is a strong move to develop new and exotic crops, often drawn from diverse species growing in the wild, which have the potential to produce good profits for growers and others involved in horticultural trade. On the other hand, there is a reduction in the number of cultivars being grown as market requirements define apparently narrower quality characteristics.

New Zealand horticulture generally follows the first trend. While Maoris, the original inhabitants of New Zealand, brought several vegetable crops, notably the sweet potato, with them from the Pacific, the majority of new plant introductions occurred with the arrival of English settlers in the late 19th century.

Most of the traditional horticultural crops grown in New Zealand are well known in other fruit growing countries in temperate climates. Introductions of apples, pears, stonefruit, berryfruit, citrus, flowers, and ornamental plants continue to this day from diverse international sources.

However, there has been a large element of serendipity in the introduction of new or different plants. Missionaries, travellers, explorers, and visitors have all had an influence on the introduction of new and unusual plants. The kiwifruit from China and the range of species from South America exemplify this fact.

Highly skilled, observant, and entrepreneurial nurserymen probably had the major role in transforming wild growing species into potential commercial cultivars. Many of these nurserymen were very talented plantsmen who initiated plant improvement programs themselves by selection and breeding. The seminal influence of Alexander Allison, Bruno Just, and Hayward Wright in the initial development of the kiwifruit has been well documented (Ferguson and Bollard 1990). The influence of nurserymen on the development of other crops mentioned in this article is not documented.

Invariably, success depended on the efforts of a "champion" of the crop. Whether this champion was a nurseryman, a grower, a scientist, or a marketer, almost without exception, any product which has achieved any economic significance in New Zealand can be identified with an enthusiastic, committed, and skillful plantsman who are unabashed advocates for their particular crop.

A more recent feature of new crop development in New Zealand has been the involvement of Government scientists, mainly from DSIR, but also from the Ministry of Agriculture and Fisheries and from Universities. The Government has funded a number of plant improvement programs, both in selection and breeding in major and minor crops, and the scientists involved have worked closely with growers and nurserymen. This collaboration has accelerated in the last two decades, particularly but not exclusively with the major crops such as apples and kiwifruit.

Both of these industries have well developed infrastructures and a strong marketing role. Industry personnel have agreed with scientists on the strategic importance of developing an extended range of cultivars which should provide a market advantage for this country in the future. Input from marketing experts to the scientists breeding program is an important characteristic of today's efforts which are underpinned by both Government and industry funding.

While many other groups have developed to represent the collective interests of those producing or marketing particular products, they lack the organizational structure and the financial success of the major product groups. Consequently less "seed" money has been available for attracting subsequent Government research effort.

Recent structural and philosophical changes have occurred in science organization in New Zealand which is impacting on research carried out on minor horticultural crops. The 1980s have seen the introduction of "user pays;" that is research perceived to bring direct benefit to an individual or an industry is expected to be increasingly funded by that individual or industry. Therefore, while the apple and kiwifruit industries currently contribute nearly $6 million to research, and as a consequence still receive substantial Government support, minor industries are in no position to provide enough funding to attract significant Government support. In spite of the fact that there is potential for commercial success from one or more of a range of "sunrise" crops, (i.e. crops at early stages of development and perceived to have potential for growth), the Government policy of not picking winners and not funding research on crops/sectors that do not provide research funds, means that the effort being directed into minor crops has diminished drastically over the past eight years.

New Zealand has turned a complete circle. Successful development of new and exotic crops in the future will come again from the private nurseryman, the enthusiastic amateur horticulturist, the perceptive grower, and from the non-institutional groups such as the Tree Crops Society. Either individually or collectively they will collect, import, select, and develop horticultural crops which they will champion. Only when an individual crop can be demonstrated to have commercial success will the Government research scientists be in a position to lend their considerable expertise to further improvement. New Zealand will continue to have an international reputation for producing a diverse range of new and exciting horticultural crops. New apples and kiwifruit, diverse and colorful plants and flowers, and exotic fruits sourced from South America will be traded successfully in world fruit markets during future decades.

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Calliandra calothyrsus Meissn.

Mimosaceae
Calliandra

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Calliandra is unusually promising as a firewood source because of its excellent coppicing ability and very quick growth. In Indonesia it is cut for fuel after only a year's growth and harvested annually for the next 15–20 years. Even when harvested on such short rotations, it produces a sizable yield of branch wood that makes good household fuel. Like many other genera favored for charcoal making, Calliandra often travels under the Spanish name of 'carbonaria' or 'carbonero'. Indonesians use the tree to supress Imperata, and to make firebreaks. Livestock relish the leaves of this good fodder crop, grown with elephant grass in large areas previously unable to support any crop. An exciting ornamental, producing beautiful red "powderpuff" flowers, it forms attractive hedges. Planted in strips on Indonesian state forest lands to protect the forest against fire (as well as illegal woodcutting). Honey produced by bees foraging on Calliandra has a bittersweet flavor. The species grows very quickly, its dense foliage provides ground cover, and its extensive and deep root system makes Calliandra particularly suitable for erosion control on slopes and for rejuvenating degraded soils. By nitrogen fixation and litter production, Calliandra improves soil quality and productivity. Farmers in East Java sometimes rotate agricultural crops with Calliandra plantations. Calliandra serves as a suitable host for the shellac insect, *Kerria lacca* (NAS, 1980a, l983b).

Folk Medicine

Closely related *Calliandra houstoni* is reported to be febrifugal in homeopathic doses (List and Horhammer, 1969–1979). The root bark has been sold in Mexico under the name 'pambotani'.

Chemistry

Calliandra houstoni is reported to contain tannin, fat, resin, glycosides, alkaloids, and saponins (List and Horhammer, 1969–1979). Dry fodder

Toxicity

"No toxic components have been found so far, although tannin levels are high." (NAS, 1983b).

Description

Slender shrubs, rarely to 10 m tall, nearly glabrous; leaves with 15–20 pairs of pinnae; the leaflets rounded or very obtuse, not curved. Flowers in pink, mimosa-like "powderpuffs", the corolla glabrous or nearly so. Pods 8–11 cm long, ca 1 cm wide, with 3–15 seeds (14,000/kg).

Germplasm

Reported from the American Center of Diversity, calliandra, or cvs thereof, is reported to tolerate heavy soils, poor soils, some shade, slope, and weeds (NAS 1980a, 1983b). It does not tolerate prolonged waterlogging, nor poorly drained calcareous clay soils.

Distribution

The plant is native to Central America, but seeds were introduced from Guatemala to Indonesia in 1936. Calliandra proved so successful as a plantation crop that in 1950 the Indonesian State Forest Enterprise (Perum Perhutani) began planting it on a large scale, so that by early 1979 about 30,000 ha in Central, East, and West Java were under cultivation.

Ecology

Estimated to range from Subtropical Dry to Rain through Tropical Moist to Wet Forest Life Zones, this Calliandra is reported to tolerate annual precipitation of 10–44 dm and estimated to tolerate annual temperatures of 20–26°C and pH of 4.5–8.0. On Java, the plant grows at altitudes between 150 and 1,500 m. It can withstand drought for several months. It grows on many different soils, including infertile ones (reported from andosols, laterites, latosols, litosols, podsols, regosols, ultisols, and vertisols; NAS, 1983b) tiles, or bricks. It converts to charcoal (34% yield in one test) with a fuel value of 7,200 kcal/kg. Indonesians estimate one hectare can produce 14 tons charcoal (NAS, 1983b).

Cultivation

Plantations are established by direct seeding or by seedlings, usually Planted at the beginning of the wet season. Seedlings are transplanted from nurseries at about 4–6 months, spaced at 2m x 2m or 1m x 1m. Seeds are treated with hot water and then soaked in cold water for 24 hours. Because it grows so rapidly and densely, Calliandra supresses competing plants very quickly. There is little information on performance of this species on different sites. The plant is so hardy and reproduces so easily that it may become a weed of sorts, difficult to keep in check.

Harvesting

Cut as needed, regenerating rapidly. Cut stumps coppice readily.

Yields and Economics

Indonesian trials showed initial growth of 2.5–3.5 m in 6–9 months. After 1 year's growth, calliandra can be cut at about 50 cm above the ground, reportedly yielding about 5–20 m^3 per ha. Afterwards, yearly cuttings are possible, producing between 35 and 65 m^3 of small-sized fuelwood per ha, a rather incredible yield. In Indonesia, annual yields of 7–10 MT of dry fodder (22% crude protein) per ha have been recorded. In Toyomarto, East Java, villagers earn more money selling calliandra firewood than they do from food crops, often intercropped with calliandra. A hectare of Calliandra is estimated to Yield 1 MT honey (NAS, 1983b).

Energy

In parts of Java, Calliandra is a favorite fuelwood. (In one instance, an experimental plantation of 0.5 ha was established in 1963; by 1975, over 250 ha of firewood plantations had been independently established on nearby privately owned farms and home lots.) The wood has a specific gravity of 0.51–0.78, its calorific value is 4,500–4,750 kcal per kg, and its ash content is 1.8%. It is used for cooking as well as in small industries; for example, those making lime, derived from *Calliandra calothyrsus* contains 22% protein, 30–75% fiber, 4–5% ash, 2–3% fat, and 1–3%

tannin. There is ca 1% quercetin-3-rhamnoside.

Biotic Factors

Bees forage heavily on the flowers. *Ravenelia reticulatae*, a rust, has been reported on an Arizonan species of *Calliandra* called False-mesquite (Ag. Handbook 165). Few pests have been reported from *Calliandra calothyrsus* in Indonesia—a scale insect on branches and stems, a trunk borer, and a looper eating the leaves. Snails and rats may destroy seedlings in nurseries. Fungi (e.g. *Corticium salmonicola* and *Xylaria* sp.) may kill weakened stems following careless coppicing (NAS, 1983b).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, December 30, 1997

Calocarpum sapote (Jacq.) Merr.

Sapotaceae

Mamey sapote, Sapota, White sapote

We have information from several sources:

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Sapote, White

Mamey zapote

Sapotaceae *Calocarpum sapota* (Jacq.) Merr.

Sapote, Green

Injerto

***C. viride* Pettier**

Source: Magness et al. 1971

The white sapote tree is a large - up to 80 feet - tropical evergreen with leaves up to 12 inches long by 4 inches wide. Fruits are ovoid or elliptical, 3 to 6 inches long, with usually one large seed. The fruit peel is thin, scurfy and roughened. Flesh is red or reddish brown, firm and somewhat granular, with a rich, sweet flavor.

The green sapote tree is similar to the white, but with smaller leaves. Fruits are similar in size and other characteristics to the white sapote.

Season, bloom to maturity: 6 to 8 months.

Production in U. S.: No data. Dooryard trees only,

Use: Fresh eating, preserves.

Part of fruit consumed: Inner pulp.

Last update June 28, 1996 bha

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Cragg, G.M., J.E. Simon, J.G. Jato, and K.M. Snader. 1996. Drug discovery and development at the National Cancer Institute: Potential for new pharmaceutical crops. p. 554-560. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Drug Discovery and Development at the National Cancer Institute: Potential for New Pharmaceutical Crops

Gordon M. Cragg, James E. Simon, Johnson G. Jato, and Kenneth M. Snader

Plants have formed the basis for the treatment of diseases in traditional medicine systems for thousands of years, and continue to play a major role in the primary health care of about 80% of the world's inhabitants (World Health Organization statistic, Farnsworth et al. 1985). In the area of cancer treatment, many claims have been made for the beneficial effects of plants (Hartwell 1982), though many of these claims may be viewed with some skepticism since cancer, as a specific disease entity, is likely to be poorly defined in terms of folklore and traditional medicine. Nevertheless, the discovery and development of efficacious anticancer agents, such as vinblastine and vincristine isolated from the Madagascar periwinkle, *Catharanthus roseus* (L.) G. Don, provided convincing evidence that plants could be a source of novel cancer chemotherapeutic agents. While the natural product isolated as the active compound might not be suitable for development as an effective drug, it can provide a suitable lead for conversion into a clinically useful agent. This approach is well illustrated by the development of the anticancer drugs, etoposide, and teniposide, as semisynthetic derivatives of epipodophyllotoxin, isolated from *Podophyllum peltatum* L. and *P. emodii* Wall. (Cragg et al. 1993a).

PLANT ACQUISITION AND DRUG DISCOVERY

In 1960, the National Cancer Institute (NCI) initiated a plant collection program in collaboration with the United States Department of Agriculture (USDA) (Perdue 1976). During the next twenty one years, over 35,000 plant samples representing some 12,000 to 13,000 species were collected by the USDA, mainly from temperate regions; over 114,000 extracts were tested for antitumor activity, primarily in the in vivo L1210 and P388 mouse leukemia systems. While many active agents belonging to a wide variety of chemical classes were isolated and characterized (Cragg et al. 1993a), few satisfied the stringent requirements for preclinical and clinical development. The major clinically active agents to emerge from this program were paclitaxel isolated from *Taxus brevifolia* Nutt. and other *Taxus* species (Suffness 1995), and hycamptamine (topotecan), CPT-11, and 9-aminocamptothecin, all semisynthetic derivatives of camptothecin isolated from *Camptotheca acuminata* Decne (Wall and Wani 1993). The structures of these compounds are shown in Fig. 1.

In 1986, NCI expanded its program to the collection of plants from tropical and subtropical regions. Contracts were awarded to Missouri Botanical Garden (Africa and Madagascar), New York Botanical Garden (Central and South America), and the Univ. of Illinois at Chicago, assisted by the Arnold Arboretum and the Bishop Museum in Honolulu (Southeast Asia), and were renewed, after open competition, in 1991. Collections have been performed in over 25 countries, with the contractors working in close collaboration with qualified organizations in each source country. The collaboration of the source country organizations and scientists has been indispensable in the procurement of the necessary collection and export permits, in the successful performance of in-field collecting activities and taxonomic identifications, as well as the provision of facilities for the preparation, packaging, and shipment of the samples to the NCI natural products repository in Frederick, Maryland. In turn, the NCI program has provided support for expanded research activities by source country scientists, and the expansion of source country holdings of their flora through deposition of a voucher specimen of each species collected in the national herbarium. Through its Letter of Collection (LOC), the NCI has committed itself to policies of collaboration with source countries in the drug discovery and development process, and fair and equitable compensation in the event of commercialization of a drug developed from a plant collected within their borders (Cragg et al. 1994). A key provision of the LOC is the commitment to utilize source country resources, either through sustainable harvest or cultivation, in the large-scale production of an agent for preclinical and clinical development. In the event that a drug is licensed to a pharmaceutical company for advanced development and commercial production, the successful licensee will be required to seek as its first source of supply the natural resources available from the source country, provided a mutually agreeable fair price can be determined.

To date, over 45,000 plant samples have been collected by the NCI contractors, and over 40,000 have been extracted to yield more than 87,000 organic solvent and aqueous extracts. These extracts are tested in vitro for selective cytotoxicity against panels of human cancer cell lines representing major disease types, including leukemias, breast, central nervous system, colon, lung, ovarian, prostate, and renal cancers (Boyd and Paull 1995), as well as for anti-AIDS activity in a screen comprising human lymphoblastoid cells infected with the live AIDS virus (Bader 1992). Extracts showing significant activity in either screen are subjected to bioassay-guided fractionation aimed at the isolation of the pure, active agents. Of the more than 44,000 extracts tested so far in the in vitro human cancer cell line screen, less than 1% have shown some level of selective cytotoxicity. In some instances, the patterns of differential cytotoxicity have been associated with known classes of compounds such as cardenolides, cucurbitacins, lignans, and quassinoids, but others appear to be new leads which are being investigated further. Over 36,000 extracts have been tested in the anti-AIDS screen, and approximately 10% have exhibited some in vitro activity; however, most of the active extracts are aqueous and, in the majority of cases, the activity has been attributed to the presence of ubiquitous chemotypes, such as polysaccharides and tannins. Such compounds are not a current NCI focus for drug development and are typically eliminated early in the drug discovery process (Cardellina et al. 1993). A number of in vitro active anti-AIDS agents have been isolated and selected for preclinical development. Of these, michellamine B isolated from the leaves of the Cameroon liana, *Ancistrocladus korupensis*, and the calanolides isolated from *Calophyllum* species collected in Sarawak, Malaysia, are in advanced preclinical development, and their production is discussed later in this paper.

DRUG DEVELOPMENT: SUPPLY ISSUES AND THE POTENTIAL FOR NEW PHARMACEUTICAL CROPS

Alternative Methods of Production

The isolation of an active compound is the first stage in the development of a new agent which might be developed as a drug for advancement to clinical trials and possibly to commercial use (Grever et al. 1992). While the initial plant sample (0.3-1.0 kg) collected generally yields enough extract (10-40 g) to permit the isolation and structural elucidation of the pure, active constituent, subsequent secondary testing and preclinical development might require gram or even kilogram quantities. Approval of an agent for clinical development could require multi-kilogram quantities.

In order to isolate sufficient quantities of an active agent for preclinical development, re-collections of 5 to 200 kg of the dried plant material might be necessary, preferably from the original collection site. Such large re-collections necessitate surveys to determine the abundance and distribution of the plant, as well as the variation in drug content with the season of harvesting. The feasibility of propagation and the potential for mass cultivation of high-yielding phenotypes of the plant would also need to be assessed. If problems are encountered due to the scarcity of the wild plant or inability to adapt it to cultivation, alternative sources need to be sought. Other species of the same genus or closely related genera may be analyzed for drug content, and other biomass production techniques, such as plant tissue and cell culture can be investigated. Another potential route for bulk production of the active agent is total synthesis, but experience has shown that the complex structures of most bioactive natural products require the development of multi-step bench-scale syntheses which often are not readily adapted to economically feasible large-scale production. Thus, despite over 30 years of extensive research into the synthesis and tissue culture production of the commercial anticancer drugs, vinblastine and vincristine, isolation from the source plant, *Catharanthus roseus*, grown in various regions of the world, remains the most economically viable method of large-scale production.

The Large-Scale Production of Paclitaxel

The development of paclitaxel as an effective drug for the treatment of breast and ovarian cancers illustrates how escalating demands necessitated the development of various methods of biomass production. While the original wild source, the bark of the Pacific yew (*Taxus brevifolia*), provided adequate supplies of the drug for preclinical and early clinical studies, it was soon apparent that the destructive method of harvesting the bark would not meet the large demands resulting from the observation of clinical efficacy against ovarian cancer. An extensive program was initiated to develop alternative, renewable resources , and the current needs are now being met through the harvesting of needles from wild and cultivated *Taxus* species; in addition, scale-up production through tissue culture has been developed by the company, Phyton Inc., but whether such in vitro systems will be commercially viable as a source for paclitaxel or as a source of high taxane-yielding plants is as yet unproven. The evolution and solution of the paclitaxel supply problems has been reviewed in detail (Cragg et al. 1993b).

NCI Policies for Biomass Production

In response to the experience gained in the production of paclitaxel, the NCI has implemented policies which permit the study of various methods of biomass production at an early stage of development of a new anticancer or anti-AIDS agent (Cragg et al. 1993b). Through a Master Agreement (MA) mechanism, pools of qualified organizations have been established with expertise in: the large-scale re-collection of source plant materials; the cultivation of source plants; and source plant tissue culture. Allowance has been made for two phases in the cultivation and tissue culture projects, one involving the initiation of pilot-scale studies aimed at exploring the feasibility of techniques for biomass production, and the second involving the application of methods developed in the feasibility studies to large-scale production. When a plant-derived agent is approved for preclinical development, a Master Agreement Order (MAO) Request for Proposals (RFP) for projects in one or more of the above areas may be issued to the relevant pools of MA Holders who then submit technical and cost proposals addressing the particular RFP specifications. An award is made to the MA Holder whose proposal is judged to be best suited to the Government requirements.

Sustainable Harvesting of *Calophyllum* species. Production of (-)-Calanolide B

Several calanolides have been isolated as potential anti-AIDS drugs from *Calophyllum* species collected in the rainforest regions of Sarawak, Malaysia. Calanolide A is a novel coumarin isolated from leaves and twigs of *Calophyllum lanigerum* Miq. var. *austrocariaceum* (T.C.Whitmore) P.F.Stevens, collected in 1987 as part of the NCI contract with the Univ. of Illinois at Chicago for collections in Southeast Asia (Kashman et al. 1992). Recollections of plant material identified as *C. lanigerum* from the same general location as the original collection failed to yield substantial quantities of calanolide A required for preclinical development. This isomer has not been detected in any related species analyzed thus far, but an extensive analytical survey has shown that the latex of *C. teysmanii* var. *inophylloide* P.F. Stevens collected in the same region yields a related compound, (-)-calanolide B (costatolide) which also shows significant anti-HIV activity (Fuller et al. 1994). Latex collections are made by making small slash wounds in the bark of mature trees. After scraping the latex from the trees, the wounds heal and new collections can be performed. Repeated collections have not affected the health of the trees, and 50 kg has been collected from several hundred trees for the production of sufficient (-)-calanolide B for possible preclinical and clinical development. The latex collections are being performed by the Sarawak State Department of Forests working in collaboration with the NCI collection contractor, the Univ. of Illinois at Chicago. In addition, these two organizations are studying the propagation and cultivation of the source species in Sarawak.

Feasibility Studies of the Cultivation of *Ancistrocladus korupensis*

In 1987, a sample of the leaves of a liana identified as an *Ancistrocladus* species was collected in the Korup region of southwestern Cameroon as part of the NCI contract with Missouri Botanical Garden for collections in Africa and Madagascar. Extracts of the leaves exhibited significant in vitro anti-HIV activity, and the dimeric naphthylisoquinoline alkaloid, michellamine B, was isolated as the active agent (Manfredi et al. 1991; Boyd et al. 1994). The plant was later identified as a new species and named *Ancistrocladus korupensis* D. Thomas & Gereau (Thomas and Gereau 1993). Michellamine B shows in vitro activity against both HIV-1 and HIV-2, and is in advanced preclinical development.

An initial botanical survey indicated that the range of *A. korupensis* was limited to the Korup National Park and that the vines were found in limited abundance with several related species closely resembling *A. korupensis*. Fallen leaves collected from the forest floor were found to contain reasonable quantities of michellamine B, and collections of these leaves should provide sufficient quantities of the drug to complete advanced preclinical development. The collection of fallen leaves thus far, has obviated the necessity for large-scale harvest of fresh leaves, which would be most difficult to collect from a liana, and avoids the possible endangerment of a wild species found endemic primarily in a national park. As larger quantities of leaves would be required if any clinical efficacy is observed, the NCI utilized its Master Agreement mechanism to provide a contract with the Center for New Crops & Plant Products, Purdue Univ., to examine the feasibility of cultivating *A. korupensis* in Cameroon as a potential long-term source of michellamine B. By cultivating high michellamine B yielding plants, the limited wild stands could be preserved and the danger of encroachment into a national park avoided. Purdue Univ. established such a project, working in concert with American scientists such as Roy Gereau and Jim Miller from the Missouri Botanic Garden (the original contracting source which collected this plant), Duncan Thomas from Oregon State Univ., and Cameroon scientists and institutions including the Univ. of Yaounde, the Korup Project, and the World Wide Fund for Nature which is coordinating conservation projects in Korup National Park (Simon et al., 1995). The project is being performed entirely in Cameroon except for the analyses of michellamine B and the entire project staff on site are Cameroonians. This project has the full permission and cooperation of the Cameroon government and is overseen by an Intraministrial Committee for Research on *A.*

korupensis. Working in collaboration with the government of the source country is valuable because at present few legal regulations address bioprospecting of plants for non-timber use in Cameroon (Jato et al. 1996).

This project has several objectives. First, to complete a botanical survey of the region so that the total number of wild vines could be determined as well as to identify high michellamine B yielding vines. To accomplish this objective a rapid and quantitative assay was needed. An NCI contractor, Science Applications International Corporation (formerly Program Resources, Inc.), Fort Detrick, MD, developed a very efficient quantitative assay for michellamine B based upon HPLC. Over 1,000 analyses have already been performed and this cooperation enabled the project team to identify high michellamine B yielding phenotypes (Simon et al. 1995).

More than 1,000 kg of dried leaves from the forest floor were also collected in the first year of this project. Leaf collections were made in different regions by a team of locally-hired and trained leaf collectors. Leaves were air-dried, bulked in sacks and stored. The alkaloids appear very stable and not subject to easy degradation. The bulk collection of leaves provides a buffer of raw material for future NCI preclinical studies. As fallen leaves do contain considerable amounts of michellamine B, this technique can be used on a recurrent basis as a sustainable method to collect leaves without any harvesting or cutting of the wild vines. Such a technique can be used for both native stands as well as for cultivated vines (Thomas et al., 1994).

The geographical areas of collection and the averaged michellamine B content from each of the areas was calculated based upon subsampling of the leaf collection bags. Results indicate that the Rengo Camp and the Ekundo-Kundu areas yielded the highest michellamine values averaging 5.5% and 4.5% (w/w basis), respectively. This was followed by Akpasang, Chimpanzee Camp, Mana River, and the lowest, Ikassa. The very high values from the Rengo Camp and the Ekundo-Kundu sites need to be reconfirmed, but suggest that wild vines from these two areas should also be relatively higher in michellamine B than vines from other areas. The completed botanical survey identified several new populations, though all were still in the Korup region. An estimated 10,000 vines are in the wild, and plants are found at an elevational range of 50-160 m in skeletal highly leached soils and with soil pH about 4.0.

An analysis of 791 samples indicated that the average michellamine B content in leaves was 2.1l% (dry wt.). This distribution reflects all manner of samples that we collected (single leaf, leaf clusters, and leaves of varying ages). The highest levels of michellamine B were found in mature leaves but young, fully expanded pale green leaves also contained michellamine B. Younger leaves and the older, fallen, brown leaves had significantly less alkaloid (Simon et al. 1995). More than 400 individual vines were sampled for michellamine B and variation between vines was significant. Despite problems in sampling procedures, high michellamine B vines were identified and are being vegetatively propagated. Of interest to note is that some samples appeared devoid of michellamine B.

Many *A. korupensis* seedlings were also collected from the forest by digging the plants up and replanting into polyethylene plastic bags. While lower levels of michellamine B were expected from these young plants, their relative concentrations could be effective markers for high michellamine B. Seedling plants which already exhibit higher michellamine B levels, given the similar age and sampling techniques, may represent a genetic source that will continue to exhibit higher levels of michellamine B over time. Variation in plant growth and in michellamine B content among seedlings was also observed. Plants with the highest michellamine B content (0.6%-0.8% dry wt.) were identified and are also being propagated.

In parallel to the large leaf collection, wild vines were assayed several times for michellamine B content. Samples indicating high values of this dimeric alkaloid were then re-sampled for verification. Vines containing michellamine B contents >3.5% were targeted for propagation. By the end of Year 1, many of the high michellamine B yielding plants were being vegetatively propagated. Methods to improve the vegetative propagation success rate are being investigated. As all work is taking place in the jungle, specialized facilities to propagate and maintain the propagules were needed. Therefore, a medicinal plant nursery was designed and constructed by Purdue and the Korup Project staff at the Korup National Park. This new facility now provides, for the first time, specialized propagation units and a nursery for the *Ancistrocladus* plants which now comprise our germplasm collection.

Field plots have been established including unreplicated demonstrations which provide initial insight into the growth patterns of the plants once introduced into fields of full-sun, shade, and into darkened forest. Seven field studies using more than 5,000 plants are ongoing--all under varying environmental and field conditions which include cleared areas, secondary growth areas, mature forest, and underneath mature palms. In additon, plant population and fertilizer studies in open cleared areas are underway. Plantings in the forest are situated under varying light conditions. Although under natural conditions the seedlings are found only in shaded conditions, plants growing under full-sun are growing rapidly. The plants appear to be responsive to both sunlight and fertilizer, such as nitrogen. Plants growing in full-sunlight look good and have exhibited robust and large leaves. As the plantings mature, trellis systems or trees which the *A. korupensis* plants can eventually use for structural support will be needed. This will provide needed background information and test various shading and trellising systems. Both low and high input production systems within agricultural and agroforestry systems are being explored.

The collection, germplasm preservation, and horticultural studies should permit us to develop strategies to collect the leaves and introduce this plant into cultivation, whether in an open field, through enrichment of the jungle with high yielding clones, or in fallow ground. All this is being done in a manner compatible with the needs of the Cameroon people, the Cameroon government and the preservation of the rainforest to which the plant is endemic.

These studies become integral to drug discovery programs for several reasons. First, we need to ensure the availability of the raw plant material. In general, such a discovery is often focused on a wild plant that has not previously been studied--chemically, botanically, or horticulturally. The procurement of the raw plant material is not always easy. In the case of *A. korupensis*, this plant was not used in local medicine and, thus, is not part of the regional ethnopharmacopia. This suggests that a random screening of flora was successful, since a study only of locally used medicinal plants would never have led to the discovery of this plant. Secondly, as the discovery of new drugs from plants should not infringe upon the natural and undisturbed forest areas to which they may be native, the establishment of partnerships between the countries to which a potential drug plant candidate is native and the country that seeks to develop a drug from the plant is critical. Most tropical countries lack the financial support to initiate and sustain such a preservation and development program.

CONCLUSION

Natural products and plant-derived products continue to be excellent sources of new drug candidates. A program such as the one that has evolved at the National Cancer Institute can achieve three of the most important goals. It can be successful at helping to protect the rights and benefits of the source country which provides the new bioresource. It can anticipate and reduce the problems of providing adequate biomass supplies for drug studies by encouraging early cultivation and plant tissue culture programs. Finally, it can achieve both of these goals in a manner compatible with the needs of the source country. and still be successful in our third and primary goal, that of discovering new pharmacologically useful drug candidates.

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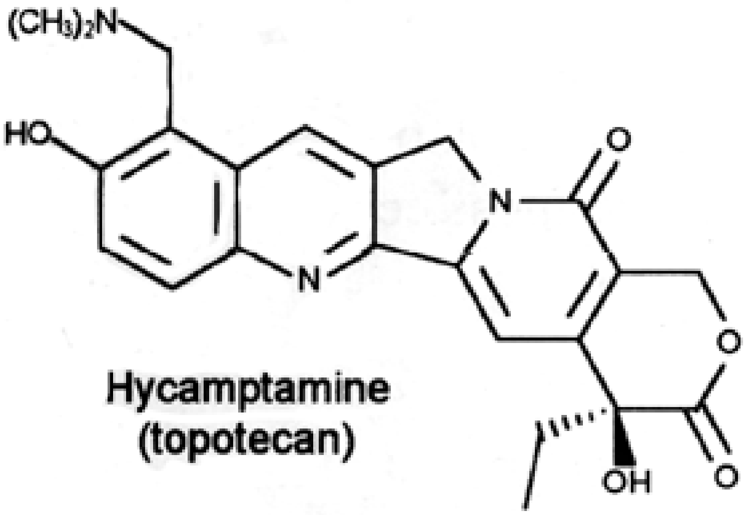
Fig. 1. Clinically active agents identified during plant collection programs conducted by the National Cancer Institute.



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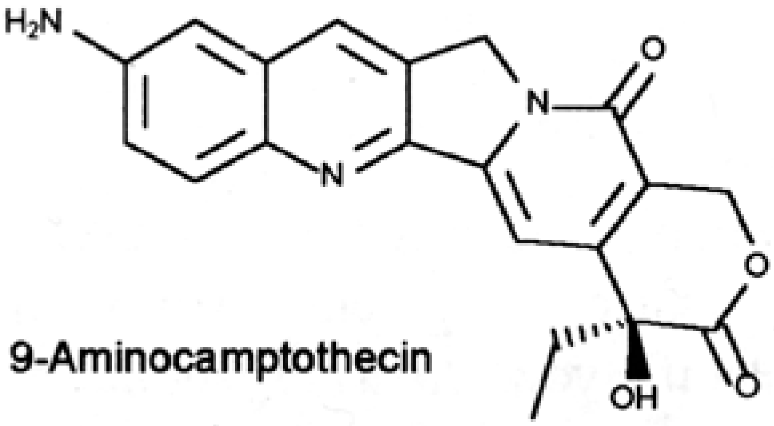
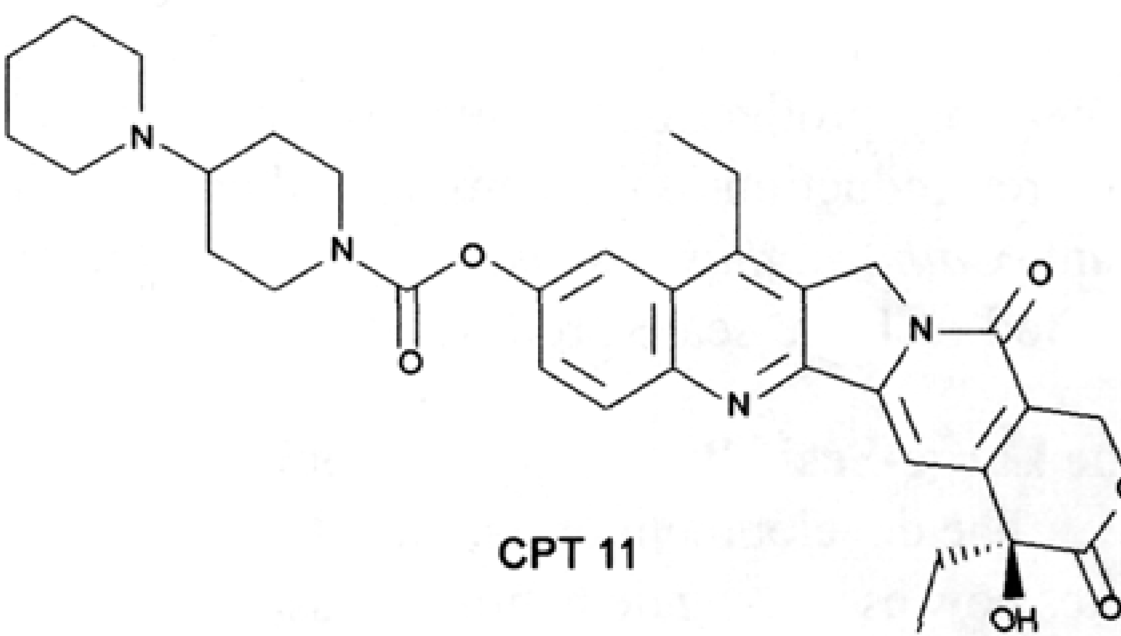


9-Aminocamptothecin



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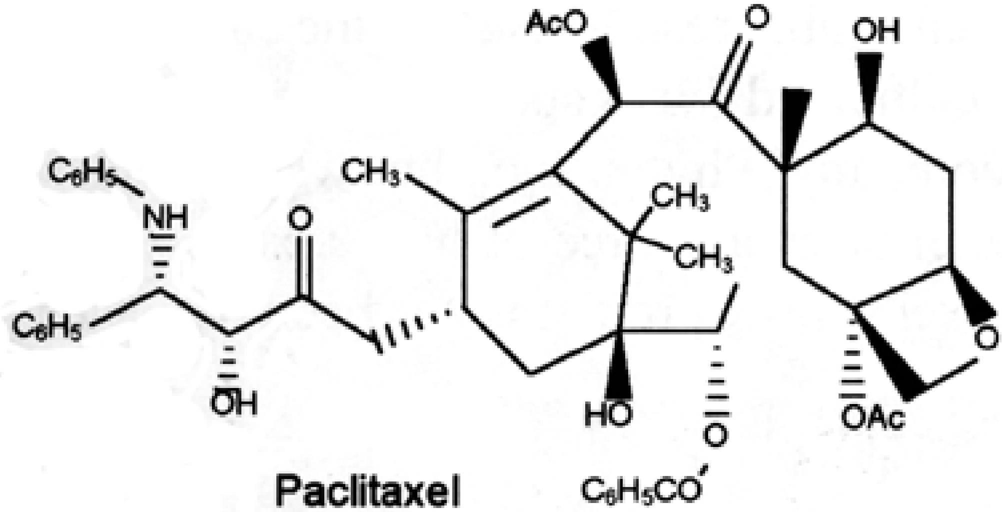
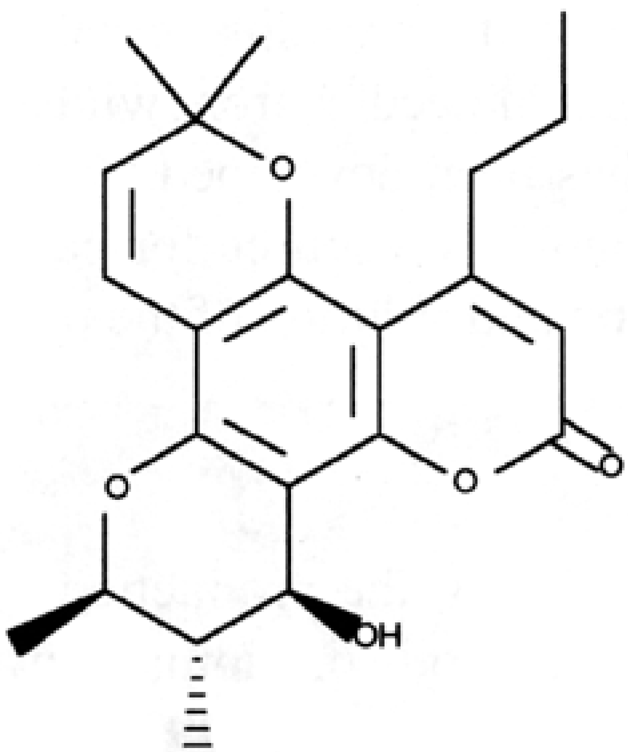
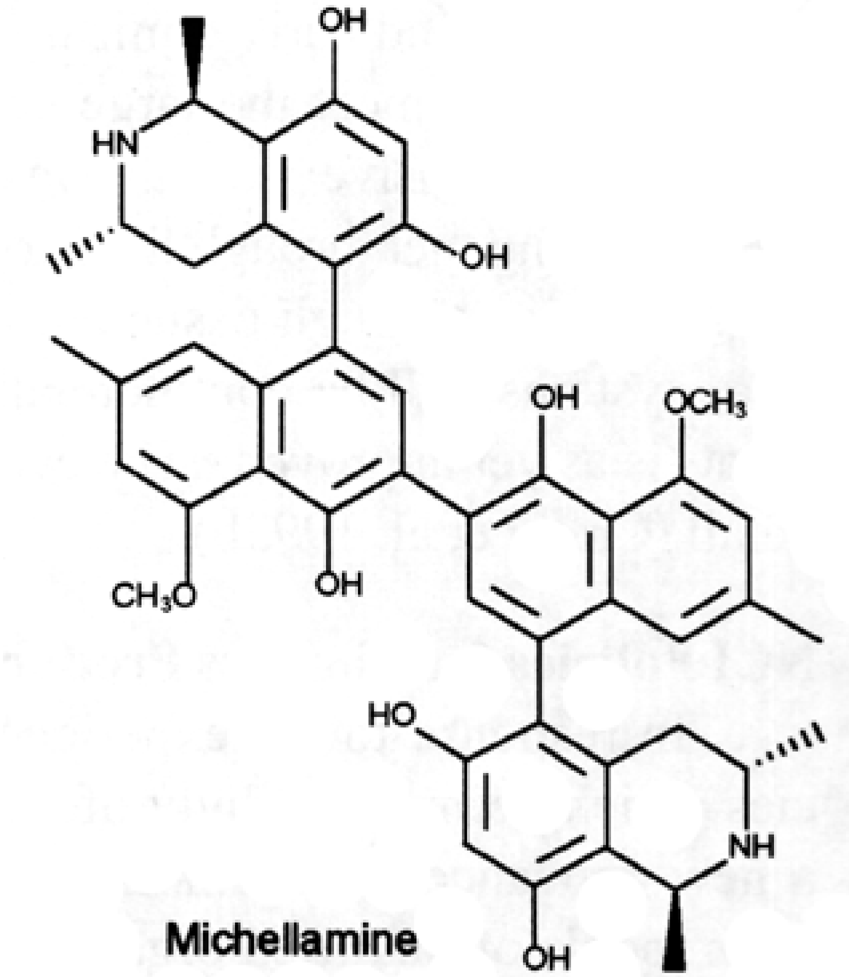


Paclitaxel



(-)-Calanolide B



Michellamine

Last update August 24, 1997 aw

Calotropis gigantea: Useful Weed

Pankaj Oudhia
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Calotropis gigantea R.Br. Asclepiadaceae, commonly known as milkweed or swallow-wort, is a common wasteland weed (Singh et al. 1996). *Calotropis* belongs to Asclepiadaceae or Milkweed or Ak family which includes 280 genera and 2,000 species of world-wide distribution but most abundant in the sub-tropics and tropics, and rare in cold countries. Other familiar plants of *Calotropis* are Milk weed or Silk weed (*Asclepias syriaca* L.), Butterfly weed (*Asclepias tuberosa* L.) and *Calotropis procera* (Ait.) Ait.f. Comparision of these plants is given in Table 1. Native to India (Lindley, 1985), *Calotropis* grows wild up to 900 meters throughout the country (Sastry and Kavathekar, 1990) on a variety of soils in different climates, sometimes where nothing else grows

Table 1. Comparison of *Calotropis* and *Asclepias* species.

Species Common name(s)	Origin	Height (ft.)	Leaf arangement	Flower		Leaves	Fruits
				Size (inches)	Color		
Calotropis gigantea Gigantic swallow wort, Madar	India	8-10	Opposite	2	White to purple, rarely light green yellow or white. Flowers not scented	Sessile	Follicles recurved, 2 or 1 follictes, second more often suppressed, 3-4" long

Asclepias tuberosa Butterfly weed	South America	2-3	Alternate	0.5	Corolla greenish-orange, scented	Sessile or very short petiolated	Follicles finely pubescent, 4-5" long
Asclepias syriaca Common milkweed Sikweed	South America	Up to 5	Opposite or verticillate	0.5	Corolla greenish to purplish white, scented.	Petiolated	Follicles tomentose and echinate, 3-5" long.
Calotropis procera Swallow-wort	India	3-6	Opposite	1.5	White to pink, scented.	Sub-sessile	Follicles 3-4", recurved

Uses

Calotropis is used as a traditional medicinal plant (Rastogi and Mehrotra 1991; Oudhia and Dixit 1994; Oudhia 1999a,b,c,d) with unique properties (Oudhia and Tripathi 1998, 1999a). Traditionally alotropis is used alone or with other medicinals (Caius 1986) to treat common disease such as fevers, rheumatism, indigestion, cough, cold, eczema, asthma, elephantiasis, nausea, vomiting, diarrhea (Das 1996). According to Ayurveda, dried whole plant is a good tonic, expectorant, depurative, and anthelmintic. The dried root bark is a substitute for ipecacuanha. The root bark is febrifuge, anthelmintic, depurative, expectorant, and laxative. The powdered root used in asthama, bronchitis, and dyspepsia. The leaves are useful in the treatment of paralysis, arthralegia, swellings, and intermittent fevers. The flowers are bitter, digestive, astringent, stomachic, anthelmintic, and tonic (Agharkar 1991; Warrier et al. 1996). *Calotropis* is also a reputed Homoeopathic drug (Ghosh 1988; Ferrington 1990).

Calotropis yields a durable fiber (commercially known as Bowstring of India) useful for ropes, carpets, fishing nets, and sewing thread. Floss, obtained from seeds, is used for stuffing purposes. Fermented mixture of *Calotropis* and salt is used to remove the hair from goat skins for production of "nari leather" and of sheep skins to make leather which is much used for inexpensive book-binding (Singh et. al. 1996). Fungicidal and insecticidal properties of *Calotropis* have been reported (Ganapathy and Narayanasamy 1993).

Allelopathic effects of *Calotropis* on different agricultural crops have not been well studied. Extracts of different plant parts viz. root, stem, leaf ,and stem+leaf of *Calatropis* affect germination and seedling vigor of many agricultural crops have been reported (Oudhia and Tripathi 1997, 1999; Oudhia et al. 1997, 1998a,b). However, extracts of *Calatropis* failed to produce any detrimental effects on weeds such as *Chenopodium album Melilotus alba*, *Melilotus indica*, *Sphaeranthus indicus*, and *Phalaris minor* (Oudhia and Tripathi 1997).

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Oudhia, P. and R.S. Tripathi, Abstract National Seminar on Institute/Industry Cooperation Programme for Developing Skills in Students of Seed Technology, Govt. Motilal Vigyan Mahavidyalaya, Bhopal, India 20-21 Nov. p. 88-89.

Oudhia, P., S.S. Kolhe, and R.S. Tripathi. 1997. Legume Res. 20(2):133-136.

Oudhia, P., S.S. Kolhe, and R.S Tripathi, 1998a. In: Abstract. III International Congress on Allelopathy in Ecological Agriculture and Forestry, UAS, Dharwad, India 18-21 Aug. p. 151.

Oudhia, P., S.S. Kolhe, and R.S. Tripathi, 1998b. Extended Summaries. First International Agronomy Congress on Agronomy, Environment and Food Security for 21st Century, Vigyan Bhawan, New Delhi. 23-27 Nov. p. 27.

Oudhia, P., R.S Tripathi, S. Puri, and D.S. Chandel, 1999a. Vasundhara The Earth 1(1):12-15.

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Cowslip

***Caltha palustris* L. Cowslip greens, Marsh marigold**

Ranunculaceae

Source: Magness et al. 1971

This plant is a perennial native in eastern U.S., from the Carolinas to Canada, growing in marshy areas. Stems are hollow, 1 to 2 feet high. Leaves are cordate or rounded. They are gathered in spring before flowering, and used as pot herbs.

Season: Leaves gathered within 2 or 3 weeks of growth start in spring.

Production in U.S.: None commercial, harvested from wild plants.

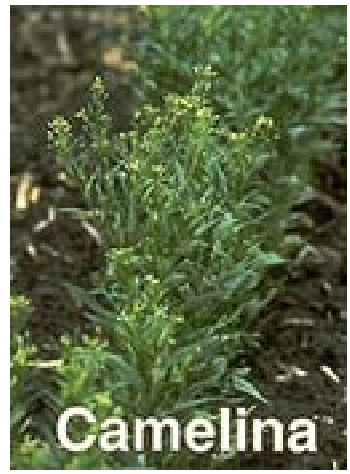
Use: Pot herbs. Part of plant consumed: Leaves.

Last update February 18, 1999 by ch

Camelina sativa (L.) Crantz

Brassicaceae, or Cruciferae

Camelina, falseflax, linseed dodder, or gold of pleasure



NewCROP has Camelina information at:

Improvement of *Camelina sativa*, an Underexploited Oilseed. Vollmann, J., A. Damboeck, A. Eckl, H. Schrems, and P. Ruckenbauer. 1996. p. 357-362. In: J. Janick (ed.), Progress in New Crops. ASHS Press, Alexandria, VA.

Camelina: A Promising Low-input Oilseed. Putnam, D.H., J.T. Budin, L.A. Field, and W.M. Breene. 1993. p. 314-322. In: J. Janick and J.E. Simon (eds.), New Crops. Wiley, New York.

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Photographs from University of Minnesota Center for Alternative Plant & Animal Products.

Camellia oleifera Abel

Theaceae

Tea Oil Camellia

We have information from several sources:

Nursery Production of Tea Oil Camellia Under Different Light Levels—John M. Ruter

Outside Links:

Camellia cousin could become Georgia farm crop

Camellia sinensis (L.) Kuntze

Theaceae

Tea, assam, black tea, Broken Orange Pekoe Pannings, ch'a, Darjeeling, dust, Flowery Orange Pekoe, green tea, gunpowder, hyson, iced tea, imperial, Keemum, Keemun, Lapsung Souchong, leaf pekoe, Oolong, orange pekoe, pekoe souchong, pekoe tip, sencha, souchong, tsocha, twanky, women's-tobacco, young hyson

We have information from several sources:

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links:

Tea—Descriptors for Tea (*Camellia sinensis*)—Link to the publication on the International Plant Genetic Resources Institute web site

Rampion

Bellflower, Little turnip

Campanulaceae *Campanula rapunculus* L.

Source: Magness et al. 1971

Rampion is a biennial plant, but in cultivation is grown as an annual. Both roots and leaves are eaten, mainly in salads. Leaves are entire, obovate to linear lanceolate in shape, 6 inches or more in length. They form a rosette at the root crown. The roots are long, up to 1 foot, slender, and white. The plant resembles radish in culture and exposure. Roots can be stored for winter use.

Season, seeding to harvest: Up to 5 inches.

Production in the U.S.: No data. Minor.

Use: Mainly in raw salads.

Part of plant consumed: Mainly root, but leaves also.

Last update July 1, 1996 bha

Canada wild-rye

Gramineae *Elymus canadensis* L.

Source: Magness et al. 1971

This grass is a native bunchgrass in the Plain, Rocky Mountain and Pacific Northwest States. Seed heads may reach to 5 feet. Leaf blades are broad, flat and rough, up to 12 inches long and 0.5 inch or more broad. Growth begins later in spring than most grasses but continues throughout summer if moisture is available. Palatability while succulent is fair, but poor when the plants become woody. Good quality hay can be obtained with early mowing. It is usually seeded in combination with other slower-growing grasses in order to obtain a quick cover.

Last update February 18, 1999 by ch

Canarium ovatum Engl.

Burseraceae

Pili nut

We have information from several sources:

FactSHEET contributed by: Francis T. Zee

Rambutan and Pili Nuts: Potential Crops for Hawaii—Francis T. Zee

Outside Links:

Pili nut—*Canarium ovatum* Engl.—Link to the publication on the International Plant Genetic Resources Institute web site

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Phalaris canariensis L.

Gramineae

Annual canarygrass

We have information from several sources:

Annual Canarygrass: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

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Phalaris arundinacea L.

Syn: *Phalaris japonica* Steud.

Poaceae

Reed canarygrass

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Food and feed crops of the United States Magness, J.R., G.M. Markle, C.C. Compton. 1971

Sesbania bispinosa (Jacq.) W.F. Wight

Syn.: *Coronilla cannabina* Willd.
Closely related, if not synonymous with *S. aculeata* and *S. cannabina*
Fabaceae
Canicha, Danchi, Dunchi fiber

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Danchi stems, used for pipe-stems, provide a strong durable fiber, substituted for hemp in rope, twine, cordage for fish net, gunny sacks, and made into a cloth used for sails. According to NAS (1980a), the plant, with fibers simliar to those of birch, "is an exciting potential new source of paper products." The crop is grown as green manure (adding 150 kg N/ha), leaves for forage, and in South Africa, for poultry feed. Plant is eaten in time of famine. Seeds contain a guar-like gum used in films for sizing textiles and paper products and for thickening and stabilizing solutions. Grown also for firewood, the plant is used for erosion control, hedges, intercropping "mother plants," nitrogen fixation, and windbreaks. In Vietnam, it is planted in the rice fields and harvested for firewood before the rice crop is harvested. It is said to have the admirable trait of supressing weeds like *Imperata cylindrica* in moist situations (Duke, 1981a; NAS, 1980a).

Folk Medicine

Medicinally, seeds are mixed with flour and applied to ringworm, other skin diseases, and wounds (Duke, 1981a). Ayurvedics regard the root as alexiteric, anthelmintic, collyrium, diuretic, and lactagogue. Kirtikar and Basu (1975) report that around Las Bela it is used for wounds, and powdered roots are administered to snakebite victims, inducing emesis and perhaps a cure.

Chemistry

Seeds of the genus *Sesbania* are reported to contain trypsin inhibitors and chymotrypsin inhibitors. Seed are reported to contain 6.2% of a fixed oil and 32.9% crude protein. Gohl (1981) reports seed analyses from South Africa showing 36.4% CP, 12.1% CF, 1.5% ash, 6.9% EE, and 43.1% NFE; from India showing 32.7% CP, 10.7% CF, 5.0% ash, 2.9% EE, 48.7% NFE, 0.37% Ca, and 0.59% P. Oven-dry fiber is reported as 0.71% ash, 0.94 fat and wax, 2.3 nitrogenous matter, 9.76 pentosan, 16.3 lignin, 85.2 holocellulose (63.6% alpha cellulose), etc. (These figures from Mazumdar et al, 1973, add up to more than 100%, and must be evaluated carefully.) (Duke, 1981a).

Description

Erect suffuticose low annual subshrub, up to 7 m tall; stems fairly thick, glabrous, branched from the base but soft and pithy; leaves up to 38 cm long, pinnate, leaflets 18–55 pairs, 1.2–2.5 cm long, 0.3 cm wide, glabrous, glaucous; inflorescence 2–8-flowered, 2.5–7.5 cm long; flowers yellow and purple-spotted; pods up to 25 cm long, 0.3 cm thick, curved, many-seeded. Fl. Sept.–Nov. (India).

Germplasm

Assigned to the Hindustani Center of Diversity, danchi, or cvs thereof, is reported to exhibit tolerance to alkaline soils, drought, heavy soil, low pH, salt, sandy soil, weeds, and waterlogging. ($2n$ = 12, 24). (Duke, 1981a; NAS, 1980a).

Distribution

Native to northern India, Pakistan, China, Sri Lanka, and tropical Africa, this crop is cosmopolitan in the Old World Tropics, and has been introduced in southern United States and the Phillippines; a common weed in tropical Africa from Senegal to the Cameroons.

Ecology

Crop adapted to wet areas and heavy soils, which do not require much preparation. Under waterlogged conditions stem produces a spongy mass of aerenchyma. It thrives in low to medium elevations (0–1200 m), along streams, in open wetlands or often as a weed in rice paddy fields. Ranging from Subtropical Moist through Tropical Dry to Moist Forest Life Zones, danchi is reported to tolerate annual precipitation of 5.5–22.1 dm (mean of 4 cases = 3.4), annual mean temperature of 19.9–27.3°C (mean of 4 cases = 23.8), and pH of 5.8–7.5 (mean of 3 cases = 6.9) but has been grown in pH 9.2 (Duke, 1981a; NAS, 1980a).

Cultivation

In India seed sown in June–July at onset of southwest monsoon; sowings after September produce poor seed production. In southern United States seed broadcast after soil has been moistened by rains in April or May and harrowed. In India seed is usually broadcast, but sometimes drilled in rows 30 cm apart. Seed may be drilled or broadcast at rate of 20–60 kg/ha. Thicker planting facilitates harvest of small plants. The crop is fast-growing, needs little weeding. Usually no fertilizers are applied. In India, grown either as a main crop in rice rotation or as a border crop on the edge of rice fields. On alkali soils (pH 9.2) with added N, P, K, and zinc sulfact rice ('IR8-68') yielded 6.74 MT/ha where danchi was plowed in, on 16 4.52 MT/ha after fallow. The effect of green manuring was equivalent to the addition of 80 kg N/ha (Duke, 1981a).

Harvesting

Ready to cut in September or October, but the fiber does not suffer if left standing until seed is ripe in November. In India seed matures in about 5–5 1/2 months; in the United States in about 2 months. Ripe pods normally do not shatter. In India pods are usually hand-picked and threshed by beating with sticks; however, if hand-picking is delayed beyond March, some pods shatter. In the United States crop is harvested by machine and windrowed, and then threshed with an ordinary grain thresher. Seeds must be treated with insecticides before storing, as they are liable to damage by insects. Processes for steeping and cleaning the fiber are similar to those for sunn hemp (*Crotalaria juncea*). About 2 kg of fiber can be dressed per day (Duke, 1981a).

Yields and Economics

In India yields of seed are about 600 kg/ha; in Peru, 900 kg/ha; in California, 1,000 kg/ha. Fiber yields are 100–1,000 kg/ha.

Energy

Recommended as a firewood crop by NAS (1980a), the stems of danchi have low density (sp. grav. 0.3) but yield well in 6 months. It is used for firewood for example in Vietnam and Pakistan, where villagers use it to evaporate water from sugar. In Italy, a yield of 15 MT/ha DM is reported. The NAS states, "In the tropics, where more than one crop can be harvested each year, the annual production could be even higher." (NAS, 1980a). In a table comparing oil seed yields, Duke and Bagby (1982) report 1,000 kg seed per hectare for *Sesbania bispinosa*, with 200 kg/ha seed (*Vigna umbellata*) the lowest reported in that table, and 14,000 kg/ha (*Sapium sebiferum*) the highest, both rather extreme.

Biotic Factors

This crop is self-pollinating and requires no isolation for pure seed production. Several nematodes attack this Sesbania: *Meloidogyne incognita*, *M. javanica*, and *Trichodorus minor*. In southern United States, this crop usually precedes autumn planted vegetables. However, because of nematode attack, it is not recommended for growing in sandy soils with other susceptible crops, as cucurbits. Weevils and caterpillars attack seed pods, and the seeds in storage. These may be controlled with insecticides. Plants are attacked by the parasitic flowering plant, *Dendrophthoe falcata*.

References

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- Duke, J.A. and Bagby, M.O. 1982. Comparison of oilseed yields: A preliminary review. Typescript of paper presented in North Dakota.
- Gohl, B. 1981. Tropical feeds. Feed information summaries and nutritive values. FAO Animal Production and Health Series 12. FAO, Rome.
- Kirtikar, K.R. and Basu, B.D. 1975. Indian medicinal plants. 4 vols. 2nd ed. Jayyed Press, New Delhi.
- N.A.S. 1980a. Firewood crops. Shrub and tree species for energy production. National Academy of Sciences, Washington, DC.

Complete list of references for Duke, Handbook of Energy Crops

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Last update Friday, January 9, 1998 by aw

Chenopodium pallidicaule Heller

Chenopodiaceae

Kaniwa, quañiwa, cañihua

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside links:

Kaniwa can be found in Lost Crops of the Incas from National Academy Press

Pouteria campechiana Baehni

Sapotaceae

Canistel, Eggfruit

We have information from several sources:

Canistel —Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Canna spp.

Cannaceae

We have information from several sources:

Starch Noodles from Edible Canna—Michael Hermann

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

New Bedding Plants—Lowell C. Ewart

Outside links

Achira, *Canna edulis* can be found in Lost Crops of the Incas from National Academy Press

Cannabis sativa L.

Cannabaceae

Hemp, Marijuana

We have information from several sources:

Hemp: A New Crop with New Uses for North America—Ernest Small and David Marcus

Hemp: Specialty Crop for the Paper Industry—Anthony Capelle

Agronomic Research on Hemp in Manitoba—Jack Moes, Allen Sturko, and Roman Przybylski

Low-THC Hemp Research in the Black and Brown Soil Zones of Alberta, Canada—S.F. Blade, R.G. Gaudiel, and N. Kerr

New Crop Development in Europe—Louis J.M. van Soest

New Industrial Crops for Europe—Anthony Capelle

Characterization and Processing Research on New Crops for Increased Industrial Applicability of New and Traditional Crops: A European Perspective—Willem M.J. van Gelder, F.P. Cuperus, J.T.P. Derksen, B.G. Muuse, and J.E.G. van Dam

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside links for industrial hemp:

Hemp Report: North America's top web magazine on industrial hemp

Industrial Hemp

Natural Hemphasis charting new directions for Canada's growing hemp community

Cucumis melo L.

Cucurbitaceae

Melon, Muskmelon, Cantaloupe, Honeydew, Sugar melon

Including specialty melons such as Garden Lemon, Japanese Cucumber, and Winter Melon.

We have information from several sources:

Melofon: A New Crop for Concentrated Yield of Pickles—Haim Nerson, Harry S. Paris, and Menahem Edelstein

Specialty Melons for the Fresh Market—James E. Simon, Mario R. Morales, and Denys Charles

New Opportunities In Melons—Glenn Sullivan

Screening Melons for Adaptability in North Carolina—J.R. Schultheis, W.R. Jester, and N.J. Augostini

Midwest Vegetable Production Guide for Commercial Growers 1998

Muskmelons and Specialty Melons production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Garden lemon (Chito group)
- Armenian Cucumber (Flexuosus group)
- Winter Melon (Inodorus group)
- Cantaloupe (Reticulatus group)
- Muskmelon

Muskmelon Problems on Acid Sandy Soils—Cooperative Extension Service, Purdue University, West Lafayette, Indiana

Identifying Air Pollution Damage on Melons—Cooperative Extension Service, Purdue University, West Lafayette, Indiana

Cantaloupe: Marketing and Production Opportunities for Indiana—Cooperative Extension Service, Purdue University, West Lafayette, Indiana

Midwest Vegetable Production Guide for Commercial Growers 2000

Brassica rapa
B. campestris L., and
B. napus L.

Brassicaceae, Cruciferae

Rapeseed, Canola (low erucic acid rapeseed)

NewCROP Links to other*Brassica napus* crop information (Rutabaga, Siberian Kale, etc.).

NewCROP has Rapeseed and Canola information at:

Canola: An Emerging Oilseed Crop—Paul L. Raymer

Prospects of Canola as an Alternative Winter Crop in Virginia—David E. Starner, Anwar A. Hamama, and Harbans L. Bhardwaj

Performance of Canola in Southern Sonora, México—Sergio Muñoz-Valenzuela, Greg Buzza, and Roberto Avalos-Pérez

Canola: A Quality Brassica Oilseed—R.K. Downey

Potential of Canola Production in Ohio—Walter H. Schmidt

Canola Seed Yield in Relation to Harvest Methods—Casimir A. Jaworski and Sharad C. Phatak

Evaluation of Planting Date for Winter Canola Production in Indiana—Ellsworth P. Christmas

Potential of Canola as a Dryland Crop in Northeastern Colorado—David C. Nielsen

Canola Production in Virginia—David E. Starner, Harbans L. Bhardwaj, Anwar A. Hamama, and Muddappa Rangappa

High Performance 4-Cycle Lubricants From Canola—Duane L. Johnson

Canola-based Motor Oils—Duane L. Johnson, Blaine Rhodes, and

Robert Allen

Evaluation of Salinity Tolerance of Canola Germination—Naveen Puppala, James L. Fowler, Linnette Poindexter, and Harbans L. Bhardwaj

Canola Oil Yield and Quality as Affected by Production Practices in Virginia—David E. Starner, Anwar A. Hamama, and Harbans L. Bhardwaj

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

New Crops or New Uses for Old Crops: Where Should the Emphasis Be?—Shelby F. Thames and Thomas P. Schuman

Determining Amaranth and Canola Suitability in Missouri Through Geographic Information Systems Analysis—Robert L. Myers

Canola: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Canola: A Potential New Crop for Indiana"Indiana canola crop resulted in the harvest of approximately 7,000 acres in early summer of 1991."

The 1990-91 Indiana Canola Update: —Elsworth Christmas

The 1991-92 Indiana Canola Update:"Late fall and winter weather conditions in Indiana proved to be disastrous for fall seeded crops, including alfalfa, canola, and wheat."

Potential of Winter and Spring Rapeseed Cultivars for Oilseed Production in the Southeastern United States—P.L. Raymer, D.G. Bullock, and D.L. Thomas

Rapeseed, a New Oilseed Crop for USA—Matti Sovero

Selecting Winter Hardy Oilseed Rape for the Great Plains—C.L. Rife and J.P. Salgado

Rapeseed Performance in West Tennessee (Abstract)—H.A. Fribourg, C.R. Graves, G.N. Rhodes, Jr., J.E. Bradley, and E.C. Bernard Gorczanski

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

High Glucosinolate Rapeseed Meal as a Supplemental Protein Source in Finishing Cattle Diets (Abstract)—Jean Heidker and C.F. Klopfenstein

Influence of Irrigation Timing and Nitrogen on Growth, Yield, and Quality of Rape

(Abstract)—Joseph G. Lauer

New Crops Research and Development: A Federal Perspective—L.H. Princen

New Crops In The UK: From Concept to Bottom Line Profits—Francis H. Nicholls

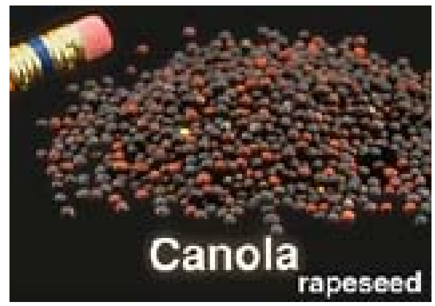
Engineering New Oilseed Crops from Rapeseed—H. Maelor Davies

Rapeseed Meal as a Natural Pesticide—Harbans L. Bhardwaj, Anwar A. Hamama, D. Morris Porter, and Paul F. Reese, Jr.

Bioassembly of Storage Lipids in Oilseed Crops—David C. Taylor, Ljerka Kunst, and Samuel L. MacKenzie

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States..
Rapeseed Oil
Napobrassica group
Pabularia group



And outside links to more canola info:

Canola Council of Canada

The Facts About Canola by Canbra Foods Ltd.

Quality of Western Canadian Canola 1996 - Canadian Grain Comission

Canola Disease Index from Texas A & M.

Canola diseases (North Dakota)

Canola / Rape as Covercrops

Photographs from University of Minnesota Center for Alternative Plant & Animal Products.

Physalis peruviana L.

Solanaceae

Goldenberry, Cape Gooseberry, Golden Husk, Groundcherry, Peruvian Cherry, Peruvian groundcherry, Strawberry Tomato, Winter Cherry

We have information from several sources:

Cape Gooseberry—Julia Morton, Fruits of warm climates

Goldenberry—R. McCain, Potential fruits for cool subtropical areas

New Horticultural Crops in New Zealand—Errol W. Hewett

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971

Outside links:

Goldenberry can be found in Lost Crops of the Incas from National Academy Press

Hof, L. 1996. *Dimorphotheca pluvialis*: A new source of hydroxy fatty acid. p. 372-377. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Dimorphotheca pluvialis: A New Source of Hydroxy Fatty Acid

Lysbeth Hof

In the search for alternative crops for Dutch agriculture, *Dimorphotheca pluvialis* L. (Mnch), Asteraceae, is being considered as a potential new crop with industrial applications. Its seeds contain oil with 60% to 65% dimorphecolic acid (d9-hydroxy,t10,t12-octadecadienoic acid): a hydroxy fatty acid with two conjugated double bonds. This feature provides dimorphecolic acid with a unique functionality and properties that are totally different from other known hydroxy fatty acids as ricinoleic and lesquerolic acid. The chemical structure suggests that the molecule should be very reactive, and hence suitable for a wide range of industrial products such as surface coatings, surfactants, plastic foams, or as additive in plastics (Knowles et al. 1965; Muuse et al. 1992). New applications and markets need to be developed, possibly leading to new products with a high added value.

Dimorphotheca pluvialis is a herbaceous annual native to South West Africa (Norlindh 1977). As is common in the Asteraceae, the capitulum (flower head) bears two types of florets. The species *Dimorphotheca* is characterized by hermaphrodite disc florets and female-fertile (male-sterile) ray florets. Both types of florets produce distinctly different types of seeds (achenes). Seeds produced by ray florets are small, angular, while those of the disc florets are flattened and have winged margins (Barclay and Earle 1965). The ray florets have one large white petal, which is often colored purple at the base, giving the appearance of a "ring" in the inflorescence.

The species is well adapted to the maritime climate of Northern and Western Europe, and fits in a rotation system with annual crops. Although it is known as a garden ornamental, *Dimorphotheca* is considered an undomesticated species showing many primitive characteristics. Populations collected from the natural habitat in general have a long, unsynchronized flowering period and show poor seed retention. These factors together account for severe yield losses prior to and during harvest. Realized yields at trial fields range 500-1500 kg/ha, with potential yields of at least 2000-2500 kg/ha. As it is sensitive to frost, in the Netherlands, *Dimorphotheca* is grown as a summer annual. It is sown in April, flowers in July and can be harvested in August (van Dijk et al. 1993). The average oil content of collected populations is 21%, which is too low for mechanical expelling. At present, oil recovery should be done by solvent extraction or preferably with supercritical carbon dioxide extraction (Muuse et al. 1992).

Dimorphotheca was first introduced in the Netherlands by the Dutch Gene Bank (CGN) in 1986, and since 1990 has been studied extensively in the framework of three large multidisciplinary projects (the Dutch National Oilseeds Program, and the EC-projects VOICI and VOSFA). In these projects expertise from the whole production chain was brought together including germplasm collection, evaluation, cultivation, breeding, crop physiology, pathology, harvest techniques, oil recovery, processing of the oil, application, and market research (van Soest and Mulder 1993).

At the Centre for Plant Breeding and Reproduction Research (CPRO-DLO), research in *Dimorphotheca* has been focusing on improvement of synchronization of flowering and seed ripening, oil content, and plant architecture. Furthermore, research is carried out to study pollination and mating system.

EXPERIMENTAL

In order to determine optimal selection strategies for synchronization of flowering and oil content, variation and heritability of these characters were estimated. Flowering synchronization was considered particularly important. Large differences in time of flowering make it difficult to detect slight differences in seed retention, hence making selection for this character at present almost impossible. More synchronized populations are expected to have a shorter flowering and seed ripening period, facilitating the determination of the optimal harvest date. A too early harvest causes reduction of seed yield because of a large proportion of immature seeds. If harvest is carried out too late, yield is severely reduced because of seed losses due to shattering.

For synchronization of flowering two distinct characteristics were distinguished:

1. The synchronization between plants, which was defined as the period of time between sowing and the first flower to open. A population flowers synchronously if all plants start flowering at the same time.
2. The synchronization within plants, which was defined as the period of time in which individual plants produced 90% of their total number of flowers. A plant flowers synchronously if it produces its flowers in a relatively short period of time.

Both the synchronization between plants of a population, as well as the synchronization within plants of that population are considered to have a large effect on the synchronization of flowering of a population.

To establish the variation for synchronization of flowering (both between and within plants) and oil content, two experiments were carried out on loam soil at location Lelystad in the Netherlands. Heritabilities were estimated by means of parent-offspring regression in the following year.

Synchronization Between Plants

In 1992, 350 plants of population 883168 were sown at a wide density (50 x 50 cm), allowing scoring and harvesting of individual plants. Time of flowering was scored every Monday and Thursday, and for further analyses expressed as the number of days from sowing until first open flower. The mean time of flowering was 78 days after sowing (range: 68-90 days). Although most plants started to flower after 75 to 80 days, some started to flower one week earlier, others as much as three weeks later. This means there was a difference of four weeks between the first and last plant to open its first flower.

To estimate the heritability of this character in this population, 40 plants were selected and their seeds collected. *D. pluvialis* is considered a predominantly outcrossing species, and the progenies of the selected plants are considered to be half-sib families. In 1993, a trial field was sown with 24 (three rows of eight) plants of each of the 40 families, and time of flowering was scored.

The relationship between selected plants and the mean of their progenies for time of flowering is presented in Fig. 1. It is clear that selected plants and their corresponding families showed considerable resemblance, this despite difference in weather conditions in 1992 and 1993.

Narrow sense heritability (h^2_n) is described as the ratio between genotypic and phenotypic effects. High heritabilities indicate that the genetic component in the observed phenotype is relatively important to the environmental component. This means that high heritabilities for a character usually result in a quick response to selection. With low heritabilities the response to selection is not necessarily lower, but more time consuming. From the linear regression of offspring (Y) on female parents (X), expressed as Y = a + bX, the (narrow sense) heritability can be estimated by $h^2_n = 2b$ (Falconer 1989). The estimated heritability for time of flowering in this experiment was 0.94, which is very high.

Synchronization Within Plants

For estimation of duration of flowering of individual plants a similar experimental lay out was used. In 1992, a field was sown with 220 plants of an unselected population (879585). Plant spacing was approx. 100 x 100 cm. Twice a week the number of open flowers per plant (NOF) was scored. At the end of the growing season plants were removed from the field and the total number of heads per plant (TNH) was counted. Knowing the total number of heads per plant, a correction could be made for the error caused by counting open flowers twice on two consecutive counting dates. In general, flowers stay open about 4 to 6 days. For each plant a correction term (CT) was estimated, being the ratio between the actual total number of heads (TNH) and the mathematical sum of counted open flowers on the counting dates (MNF). This ratio is 1 if no flowers are counted twice. In this experiment, in most plants the ratio was estimated between 1.0 and 2.0, meaning that 0% to 100% of the flowers were indeed counted twice on two consecutive counting dates. The number of newly opened flowers per counting date (NNOF) was estimated by the product of the number of counted open flowers (NOF) and the estimated correction term (CT): NNOF = NOF x CT, where CT is TNH/MNF.

The cumulative numbers of open flowers per plant plotted against time fitted a logistic curve ($Y = c/[1 + e^{-b(X - m)}]$). In this curve, *c* represents the upper asymptote (being the total number of heads, TNH), *b* the "slope parameter," and *m* the inflexion point of the curve, which is also the date at which the maximum number of open flowers was counted: peak bloom. The flowering of each individual plant was characterized by these three parameters. In this experiment this model on average accounted for 99.6% of the observed variation, indicating that it described the flowering of individual plants well.

Using this model, the period in which the plants produced 90% of their total number of flowers (the duration of flowering) could be calculated. The 90% interval, and not 100%, was chosen because slight deviations from the model occurred at beginning and end of flowering, accounting for relatively large aberrations in estimates of duration of flowering when using the 100% interval.

Duration of flowering ranged from 11 to 63 days, with a mean of 27 days. Since plants did not start flowering at the same time, environmental factors may have had a considerable effect. Therefore, also for this character heritability was estimated by means of parent-offspring regression.

From the population grown in 1992, 20 plants were selected showing much variation for duration of flowering. In 1993, ten plants per progeny were sown in a complete randomized block design, and flower counts were made in the same way as before. The explained variation for the fit of the logistic model on the data was 99.8%.

The relationship between female parents and the mean of their corresponding families is shown in Fig. 2. The calculated regression line explained only 13% of the variation. This means that it leaves 87% of the variation still to be accounted for, and seems drawn rather arbitrarily through a cloud of data points. The estimated heritability (based on the slope of this regression line) of 0.27 can therefore be regarded as unreliable.

Oil Content

The same trial field as described in the first experiment was used to assess the variation and heritability for oil content. Of all plants seeds were harvested and separated in winged and unwinged seeds. Oil content of the winged seeds was measured with Near InfraRed Spectroscopy (NIRS) equipment (InfraAlyzer 500, Bran+Lübbe). Oil content of individual plants ranged from 15% to 29%, with a mean of 21.5%. From this experiment 40 plants were selected representing almost the whole range. Progenies were tested in 1993 (same experimental lay out as in time of flowering experiment). Seeds were collected and oil content was measured with NIRS. The relationship between the female parents and the mean of the corresponding offspring is presented in Fig. 3. The estimated heritability was 0.36 but the regression line explained only 17% of the observed variation.

Pollen Transfer

Dimorphotheca pluvialis is considered a predominantly outcrossing species, however little is known on the mode of pollen transfer. The influence of insects on seed set was investigated in a complete randomized block design with three replications, three populations, and three treatments. The treatments consisted of: (1) plots in open air (free insect visitation), (2) plots with cages open at the North side (free insect visitation + shading effect of cage), and (3) plots with cages (no insects, shading effect). The second treatment was included as a control, to determine possible effects of the shading caused by the cages on growth and development of the crop. Plot size was 3 x 3 m. The number of open flowers was counted weekly on two subplots of 0.25 m^2. Seed set was determined by picking 20 flowers randomly, and counting the number of winged and unwinged seeds.

Analyses of variance revealed no difference between treatments 1 and 2 for crop development, seed set and thousand seed weight. Apparently the light shading did not effect these characters (Table 1). Population 879585 flowered slightly earlier than the other two. No population x treatment interaction was found for any of these characters.

Seed yield of plots with open cages was lower than yield of open fields. This could not be explained by a lower seed set, lower number of flowers, or lower thousand seed weight. In the harvest bags of this treatment moths were found, which might have caused severe damage.

Exclusion of insects led to a prolonged flowering of the crop, and a severely reduced seed set and yield. Thousand seed weight was higher.

CONCLUSIONS

For time of flowering, duration of flowering, and oil content of seeds, sufficient variation was found to enable improvement by means of selection. Heritability for time of flowering appears to be high, indicating that selection for this character will show quick response. For duration of flowering and oil content of the seeds, heritability estimates by means of parent-offspring regression were questionable, but most likely these heritabilities are not very high. In this case the result of selection does not necessarily have to be less, but is more time consuming. The environmental component of the observed phenotype is relatively large, and therefore may conceal the genotypic component.

For these experiments it was assumed that random mating and complete cross pollination has taken place. Furthermore, interaction effects (epistasis, genotype-year, year-location, and genotype-location) were considered negligible. It is likely that some of these assumptions were incorrect, and may have affected the outcome. Year and location effects can only be studied when experiments are carried out at several locations in several years. The presented results on heritability estimates are therefore preliminary, but nevertheless give an indication of what can be expected from selection.

Presence of insects during flowering is essential for a good seed set. Exclusion of insects may result in yield losses up to 75%.

Dimorphotheca pluvialis is as yet not ready for commercialization. Several agronomic constraints are recognized, but most can be overcome given time. Other problems still lay in the area of oil recovery and purification. However, the unique structure of dimorphecolic acid justifies further studies.

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- Muuse, B.G., F.P. Cuperus, and J.T.P. Derksen. 1992. Composition and physical properties of oils from new oilseed crops. Ind. Crops Prod. 1:57-65.
- Norlindh, T. 1977. Calendulae--systematic review. p. 961-987. In: Heywood, V.H., J.B. Harborne, and B.L. Turner (eds.), Biology and chemistry of the compositae.
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Table 1. Effect of exclusion of insects during flowering on crop development and yield characteristics of *Dimorphotheca pluvialis*.

	No. of open flowers/ 0.25 m^2								Thousand seed weight	
Variable	June 30	July 7	July 14	July 21	July 28	Seed yield (g/m^2)	No. unwinged seeds/flower	No. winged seeds/flower	unwinged seeds (g)	winged seeds (g)
Population										
879127	1.2	28.3	140.9	126.0	22.8	70.7	10.7	29.0	3.39	2.26
879731	0.7	29.6	134.6	107.0	26.1	85.7	10.3	30.2	3.50	2.28
879585	2.2	48.3	195.3	74.1	30.9	79.8	11.1	28.4	3.48	2.25
Sign.[z]	**	***	***	***	x	*	NS	NS	NS	NS
Cage treatment[y]										
1	1.4	40.6	148.9	82.9	7.5	125.9	14.4	41.3	2.90	2.14
2	0.9	33.8	142.1	71.6	4.0	83.0	15.4	41.2	3.03	2.20
3	1.7	31.9	179.7	152.6	68.4	27.4	2.4	5.1	4.46	2.46

Sign.[z]	NS	NS	*	***	x	***	***	***	***	***

[z]NS = effect not statistically significant, ***significant 0.1%, ** at 1%, * at 5%.
[y]Treatments: 1 = open plots (insects yes, shading no), 2 = partly opened cages (insects yes, shading yes), 3 = closed cages (insects no, shading yes).
[x]Distribution of residuals not Normal, ANOVA performed on Ö-transformed data.

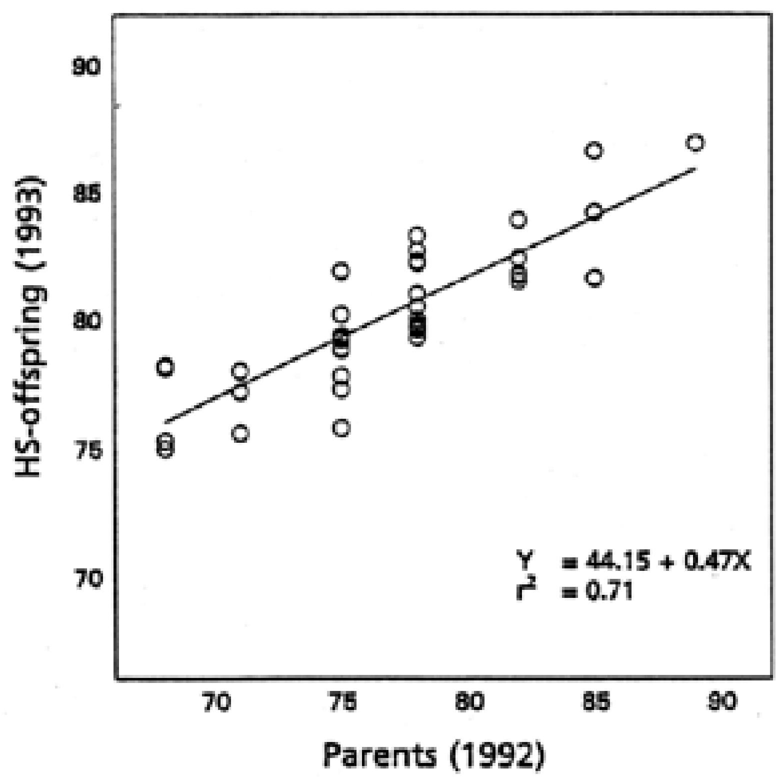
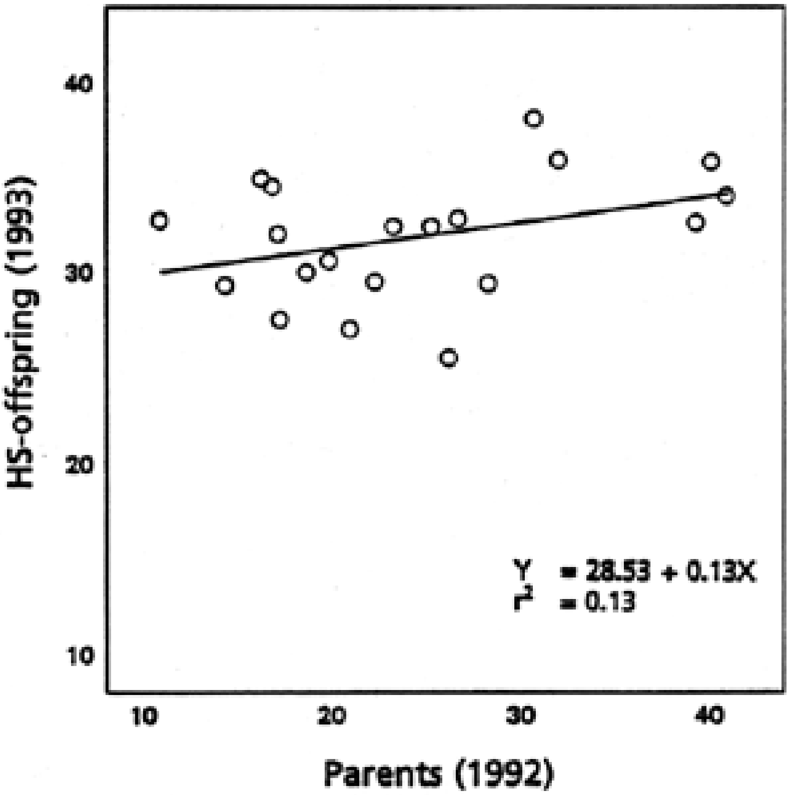


Fig. 1. Parent-offspring relationship for beginning of flowering in a population of *Dimorphotheca pluvialis* (days after sowing).

Fig. 2. Parent-offspring relationship for duration of flowering in a population of *Dimorphotheca pluvialis* (days).



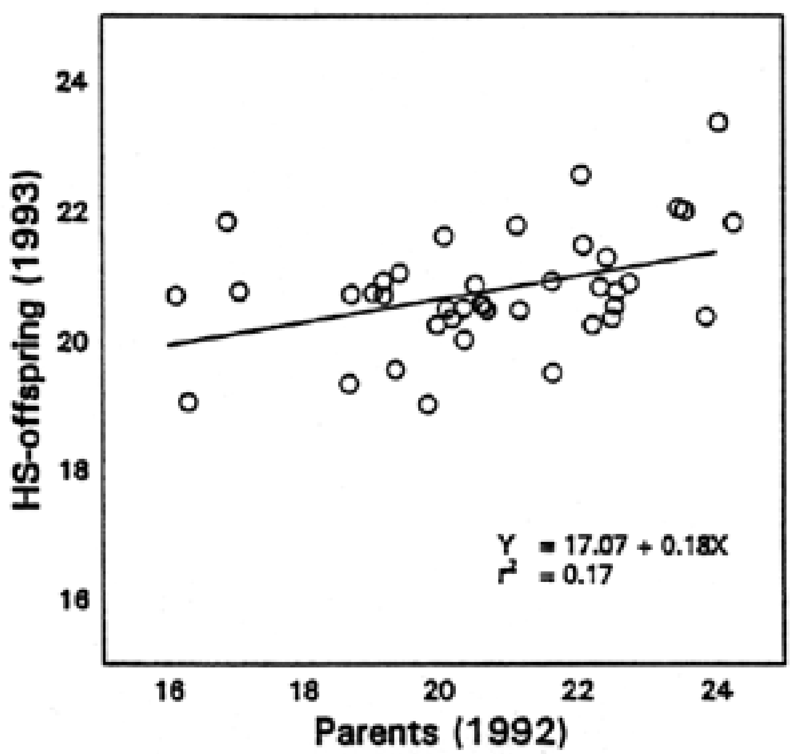


Fig. 3. Parent-offspring relationship for oil content in a population of *Dimorphotheca pluvialis* (% oil in the seed).

Last update August 21, 1997 aw

Capparis spinosa L.

Capparidaceae, or Capparaceae

Caper, *Cappero*, Alcaperro, Caper Berry, Caper Bud, Caperbush, Caper Fruit, *Kápari*, Smooth Caper, Spiny Caper, *Tapèra*

We have information from several sources:

Caper Fact Sheet from Ben Alkire.

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Euphorbia lathyris L.

Euphorbiaceae

We have information from several sources:

Arid-land Industrial Crops—Anson E. Thompson

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

last update October 23, 1997

Capsicum annuum L.

Solanaceae

Capsicum (pepper), *Chile* (pepper), Chili (pepper), Chilli(es), Japanese mustard (Korean), Pepper, Pepper of Calicut (archaic), *Pimiento*, Red pepper

We have information from several sources:

Herbs: An Indexed Bibliography. 1971-1980—J.E. Simon, A.F. Chadwick and L.E. Craker

Peppers: History and Exploitation of a Serendipitous New Crop Discovery—W. Hardy Eshbaugh

Capsicums: Innovative Uses of an Ancient Crop—Paul W. Bosland

Midwest Vegetable Production Guide for Commercial Growers 2000

Peppers production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Peppers (Aij picante)
- Peppers, Bell Type (Mango)
- Peppers, Chili
- Peppers, Pimiento
- Peppers, Small Fruited (Paprika, Tabasco, Cayenne, Chili, Red)

Outside links:

The Chile Pepper Institute

Chile Varieties database

Peppers can be found in Lost Crops of the Incas from National Academy Press

Capsicum—Descriptors for *Capsicum*—Link to the publication on the International Plant Genetic Resources Institute web site

Index | Search | Home

Fabaceae
Siberian peashrub

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

"During World War II, the Siberian peasants reportedly carried their chicken flocks through the winter feeding the seed of one small woody pland, *Caragana arborescens*." (Snell, 1983). Some ethnic groups have used young pods for vegetables. Seeds serve as a valuable wild life food. Bark provides a fiber. Leaves yield an azure dye. Because of its cold and drought tolerance, it is widely planted in the US and Canada for windbreaks. In the northern Great Plains, it is also used for hedges and outdoor screening. Because of its nitrogen-fixing capacity, it is valued as a soil-improving plant. In the Arctic Circle it is valued as a supplementary fodder for reindeer herds. It is valuable in these colder climates, but in warmer climates like New England as the eastern and western coastal areas of the US, better ornamentals are available. According to Snell (1983), Caranga "serves well as a windbreak, ground cover, soil builder, poultry cover, cattle forage, vegetable for human use, fiber plant, bee plant, dye plant, and ornamental landscape specimen."

Folk Medicine

According to the Dictionary of Chinese Traditional Medicine (Kiangsu, 1977), the whole plant, known as ning tiao, is used for cancer of the breast, and the orifice to the womb, and for dysmenorrhea and other gynecological problems.

Chemistry

According to USDA analyses, the ash content of the seed runs 3.4-3.6, protein 35.5-36.4%, oil content 13.2-13.6%. Contains a lectin or phytohemagglutinin.

Description

Deciduous shrub or small tree 6-8 m tall; stipules becoming spiny, leaves alternate, paripinnate, 5-9 cm long, with 3-6 pairs of obovate to elliptic-oblong leaflets, to 2.5 cm long. Flowers yellowish, pea-shaped, one to four in each cluster, the calyx teeth short, as broad as long. Fruit stalked to 5 cm long, with 6 reddish-brown, oblong to spherical seeds, 2.5-4 0 mm in diam. (Seeds ca 40,000-42,000/kg).

Germplasm

Reported from the Eurosiberian Center of Diversity, Siberian peashrub is reported to tolerate alkalinity, drought, cold, poor soil, and wind. Some named variations are forma *xorbergii*, var. *crasseaculeata*, var. *nana*, and var. *pendula,* the latter with handsome drooping branches. ($2n$ = 16)

Distribution

Native to Siberia and Manchuria. Extends over about 160 million ha in Siberia 77deg.-120deg. E, 48deg.-60deg. N. In the US its growth is stunted south of Nebraska.

Ecology

Apparently ranges from Cold Temperate Steppe to Moist through Boreal Moist to Wet Forest Life Zones, Siberian peashrub tolerates annual precipitation of 4 to 8 dm, annual temperature of 2 to 7°C reaching Zone 2 (Hardiness Zone) of the United States and Canada.

Cultivation

According to Hortus III (1976), pea trees grown for their flowers should be planted in.sunny locations in sandy soil. Seeds are generally sown outdoors in autumn, or in spring after soaking the seed in warm water. Softwood cuttings can be set in early June. Also propagated by root cuttings, layering, or grafting. Certain pesticides, captain, thiram, and mercuric chlorate can increase germination, possibly by inhibiting disease. No significant differences in characteristics of 1-year-old seedlings were noted following Rhizobia inoculation of seeds prior to field sowing. However, one source recommended inoculation for best results. Many nurserymen recommend planting 75-150 seeds per linear meter. A Russian report recommended planting 2.5 cm deep. In one North Dakota nursery, Siberian peashrub is seeded during the last week in July or the first week in August. A cover crop of oats is seeded between the tree rows early enough to give winter protection. Shrubs are large enough to dig the following fall (Ag Handbook 450).

Harvesting

In the US, the optimum time for collecting seed is less than two weeks, usually in July or August. Since seeds are ready to collect as soon as the fruit ripens, the pods should be gathered by hand as soon as they open. For vegetable trials, greener pods should of course be harvested.

Yields and Economics

Shrubs take ca 3-5 years to reach commercial bearing age (Ag Handbook 450). Good crops occur nearly every year.

Energy

With no data available, I speculate that this species could produce 4-10 MT/DM/yr fixing nitrogen in the process. Nitrogen-fixing rhizobia were reported in the species before 1900. There is considerable variation in the 14 strains now reported, all belonging to the slow-growing cowpea-soybean-lupine type rhizobia. Host infective patterns were quite uniform but some nonreciprocal cross-inoculation was observed. Caragana rhizobia reisolated from nodules they formed on *Trifolium pratense* retained the ability to nodulate Caragana. Throughout the life of a Caragana nodule, the volume of tissue functionally active in N-fixation remains more or less constant. As the nodule becomes larger, the ratio of the N-fixing volume to total nodule mass becomes smaller. On a one-month-old nodule, the ratio of functional bacteroidal tissue to total nodule mass is about 1:1, in 2-month-olds, 1:2; in 6-month-olds 1:5. Of particular interest is the coexistence of juvenile and senescent tissue in close proximity for long periods. Growth equilibrium, development, and function of the nodule, do not appear unbalanced during its existence (Allen and Allen, 1981).

Biotic Factors

Agriculture Handbook 165 lists: *Agrobacterium rhizogenes* (hairy root), *Ascochyta* sp. (leaf blight), *Botrytis cinerea* (pod blight), *Cucurbitaria anae* (on branches), *Hendersonia septem-septata* (on twigs), *Pellicularia filamentosa* (root rot of seedlings), *Phomopsis caraganae* and *Phomopsis rudis* (on branches), *Phyllosticta gallarum* (leaf spot), *Phymatotrichum omnivorum* (root rot), *Phytophthora cactorum* (wilt of seedlings), *Rhizoctonia solani* (damping-off), *Septoria* sp. (leaf blight), and *Sphaeropsis* sp. (on branches). Nursery stock may need pesticides to prevent damage by spiders, blister beetles, and other leaf-eating insects. Grasshoppers are especially destructive, sometimes completely defoliating the plants. Plants have also been extensively damaged by browsing deer, but mammal repellent has been effective (Ag Handbook 450).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update July 3, 1996

Carum carvi L.

Apiaceae (Umbelliferae)

Caraway, *Jintan, Karawya, Kümmel*

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Cardoon

Cardoni

Compositae *Cynara cardunculus* L.

Source: Magness et al. 1971

Cardoon is closely related to globe artichoke. Growth is up to 6 feet, with large pinnate, prickly leaves. In cultivation, plants are grown from seed. When leaves are near fully grown they are tied together near the top, and plants are banked with straw and soil - or other material - to blanch the leaf stalks or petioles. These are edible parts, but are inedible unless blanched. Cardoon appears not to be grown commercially in the U.S. In exposure of edible parts during growth, the plant is comparable to celery.

Season, seeding to harvest: 4 to 5 months.

Production in U.S.: None commercial.

Use: Fresh, as pot herb.

Part of plant consumed: Petioles and main ribs.

Last update February 18, 1999 by ch

Carica papaya L.

Caricaceae

Green papaya, Melon fruit, Melon pawpaw, Papaya, Papaw, Paw-paw, Solo papaya

We have Papaya information from several sources:

Papaya—Julia Morton, Fruits of Warm Climates

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

South American Fruits Deserving Further Attention—Richard J. Campbell

Papaya: A Potential Annual Crop Under Middle Georgia Conditions—U.L. Yadava, Janice A. Burris, and D. McCrary

Food and feed crops of the United States. Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Link to NewCROP info on Babaco, *Carica pentagona*

Outside Papaya links:

Highland Papayas can be found in Lost Crops of the Incas from National Academy Press
Carica pubescens
Carica stipulata
Carica monoica
Carica goudotiana

California Rare Fruit Growers "Papaya Fruit Facts"

Commodity Sheet FVSU-002 Papaya from Fort Valley State University

Papaya—from Mark Reiger, Dept of Horticulture, University of Georgia.

Papaya Information from the University of California Fruit & Nut Research and Information Center

Carica pubescens L.

Caricaceae

Mountain Papaya, Mountain Papaw, Chamburo

We have information from several sources:

South American Fruits Deserving Further Attention—Richard J. Campbell

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside Papaya links:

Highland Papayas can be found in Lost Crops of the Incas from National Academy Press

Carissa macrocarpa A. DC.

Apocynaceae

Carissa, Natal plum

We have information from several sources:

Carissa—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Ceratonia siliqua L.

Leguminosae

Carob, Algarroba, Locust, Locust Bean, Saint-John's-bread

We have information from several sources:

Carob—Julia Morton, Fruits of warm climates

Mediterranean Fruits—Joan Tous and Louise Ferguson

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links

Carob tree—by I. Battle, J. Tous from the International Plant Genetic Resources Institute

Carolina-Jessamine

Gelsemium sempervirens (L.) Ait. f.

Other common names.—Yellow jasmine or jessamine, Carolina wild woodbine, evening trumpetflower.

Figure 33.—Carolina-jessamine (*Gelsemium sempervirens*)

Habitat and range.—Carolina jessamine is a plant native to the South, found along banks of streams, in woods' lowlands, and thickets, generally near the coast, from the eastern part of Virginia to Florida and Texas and south to Mexico.

Description.—This highly ornamental climbing or trailing plant grows abundantly in the woods of the Southern States, its slender stems are festooned over trees and fences, and its presence is made known by the delightful perfume exhaled by its flowers. The smooth, shining stems of this vine sometimes reach a length of 20 feet. The leaves, which are from 1 1/2 to 3 inches long, generally remain on the vine during the winter. The bright-yellow funnel-shaped flowers, which appear from January to April, are very fragrant but poisonous. The rootstock, attaining a length of 15 feet or more, runs near the surface of the around. It is branched and here and there produces fibrous rootless. When fresh it is very yellow and has a peculiar odor and bitter taste.

Part used.—The rootstock, collected when the plant has come into flower, and cut into pieces from 1 to 6 inches long.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Carolina-Vanilla

Trilisa odoratissima (Walt.) Cass.

Synonym.—*Liatris odoratissima* Michx.

Other common names.—Deertongue, vanilla leaf, vanilla plant, dog's-tongue, houndstongue.

Habitat and range.—Carolina-vanilla is found in dry or wet pine barrens from southeastern Virginia to North Carolina, Florida, and Louisiana.

Description.—This is a stout erect herb 2 to 3 feet high with smooth, thick, entire leaves 4 to 10 inches long and 1 to 1% inches wide. In August to September the small purple flowers are borne, 5 to 10 in a head, in branched, rather flat-topped clusters. The leaves, especially when bruised, have a characteristic odor of vanilla.

Figure 34.—Carolina-vanilla (*Trilisa odoratissima*)

Part used.—This plant, while of minor importance as a drug plant, is included here because large quantities of the leaves are used in the flavoring of tobacco.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Juglans regia L.

Juglandaceae

English walnut, Carpathian or Persian walnut

We have information from several sources:

Nuts with Commercial Potential for America's Heartland

Exploration and Exploitation of New Fruit and Nut Germplasm—Maxine M. Thompson

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside links:

Walnuts, *Juglans* spp. University of Georgia

Walnut Crop Information University of California Davis

Daucus carota L.

Apiaceae, or Umbelliferae

Cultivated carrot, Queen-Anne's lace (Wild)

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Midwest Vegetable Production Guide for Commercial Growers 2000

Carrots production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Carthamus tinctorius L.

Asteraceae

Safflower, False saffron

We have information from several sources:

Safflower:—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Safflower Management and Adaptation for the High Plains—David D. Baltensperger, Glen Frickel, Drew Lyon, Jim Krall, and Tom Nightingale

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

New Crops for Canadian Agriculture—Ernest Small

Evaluation of Safflower Germplasm for Ornamental Use—Vicki L. Bradley, Robert L. Guenthner, Richard C. Johnson, and Richard M. Hannan

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links to safflower information:

Safflower Production in California—by Steven Kaffka and Thomas Kearney, UC Davis.

Safflower—by Li Dajue, Hans-Henning Mundel—Link to the publication on the International Plant Genetic Resources Institute web site

Hickory nuts

Juglandaceae: *Carya* sp.

Pignut hickory: *C. glabro* (Mill.) Sweet

Small pignut (False shagbark): *C. ovalis* (Wangh.) Sarg.

Shellbark (Shagbark hickory): *C. laciniosa* (Michx. f.) Loud.

Mockernut (Bigbud hickory): *C. tomentosa* (Poir.) Nutt.

Nutmeg hickory: *C. myristicaeformis* (Michx. f.) Nutt.

Source: Magness et al. 1971

The above species are all native to parts of the U.S. and produce nuts with edible kernels. They are not grown commercially for the nuts, but some quantities are harvested from native or ornamental trees. The trees become large, up to 100 feet or more, with compound, pinnate leaves. Fruits are generally near globose, glabrous, and somewhat ridged, and 1 to 1.5 inches long. The nut is encased in a fleshy husk which becomes fibrous and opens as the nuts mature. The shells are hard and woody. The kernels do not separate from the shells readily. Limited quantities either in shell or as kernels are marketed.

Last update February 18, 1999 by ch

Pecan

Juglandaceae *Carya illinoinensis* (Wangh.) K. Koch

Source: Magness et al. 1971

The pecan is a large tree, up to 100 feet in height, and with trunk diameter up to 6 feet. It is native in the lower Mississippi Valley and westward through Texas, and in northern Mexico. Leaves are large and compound, with a dozen or more long-oval, near glabrous leaflets. The fruits are generally oval, up to 2.5 inches long, and fairly smooth. The outer husk is fleshy early, becoming fibrous and splitting open at maturity. The shells are relatively thin, hard and woody. The kernel separates rather readily. Improved varieties are widely cultivated. In addition, large quantities are harvested from native trees.

Season, bloom to harvest: 5 to 6 months.

Production in the U.S.: About 200,000 tons, in shell.

Use: Direct eating, confections, ice cream, cookery.

Part of plant consumed: Internal kernels only.

Last update February 18, 1999 by ch

Cascara Buckthorn

Rhamnus purshiana DC.

Other common names.—Cascara sagrada, chittembark, chittam wood, sacred bark, bearberry-tree, bearwood.

Figure 35.—Cascara buckthorn (*Rhamnus purshiana*)

Habitat and range.—This native tree occurs on the sides and bottoms of canyons from the Rocky Mountains to the Pacific Ocean, extending north into British America.

Description.—The cascara tree is usually from 15 to 20 feet in height. The rather thin leaves are from 2 to 6 inches long and about 1 to 3 inches wide, somewhat hairy on the lower surface and rather prominently veined. The small, insignificant greenish flowers are produced in clusters and are followed by black, 3-seeded berries of a somewhat insipid taste. The bark has a somewhat aromatic odor and an extremely bitter taste. In the cascara district several other species of Rhamnus occur which are not commercially important, but their resemblance to R. purshiana may lead inexperienced persons to include the bark of such species in their collections.

Part used.—The bark collected during the summer. The collecting season opens about the end of May and closes before the rainy season sets in, as bark collected after exposure to wet weather is difficult to cure properly. The strips of bark after removal from the trees are dried in such a way that the inner surface is not exposed to the sunlight, in order to retain its yellow color. Cascara bark must be aged at least one year before it is used. If collectors in removing the bark allow enough to remain to prevent the tree from dying it will develop new bark, thus prolonging the natural supply of this valuable drug which is gradually being exhausted.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Casimiroa edulus Llave.

Rutaceae

White Sapote, casimiroa, custard apple, matasano, Mexican apple, sapota, white zapote, zapote, zapote blanco

NewCROP has information at:

White Sapote —Julia Morton, Fruits of warm climates

Golden Berry, Passionfruit, and White Sapote: Potential Fruits for Cool Subtropical Areas—Richard McCain

Introduction and Domestication of Rare and Wild Fruit and Nut Trees for Desert Areas—Avinoam Nerd, James A. Aronson, and Yosef Mizrahi

New Crops as a Possible Solution for the Troubled Israeli Export Market—Y. Mizrahi and A. Nerd

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more White Sapote info:

SAPOTE "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Manihot esculenta Crantz

Euphorbiaceae

Cassava, Mandioc, *Mandioca*, Manihot, Manioc, Tapioca, Yuca

We have information from several sources:

FactSHEET—contributed by: Stephen K. O'Hair

Tropical Root and Tuber Crops—Stephen K. O'Hair

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links

Cassava—FAO/IPGRI Technical Guidelines for the Safe Movement of Cassava Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Cassia

Cassia buds

Lauraceae *Cinnamomum cassia* Blume

Source: Magness et al. 1971

The tree is a tropical evergreen, reaching up to 50 feet, with thick, oblong leaves 3 to 6 inches long. The trees are hardy in the Gulf States in the U.S., but commercial cassia and cassia buds are not produced. The cassia of commerce, quite similar to cinnamon, is the ground, dried bark of the tree; while cassia buds are the dried, immature fruits harvested when about one-fourth their full size. They resemble cloves, but are smaller. The buds are used as a spice, mainly in confections, while the powdered bark is used in cookery, often as a substitute for cinnamon, which is more expensive.

Last update February 18, 1999 by ch

Cassia fistula L.

Fabaceae
Purging cassia, Indian laburnum, Golden-shower

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Widely planted as a handsome ornamental tree, the plant is being considered as a firewood source in Mexico. The reddish wood, hard and heavy (spec. grav. 0.9), strong and durable, is suited for cabinetwork, farm implements, inlay work, posts, wheels, mortars, etc. The bark has been employed in tanning, often in conjunction with avaram. The drug "cassia fistula", a mild laxative, is obtained from the sweetish pulp around the seed.

Folk Medicine

According to Hartwell (1967-1971), the plants are used in folk remedies for tumors of the abdomen, glands, liver, stomach, and throat, cancer, carcinomata, and impostumes of the uterus. Reported to be aperient, astringent, laxative, purgative, and vermifuge, Indian laburnum is a folk remedy for burns, cancer, constipation, convulsions, delirium, diarrhea, dysuria, epilepsy, gravel, hematuria, pimples, and glandular tumors (Duke and Wain, 1981). Ayurvedic medicine recognizes the seed as antibilious, aperitif, carminative, and laxative, the root for adenopathy, burning sensations, leprosy, skin diseases, syphilis, and tubercular glands, the leaves for erysipelas, malaria, rheumatism, and ulcers, the buds for biliousness, constipation, fever, leprosy, and skin disease, the fruit for abdominal pain, constipation, fever, heart disease, and leprosy. Yunani use the leaves for inflammation, the flowers for a purgative, the fruit as antiinflammatory, antipyretic, abortifacient, demulcent, purgative, refrigerant, good for chest complaints, eye ailments, flu, heart and liver ailments, and rheumatism, though suspected of inducing asthma. Seeds are considered emetic. Konkanese use the juice to alleviate ringworm and blisters caused by the marking nut, a relative of poison ivy. Leaf poultices are applied to the chilblains so common in the upper Sind; also used in facial massage for brain afflictions, and applied exter- nally for paralysis and rheumatism, also for gout. Rhodesians use the pulp for anthrax, blood poisoning, blackwater fever, dysentery, and malaria. Gold Coast natives use the pulp from around the seed as a "safe and useful purgative" (Kirtikar and Basu, 1975). Throughout the Far East, the uncooked pulp of the pods is a popular remedy for constipation, thought to be good for the kidneys "as those who use it much remain free of kidney stones" [Heyne as cited in Perry (1980)]. A decoction of the root bark is recommended for cleansing wounds. In the West Indies, the pulp and/or leaves are poulticed onto inflamed viscera, e.g. the liver. The bark and leaves are used for skin diseases: flowers used for fever, root as a diuretic, febrifuge; for gout and rheumatism.

Chemistry

According to Roskoski et al (1980), studying Mexican material, the seeds contain 5.31% humidity, 4.55% ash, 24.00% crude protein, 4.43% crude fat, 6.68% crude fiber, and 50.36% carbohydrates with a 81.17% in vitro digestibility. The foliage contains 11.21% humidity, 6.39% ash, 15.88% crude protein, 6.65% crude fat, 20.01% crude fiber, 39.86% carbohydrates with a 88.43% in vitro digestibility. In comparison, the FAO (Gohl, 1981) reports the leaves to contain, on a zero moisture basis, 17.6 g protein, 7.8% g fat, 66.8 g total carbohydrate, 30.2 g fiber, 7.8 g ash, 3,270 mg Ca, and 330 mg P per 100 g. Flowers contain ceryl alcohol, kaempferol, rhein, and a bianthroquinone glycoside, which on hydrolysis, yields fistulin and rhamnose. Leaves contain rhein, rheinglucoside, and sennosides A and B. The rootbark contains tannin, phlobaphenes, and oxyanthraquinone substances, which probably consist of emodin and chrysophanic acid; also contains (bark and heartwood) fistuacacidin, barbaloin, and rhein. Stembark contains lupeol, beta-sitosterol, and hexacosanol.

Description

Deciduous tree 10 m tall, the bole to 5 m, to 1 m DBH. Leaves alternate, pinnate, 30-40 cm long, with 4-8 pairs of ovate leaflets, 7.5-15 cm long, 2-5 cm broad, entire, the petiolules 2-6 mm long. Flowers yellow, in long drooping terminal clusters (racemes); petals 5, yellow; sepals 5, green, the individual flower stalks 3-6 cm long. Stamens 10, three with longer stalks. Fruits pendulous, cylindrical, brown, septate, 25-50 cm long, 1.5-3 cm in diameter, with 25-100 seeds. Seeds lenticular, light brown, lustrous.

Germplasm

Reported from the Hindustani Center of Diversity, Indian laburnum, or cvs thereof, is reported to tolerate mild drought, poor soils, and slopes. ($2n$ = 24, 26, 28).

Distribution

Native of tropical Asia, widely cultivated and naturalized in the tropics including West Indies and continental tropical America.

Ecology

Ranging from Tropical Thorn to Moist through Subtropical Thorn to Moist Forest Life Zones, Indian laburnum is reported to tolerate precipitation of 4.8 to 27.2 dm (mean of 96 cases = 14.2), annual temperature of 18.0 to 28.5°C (mean of 94 cases = 25.5), and pH of 5.5 to 8.7 (mean of 23 cases = 7.1). Hortus III (1976) assigns it to Zone 10 in the United States.

Cultivation

Although soaking the seeds in sulfuric acid results in highest germination, puncturing the seed coat proved to be the simplest, most effective method to break dormancy in Mexican studies. Seedlings planted in plastic bags containing 7 kg soil, survived transplant quite well. Cuttings did not take readily in the Mexican studies. According to Nalawadi et al (1977), *Cassia fistula* seeds were either soaked in concentrated H2SO4 for 5-20 minutes and then soaked in water for 24 hours, or soaked in water alone for 24 hours. Seeds soaked in water alone failed to germinate, but soaking in acid for 20 minutes resulted in 84% germination. Additional soaking in water did not further improve germination.

Harvesting

Timber or firewood can be felled as needed. It is usually more practical to harvest in the dry season, making it easier to suncure or airdry the timber or bark. Besides other farm duties tend to be less pressing then, at least in the garden, once irrigation is accomplished.

Yields and Economics

Among the tanners of Dindigul, Coimbatore, and other places in South India, the bark, being favored by the tanners, was collected from the forests at the rate of 200-500 MT/year in South India alone.

Energy

The plant is being considered for fuelwood, weighing slightly over800 kg/m.

Biotic Factors

Apparently this is not one of the nodulated species of *Cassia*. Certain factors may militate against nodule formation. Root hairs are uncommon; when present, they are sparse and thick walled. Simple phenolic compounds, tannins, quinones and derivatives occur in the overlapping cortical root cells. It is assumed that these cell layers present a physicochemical barrier because of their role in thwarting nematode gall formation (Allen and Allen, 1981). Agriculture Handbook #165 reports the tarspot, *Phyllachora canafistulae*, in Maryland, near its northern limit. Very susceptible to attack by scale insects. Browne (1968) lists: Fungi. *Phelospora cassiae, Polyporus anebus, Trametes incerta*. Angiospermae, *Cuscuta reflexa, Loranthus* sp. (?), *Viscum articulatum.* Coleoptera, *Acmaeodera stictipennis, Adoretus bimarginatus, Adoretus caliginosus, Adoretus lasiopygus, Anomala bengalensis, Anomala polita, Anomala rugosa, Anomala tristis, Apogonia villosella, Aristobia approximator, Bruchus pisorum, Caryedon serratus Cephaloserica thomsoni, Colasposoma semicostatum, Holotrichia problematica, Hypomeces squamosus, Idionycha excisa, Myllocerus pubescens, Schizonycha ruficollis, Sophrops cotesi, Steraspis speciosa*. Hemiptera, *Acudaleyrodes rachipora, Aonidiella orientalis, Euphalerus vittatus, Eurybachys tomentosa, Otionotus oneratus, Oxyrhachis formidabilis, Oxyrhachis mangiferana, Oxyrhachis tarandus, Parlatoreopsis chinensis, Pinnaspis aspidistrae, Pinnaspis buxi.* Lepidoptera, *Anarsia idioptila, Archips micaceanus, Buzura suppressaria, Catopsilia crocale, Catopsilia florella, Catopsilia pomona, Catopsilia pyranthe, Cleora acaciaria, Cryptophlebia illepida, Cusiala raptaria, Dasychira mendosa, Diaphania conclusalis, Ericeia inangulata, Euproctis scintillans, Fodina stola, Hypanartia blanda, H. hecabe, Hyposidra talaca, Kotochalia doubledaii, Nephopteryx rhodobasalis, Omiodes surrectalis, Phaleri raya, Phalera sangana, Pilocrocis milvinalis, Selepa discigera, Semiothisa emersaria, Spatularia mimosae, Stauropus alternus, Stegasta variana, Suana concolor, Thosea cana, Thylacoptila paurosema, Trachylepidia fruticassiella, Xyleutes persona, Zeuzera coffeae.* Orthoptera, *Schistocera gregaria.*

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- Duke, J.A. and Wain, K.K. 1981. Medicinal plants of the world. Computer index with more than 85,000 entries. 3 vols.
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- Roskoski, J.P., Gonzalez, G.C., Dias, M.I.F., Tejeda, E.P., and Vargas-Mena y Amezcua. 1980. Woody tropical legumes: potential sources of forage, firewood, and soil enrichment. p. 135-155. In: SERI: Tree crops for energy co-production on farms. SERI/CP-622-1086. USGPO. Washington.

Complete list of references for Duke, Handbook of Energy Crops

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Last update July 3, 1996

Charota or Chakod (*Cassia tora* L. syn. *Cassia obtusifolia* L.)

Contributor: Pankaj Oudhia

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English Name: Foetid cassia, The Sickle Senna, Wild Senna

Common (Indian) names:
Hindi: Charota,Chakvad,Chakavat.
Bengali & Oriya: Chakunda
Gujrati: Kawaria
Canarese: Gandutogache
Malyalam: Chakramandrakam,takara
Marathi: Takala
Sanskrit : Chakramarda,Dadmari,Dadrughra,Taga
Tamil: Tagarai
Telugu: Chinnakasinda

Family: Leguminosae

Habitat: In India it occur as wasteland rainy season weed.

Botany: It is an annual foetid herb, 30–90 cm high .

Leaves: pinnate, up to 10 cm long rachis grooved, conical gland between each of two lowest pairs of leaflet, leaflets in 3 pairs, opposite, obovate, oblong and base oblique.

Flowers: In pair in axils of leaves, petals five, pale yellow.

Fruit: Pod, Obliquely separate.

Seed: 30-50 rhombhedral

Flowering time: After the monsoon rains (in Indian conditions)

Useful parts: Roots, Leaves, and Seeds.

Medicinal Properties and Uses: According to Ayurveda the leaves and seeds are acrid, laxative , antiperiodic, anthelmintic, ophthalmic, liver tonic, cardiotonic and expectorant. The leaves and seeds are useful in leprosy, ringworm, flatulence, colic, dyspepsia, constipation, cough, bronchitis, cardiac disorders.

Ayuerveda Formulation: Chakramadha Tailamu.

Other uses: Recommended for reclamation of saline, alkaline and brackish soils. Used as green manure crop in acidic soils. Dried seed contain protein (up to 24 percent) and is given as a protien rich feed for livestock and birds. Roasted seeds are substituted for coffee like Tephrosia seeds. Seeds yield tannins and dyes (yellow, blue and red). fields a gum (7.50%),which is a good agent for suspending and binding. The aqueous extracts of whole plant and leaves produces inhibitory allelopathic effects on common weeds specially on *Parthenium hysterophorus*. Recommended to grow in Parthenium infested areas as smoother crop. Stimulatory allelopathic effects on rice and wheat have been reported. Seeds used in preparation of sweet dishes. Leaves are popular potherb. In organic farms of India, *Cassia tora* is used as natural pesticide. Fungicidal activity of chrysophanic acid-9-anthrone from *Cassia tora* have been reported.

Chemical Constituents

Roots: 1,3,5-trihydroxy-6-7-dimethoxy-2-methylanthroquinone and beta-sitosterol.

Seeds: Naptho-alpha-pyrone-toralactune, chrysophanol, physcion, emodin, rubrofusarin, cchrysophonic acid-9-anthrone.

Leaves: Emodin, tricontan-1-0l, stigmasterol, β-sitosteral-β-D-glucoside, freindlen, palmitic, stearic, succinic and d-tartaric acids uridine, quercitrin and isoquercitrin.

Resource Person:

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Phone: 91-771-253243
Mobile: 91-98271-15642
Fax: 91-771-536312

Castanea sp.

Fagaceae

Chestnut, American Chestnut, *Châtaigne*, Chinese Chestnut, Dwarf Chestnut, European Chestnut, European Horse Chestnut, Japanese Chestnut, *Kastanie*, Spanish Chestnut, Sweet Chestnut

We have information from several sources:

Requirements for a United States Chestnut Industry—Robert L. Stebbins

Chinkapin: Potential New Crop for the South—Jerry A. Payne, George P. Johnson, and Gregory Miller

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Nuts with Commercial Potential for America's Heartland

New Fruit and Nut Crops for Indiana

Outside links:

Chestnut Factsheets from the Connecticut Agriculture Experiment Station

Chestnuts—from Mark Reiger, Dept of Horticulture, University of Georgia.

Chestnut Information from the University of California Fruit & Nut Research and Information Center

Ricinus communis L.

Euphorbiaceae

Castor, Castorbean, Castor-oil Plant

(Castor seed is not a true bean.)

We have information from several sources:

Castor: Return of an Old Crop—Raymond D. Brigham

Development of Castor Bean Production in France—Françoise Labalette, André Estragnat, and Antoine Messéan

Evaluation of Castor Germplasm for Agronomic and Oil Characteristics—Harbans L. Bhardwaj, Ali I. Mohamed, Charles L. Webber, III, and Gilbert R. Lovell

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Castorbeans: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Castor Oil from: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and Feed Crops of the United States. .

Casuarina cunninghamiana Miq.

Casuarinaceae
River sheoak

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

In Egypt, *Casuarina* is the most important genus in forestry, with *C. cunninghamiana* and *C. glauca* protecting the desert highways, *C. equisetifolia*, the coastal housing. Annual plantings were one million seedlings in 1975, four million in 1980, projected at 10–15 million in 1990. In South Africa, used for firewood, poles, reclamation, shelterbelts, timer, and windbreaks. Planted as a windbreak, superior to pine, in California. The timber is durable and useful for flooring. The wood is dark, close-grain, and nicely marked. The bark can be used as tanbark. Foliage is liable to be eaten by livestock (Watt and Breyer-Brandwijk, 1962). In Argentina, it is planted on the Pampas as a windbreak and shade tree, along stream banks to protect them from erosion. Because of its importance for protecting stream banks from erosion, it cannot be felled without permit in New South Wales. In Puerto Rico, grown for ornament, shade and windbreak.

Folk Medicine

No data uncovered.

Chemistry

Once bioflavonyls were thought restricted to gymnosperms and *Casuarina,* but now they have been found in other angiospermous genera, both monocots and dicots, o-coumaric acid has been reported in the genus as well as protocatechuic acid. Asparagine and glutamine accounted for 92% of the total amino acid in the nodules. In root nodules of legumes, infection increases markedly the IAA presents but in *C. cunninghamiana* (as in *Myrica cerifera*) there is an increase in IAA oxidase and no detectable IAA. Hence the nodule-roots grow upward rather than downward. Hemoglobin levels in the root nodules are said to compare with those in the pea (Postgate, 1971). Bark grown in Natal yields 6.7–11.3% tannin. The pollen may be allergenic.

Description

Medium sized tree 15–20 m or more tall, the trunk straight, to 30 cm in diameter. Closely resembling *C. equisetifolia*, but the fruiting cones are much smaller (ca 10 mm long), globular, very regular, with prominent valves. Scale leaves 8–10, whorled at the nodes, minute. Male flowers crowded in rings equipped with grayish scales, each with one exposed brown stamen, less than 0.5 mm long, with two minute brown scalelike sepals. Seeds pale brown, ca 440,000–550,000/kg.

Germplasm

Reported from the Australian Center of Diversity, the river sheoak, or cvs thereof, is reported to tolerate acid soils, alkaline soils, calcareous soils (perhaps chlorotic), drought, muck, sanddunes, salt, weeds, and wind. This species is more cold tolerant than the other Casuarinas grown in Florida (NAS, 1983e). In South Africa, it is said to be hardy to drought and frost. Not as salt tolerant as *Casuarina glauca*. ($2n = 18$)

Distribution

Native to eastern and northern Australia, growing from southern New South Wales (latitude 37°S) to northern Queensland (latitude 12°S). It often fringes freshwater streams and rivers on both sides of the Great Dividing Range. A distinct race., possibly a separate species, occurs along larger rivers in higher rainfall areas of the Northern Territory (NRC, 1982). Introduced in Argentina, Arizona, California, Chile, Egypt, Florida, Israel, Mexico, Morocco, South Africa, Zimbabwe.

Ecology

Ranging from Warm Temperate Dry to Moist through Tropical Thorn to Dry Forest Life Zones, the river sheoak is reported to tolerate annual precipitation of 5 to 15 dm. Has survived temperatures of -8°C with no apparent injury. Said to tolerate up to 50 light frosts per year. Usually occurs in alluvial soils varying from silty loams to sands and gravels. *Casuarina* spp. have been observed as the first higher plant species to populate newly formed coral atolls in the Pacific (Postgate, 1971).

Cultivation

In Hawaii seed are broadcast in spring and covered lightly with less than one cm soil. A seedling density of ca 200–325/m^2 is recommended, but final densities should, of course, be much thinner (Ag. Handbook 450). Molybdenum is necessary for dinitrogen fixation.

Harvesting

In continental U.S., seed bearing age is 4–5 years and flowering peaks from April–June, fruiting from September–December. Good seed crops occur annually (Ag. Handbook 450). Timber can be harvested as needed. Litter and firewood is often gathered as the accumulation justifies.

Yields and Economics

No data uncovered.

Energy

Casuarina spp. have very dense wood, with specific gravity 0.8–1.2, calorific value of ca 5,000 kcal/kg, splits easily, and burns slowly with little smoke or ash. It also can be burned when green, an important advantage in fuel short areas. From their fourth year, trees shed ca 4 tons cones/year. These too make good pellet-sized fuel (NAS, 1983e). *Casuarina* spp. are good for charcoal, losing only 2/3 their weight, compared to 3/4 for most woods.

Biotic Factors

Browne (1968) lists *Perna exposita* (Lepidoptera), and *Hystrix africaeaustralis* (Mammalia). Agriculture Handbook No. 165 lists the following diseases for *Casuarina* spp.: *Armillaria mella* (root rot), *Sorosporium saponariae* (flower smut), *Synchytrium chiltoni* (leaf gall), *Synchytrium stellariae,* and *Ustilago alsinaea* (seed smut). Curly Top, Spotted Wilt, and Yellows viruses are also listed.

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Casuarina glauca Sieber

Casuarinaceae
Swamp sheoak

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Has been recommended as a good candidate for restoring Haiti's eroded mountainsides and providing charcoal, fuelwood, and poles so desparately needed there. Grown as an ornamental, windbreak, and for cattle shade in southern Florida (but some Florida counties have laws banning its planting). In South Africa it is used for firewood, poles, reclamation, shelterbelts, timber, and windbreaks. Egyptians use the trees in rows for shelterbelts. To check spread by root suckers, they dig a ditch between the crop and the shelterbelt, allowing their goats and sheep to eat the exposed shoots before they become pests. The brownish timber is nicely marked and is used for fencing rails, shingles, and salt water pilings.

Folk Medicine

No data available.

Chemistry

Modulated seedlings of *C. glauca* increased their shoot N-content (proportional to protein content) by a factor of about 13 following the appearance of the nodules. Pollen may be allergenic.

Description

Erect tree 10–15 (-30) m tall, the main stem moderately straight, often buttressed and fluted, the bark often cracked and flaky, the crown relatively sparse and narrow. Slender deciduous branchlets (ca 1 mm diameter) have 9–20 leaf teeth in remote whorls, short and broad, always tightly appressed. Male spikes dense, 1–2 1/2 cm long. Cones more or less cylindrical, ca 1–2 cm in diameter, much broader than long; valves 3–5 mm wide, in only 2 or 3 wheel-like rows. Seeds ca 700,000–970,000/kg.

Germplasm

Reported from the Australian Center of Diversity, swamp sheoak, or cvs thereof, is reported to tolerate high pH, limestone, low pH, salt and sanddunes, waterlogging, weeds, and wind. According to NAS, (1983e), this is a pest, in Florida. In Hawaiian pastures, where it spreads by root suckers, it is less cold-hardy than *C. cunninghamiana*. Still, it is said to be hardy to drought and frost in South Africa (NAS, 1983e). In fine-textured clays, even in waterlogged soils, *C. glauca* can develop a deep root system, while *C. cunninghamiana* and *C. equisetifolia* develop shallow roots and grow poorly. ($2n$ = 18)

Distribution

Found in a narrow belt hugging the coast of eastern Australia from Bega in New South Wales to Rockhampton in Queensland. It has also been successful in the marshes and saline soils of Israel, Cyprus, India, Kenya, Malawi, South Africa, Florida, and Egypt. Most common at edges of swampy flats near estuaries and tidal rivers; sometimes found on or near beach fronts. The flats may be only marginally above tidal limits; the water table is usually close to the surface (often with 30 cm of the surface).

Ecology

It grows naturally on estuarine plains that are flooded with brackish tidal water, and also thrives on dunes at the seaside, often in the path of ocean spray. Ranges from sea level to 900 m in Hawaii. Reported to tolerate annual precipitation of 5 to 40 dm, estimated annual temperature of 18 to

28°C, and pH of 5 to 8. Rarely tolerates temperatures lower than -3°C. It has grown in Israel under a soil crust of salt (50,000 ppm). Although most natural stands are on acidic soils, it has grown well on alkaline clay-loam soils with shallow water tables in hot, semiarid areas of Central Australia. Thailand seedlings have tolerated high Ca levels and as much as 30% limestone. In southern Florida it flourishes on oolitic limestone. In Hawaii it is frequently planted on much weathered parent basalt in eroded blowouts, sometimes in holes blasted by dynamite. It also does well in pure limestone sand (NAS, 1983e).

Cultivation

In Hawaii seed are broadcast in spring and covered lightly with less than one cm soil. A seedling density of ca 200–325/m^2 is recommended, but final densities should of course be much thinner (Ag. Handbook 450).

Harvesting

In continental U.S., seed bearing age is 4–5 years and flowering peaks from April–June, fruiting from September–December. Good seed crops occur annually (Ag. Handbook 450). Timber can be harvested as needed. Litter and firewood is often gathered as the accumulation justifies.

Yields and Economics

In Israel this outperforms other *Casuarinas*, reaching 20 m in 12–14 years, even on saline water tables. Based on what I read about other species, I would expect about 4 MT of litter and at least 4 MT wood per hectare per year under moderate management.

Energy

Casuarina spp. have very dense wood, with specific gravity 0.8–1.2, calorific value of ca 5,000 kcal/kg, splits easily, and burns slowly with little smoke or ash. It also can be burned when green, an important advantage in fuel short areas. From their fourth year, trees shed ca 4 tons cones/year. These, too, make good pellet-sized fuel (NAS, 1983e). Although N-nodulation is most successful at pH 6 to 8, some natural stands are well nodulated in acid soils (pH ca 4). Some of the root-suckering *Casuarinas* are discouraged except where the wood is needed. But in fuelwood plantations, cut trees rapidly regenerate from root sprouts and do not have to be replanted.

Biotic Factors

Browne (1968) lists the fungus *Fomes badius*. This species is reported to be less susceptible to the wilt and dieback attributed to the bacterium *Pseudomonas* on *Casuarina equisetifolia.*

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*Casuarina junghuhniana*Miq.

Casuarinaceae
Jemara (Indonesian)

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Introduced to Zimbabwe for street and roadside plantings and windbreaks, the species may help solve the fuelwood shortage. Introduced to Thailand around 1900 as an ornamental tree, now extensively used to reclaim land abandoned after mining, as well as for village firewood production. It was taken from Thailand to India ca 1970 for fuel for the tea-drying industry.

Folk Medicine

No data uncovered.

Chemistry

No data uncovered.

Description

Tree to 35 m tall, 1 m DBH, the stem rather straight, the crown often symmetrically conical.

Germplasm

Reported from the Indochina-Indonesia Center of Diversity, jemara, or cvs thereof, is reported to tolerate clay, drought, monsoon, poor soil, salt, sand, screes, and weeds.

Distribution

Native to highlands of eastern Indonesia—to East Java, Bali, and the lesser Sunda Islands, where it occurs in extensive pure stands on mountain summits. It pioneers the natural revegetation of deforested grassland, volcanic ash and sand, gravelly stream beds, and screes. In manmade grassland it has extended its area manyfold, at the cost of mixed mountain forest and scrub-forest that formerly prevailed. Introduced to Thailand around 1900 (NAS, 1983e).

Ecology

There are commercial plantings in salt marsh areas, sometimes inundated with saline water (NAS, 1983e), but in its native habitat it ranges up to 3,000 m. It is reported to tolerate annual precipitation of 7 to 15 dm.

Cultivation

Propagated by cuttings in India and Thailand. Cuttings allow the perpetuation of superior traits, and also allow plantings of a single sex, avoiding weed potential through the spread of natural seedlings (NAS, 1983e). In India, clusters of shoots (sprigs) are dipped in rooting hormone (or not) and placed in a humid atmosphere, e.g. a sealed plastic tent in light shade under coconut. Rooting in about 20 days, they can be outplanted. Can be propagated by coppice or root sprouts as well. Inoculation may be necessary.

Harvesting

Based on experience with other species, I suspect that seed bearing age is 4–5 years and flowering peaks from April–June, fruiting from September–December. Good seed crops occur annually (Ag. Handbook 450). Timber can be harvested as needed. Litter and firewood may be gathered as the accumulation justifies.

Yields and Economics

No data available.

Energy

As with other *Casuarina* spp.

Biotic Factors

As with other *Casuarina* spp.

References

- Agriculture Handbook 450. 1974. Seeds of woody plants in the United States. Forest Service, USDA. USGPO. Washington.
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Antimicrobial and Cytotoxic Activity of the Extracts of Khat Callus Cultures

Hamid Elhag, Jaber S. Mossa, and Mahmoud M. El-Olemy*

Khat, (*Catha edulis* Forssk., Celastraceae) is an evergreen tree indigenous to East Africa and Yemen. The fresh young leaves are commonly chewed, known as the Khat habit, to alleviate hunger and to produce stimulating effects (CNS). Such effects were shown to be due to phenylalkylamine alkaloids, primarily cathinone (Kalix 1990; Crombie et al. 1990). Habitual use of khat is often associated with social and medical problems (Shadan and Shellard 1972).

Previous work on khat cultures, in our laboratories, has dealt with in vitro micropropagation (Elhag 1991) and the production of secondary metabolites by micropropagated plantlets and callus cultures (El-Domiaty et al. 1994). In the course of our work with khat tissue cultures, the production of dark colored pigments was observed as a typical characteristic of the callus culture (Elhag and Mossa 1996). The present investigation deals with the isolation, identification, and biological effects of such pigments.

METHODOLOGY

Callus Culture

Leaves from young twigs of micropropagated greenhouse grown plants (Elhag 1991) were used as explants for callus induction and as fresh material for extraction and chemical analysis. As described previously by El-Domiaty et al. (1994) callus induction from leaf sections was best achieved on MSB5 basal medium (Murashige and Skoog inorganic salts with Gamborg-B5 vitamins) supplemented with 3.0 mg/L of either IBA (indolebutyric acid) or NAA (naphtalene acetic acid). PVP (polyvinylpyrrolidone) at a concentration of 0.1% in the medium was found beneficial in enhancing callus growth. However, PVP was excluded from the culture medium after the establishment of proliferating cultures. Callus tissues collected form several subcultures on IBA or NAA-containing media were used for extraction and analysis of pigments.

Extraction and Isolation

The freeze-dried powdered callus of *C. edulis* (25 g) was extracted with MeOH at room temperature. The MeOH extract was evaporated and the residue (3.9 g) was partitioned between $CHCl_3$ and H_2O. The dark brown residue (0.89 g) left after evaporation of $CHCl_3$ was chromatographed on silica gel column (2 × 20 cm) and eluted with $CHCl_3$ (300 ml) and $CHCl_3$ containing a trace of acetic acid (10:0.01, 200 ml). Two fractions were collected, fraction A (230 mg) and fraction B (110 mg). Fraction A (containing the pigments) was further chromatographed on reversed phase silica gel (C-18, 25–40 μ) using medium pressure column (2 × 18 cm, 75% MeOH in 5% aqueous acetic acid) with a flow rate of 3 ml/min. Upon evaporation, fractions eluted between 25–60 ml gave 32 mg of compound 1 (0.13%), while fractions 120–175 ml gave 120 mg of compound 2 (0.48%).

Antimicrobial Assays

Evaluation of the antimicrobial activity of callus extracts (petroleum ether, $CHCl_3$, MeOH, and aqueous successive extracts) and the isolated compounds 1 and 2 was conducted according to the disk diffusion and agar dilution methods (Mitscher et al. 1972; Jayasuria 1988). Chloramphenicol and streptomycin were used as positive controls. The solvent DMSO was used as the negative control for all the experiments. The bacteria used were obtained from the National Collection of Type Culture (NCTC), Central Public Health Laboratory, London; and the Center for Disease Control, Atlanta, Georgia, US. The minimum inhibitory concentration (MIC) of the two compounds (22β-hydroxytingenone and tingenone) was determined by the two-fold serial dilution assay (Hufford et al. 1975). The MIC was taken as the lowest concentration that inhibited growth after 48h of incubation at 37°C for *B. subtilis, S. aureus*, and *S. durans* and after 72 hr for *Mycobacterium* strains.

Cytotoxicity and Anti-HIV

The assays were performed according to the standard procedures of the in vitro primary screen of NCI (Weislow et al. 1989; Grever et al. 1992).

EXPERIMENTAL RESULTS

Extract Identification

Khat callus produced on MSB5 medium containing IBA or NAA continued to proliferate as compact hard clumps with snow-white top surfaces and dark-pigmented lower parts. The dark pigments partly diffused into the medium at the point of contact with the agar medium. This dark pigmentation was thought to result from the high content of polyphenols (tannins) that is known for the intact plant (El-Sissi and Abdalla 1966). However, the initial TLC (Si gel, EtOAc-HCOOH-H_2O, 90:6:5) screening of the EtOH extract of the callus detected only a trace of the polyphenolic precursors of tannins gallocatechin and epigallocatechin. On the other hand, intact khat plants did not show the same pigments detected in the callus (TLC : Si gel, EtOAc-HCOOH-toluene, 9:1:10).

The MeOH extract of the freeze-dried callus was fractionated between H_2O and CHC_3. The colored chloroformic fraction yielded two orange pigments using combined normal and reversed phase chromatography. Compound 1 gave, $[\alpha]_D$ -317.4°; UV spectrum [λ_{max} MeOH; 420, 286. and 246 nm], suggested the presence of a chromophore. IR spectrum showed bands at ν_{max} 3400 (OH), 1710 (carbonyl), and 1580 cm^{-1} (conjugated C = C). The UV spectrum and IR bands, in addition to the positive Liebermann-Burchard test suggested a quinone methide triterpene structure (Gonzalez et al. 1983; Fernando et al. 1988; Likhitwitayawuid et al. 1993). This suggestion was substantiated by the presence of proton signals at δ 6.55 (d, *J* = 2, Hz, H-1), 7.07 (dd, *J* = 7 & 2 Hz, H-6), and 6.36 (d, *J* = 7 Hz, H-7) in the ^{1}H-NMR spectrum ($CDCl_3$) (Likhitwitayawuid et al. 1993). The ^{1}H-^{1}H COSY showed a proton signal at δ 4.56 (d, *J* = 5 Hz, H-22) correlated to the signal at δ 3.66 (which is not directly correlated to any carbon signal in ^{1}H-^{13}C HETCOR), while the proton at δ 4.56 correlated to the signal at δ 76.4 in the ^{13}C NMR spectrum, (C-22). Thus the proton signal at δ 4.56 should be assigned to H-22 and the signal at δ 3.66 to OH proton. Compound 1 was thus identified as 22β-hydroxytingenone; this was confirmed by direct comparison with the reported spectral data (Kutney et al. 1981; Bavovada et al. 1990; Likhitwitayawuid et al. 1993).

Compound 2 gave $[\alpha]_D$-307.4°; its UV spectrum [λ_{max}) MeOH : 420, 286 and 252 nm], was quite similar to that of compound 1, suggesting the presence of a similar chromophore, IR spectrum of compound 2 showed the same characterstic bands of 1. ^{1}H- and ^{13}C-NMR data of compound 2 were similar to that of 1 except that 2 showed the absence of hydroxyl group at C-22, as it appeared at δ 52.6 in ^{13}C-NMR and one of the H-22 protons appeared at δ 2.92 (H, d, J= 14 Hz) in ^{1}H-NMR. Compound 2 was thus identified as tingenone; this was confirmed by comparison with reported data (Gonzalez et al. 1975; Kutney et al. 1981; Ngassapa et al. 1994).

Antimicrobial Activity

Initial antimicrobial screening of the crude callus extracts was conducted using the disk diffusion method and was confirmed with bioautography (Jayasuria 1988). The highest growth inhibition was found in the petroleum ether and chloroformic successive extracts, the latter being more active. Further fractionation and purification of the chloroformic-soluble fraction of the methanolic extract (as described in Materials and Methods), resulted in the isolation of two active compounds (1) and (2). The isolated compounds were identified as 22β-hydroxytingenone (1) and tingenone (2) by various spectral methods. Both compounds exhibited significant activities against *B. subtilis*, *S. aureus*, and *S. durans* (MIC 0.6 μg/ml), being more potent than the positive control chloramphenicol (Table 1). Both compounds were also found to be more potent against *Mycobacterium* species (MIC was 5.0 μg/ml for both compounds) than the positive controls, streptomycin and isonicotinic acid hydrazide (Table 1). However, both compounds; were found to be inactive against the gram-negative bacteria *E Coli* and the fungus *C. albicans* (Table 1).

Table 1. MIC values for 22β-hydroxytingenone (compound 1) and tingenone (compound 2) isolated from khat callus cultures.

Microorganisms	MIC values (μg/ml)		Streptomycin	Chloramphenicol	Isonicotinic acid hydrazide
	(1)	(2)			
B. subtilis [z]	0.6	0.6	NT[x]	4.0	NT
S. aureus [z]	0.6	0.6	NT	8.0	NT
St. durans [z]	0.6	0.6	NT	4.0	NT
M. chelonei [y]	5.0	5.0	10.0	NT	10.0
M. smegmatis [y]	5.0	5.0	10.0	NT	10.0
M. intracellulare [y]	5.0	5.0	10.0	NT	10.0
M. xenopi [y]	5.0	5.0	10.0	NT	10.0
E. coli	inactive	inactive	NT	NT	NT
C. albicans	inactive	inactive	NT	NT	NT

[z]MIC values after 48 hr of incubation at 37°C
[y]Incubated for 72 hr at 37°C
[x]NT = not tested.

Cytotoxic Activity

Compounds 1 and 2 have been reported to have cytotoxic activity (Kutney et al. 1981, Bavovada et al. 1990; Ngassapa et al. 1994); however, compound 1 was tested only against a few cancer cell line systems (Bavovada et al. 1990). In the present study, compound 1 was therefore tested using

NCI (USA) in vitro primary anticancer and anti-HIV screening. Table 2 shows that 22β-hydroxytingenone (1) exhibited significant cytotoxic activities against leukemia (ED_{50} 0.54 μg/ml) and prostate cancer (ED_{50} 0.85 mg/ml), while the least activity was observed against non-small cell lung cancer (ED_{50} 4.4 μg/ml). While compound 1 showed non-selective broad cytotoxicity against all tested panels (Boyd and Paul 1995), it was inactive when tested against HIV virus. Tingenone 2, was also shown to exhibit strong non-selective broad cytotoxicity against several cancer cell-line systems (Ngassapa et al. 1994).

Table 2. Results of antitumor evaluation of 22β-hydroxy-tingenone in the NCI in vitro primary screen.

Panel	ED_{50} (μg/ml)
Leukemia	0.54
Non-small cell lung cancer	4.4
Colon cancer	1.31
CNS cancer	3.3
Melonama	1.71
Ovarian cancer	2.35
Renal cancer	1.61
Prostate cancer	0.85
Breast cancer	1.11

CONCLUSIONS

The cultural conditions for khat callus induction and growth were established. Best callus induction and growth occurred on MSB5 medium supplemented with 3.0 mg/L of either NAA or IBA. The production of dark pigments was observed at the start of callus induction and continued with subcultures as a typical characteristic of khat callus.

The isolation of 22β-hydroxytingenone and tingenone from khat callus cultures is reported for the first time. They could not be detected in the mother plant grown in the greenhouse. The crude callus extracts and the isolated compounds, 22β-hydroxytingenone (compound 1) and tingenone (compound 2), showed high antibacterial activity against gram positive and myocbacteria and broad cytotoxic activity against several cell-line systems.

Large scale production of khat cultures for the commercial production of such biologically active components is a promising system worthy of further investigation. It would be ironic if khat, which is considered a plant of abuse, turned out to be a miracle plant with efficacious medical properties.

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back

Cowpea

Leguminosae *Vigna sinensis* (Torner) Savi

Catjan

***V. cylindrica* (L.) Skeels**

Asparagus bean

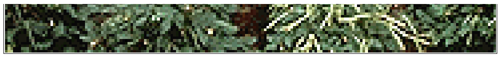
***V. sesquipedalis* (L.) Fruwirth**

Source: Magness et al. 1971

These species are grown as vegetables for food and are listed there. They are also important hay, pasture and soil improvement crops. The 3 species are very similar in growth habit and culture. Cowpea is the one mainly grown and all three are often termed cowpea in this country. All are annuals native to southern Asia that have been long grown under cultivation. Cowpeas were present in the Southeastem States as early as 1714. Formerly, cowpeas were much more grown in this country than at present. Near 5,000,000 acres were planted annually during the decade of the 1930's, while recent plantings are only about 10% of that figure.

The plants are generally near prostrate and vining although upright varieties are available. The trifoliate leaves are long stemmed. Leaflets are generally somewhat heai-t shaped, up to 6 inches long and 4 inches wide. Pods are long, slender and glabrous. Plants require a long, warm growing season, so cultivation is mainly in the "Cotton Belt." Cowpeas are palatable and nutritious both for pasture and hay. They also constitute an important soil improvement crop.

Last update February 18, 1999 by ch



Catjang

Leguminosae *Vigna sinensis* (Torner) Savi (Cylindrica group)

Source: Magness et al. 1971

The catjang is closely related to southern pea, which see. The plant and culture are similar. The pod of catjang is smaller, 3 to 5 inches long, and the seeds also are smaller. Catjang is grown mostly for feed, but is also grown for the seeds, used as food. The seeds are harvested at the green shell stage or when ripe, as are southern peas.

Season, bloom to harvest: Green shell, 15 to 20 days. Dry beans, 30 or more days.

Production in the U.S.: No separate data - included with southern peas.

Use: Green shell canned or frozen as cooked vegetable. Dry beans as cooked vegetable.

Part consumed: Seeds only as food; whole plant for feed.

Last update February 18, 1999 by ch

Nepeta cataria L.

Labiatae

Catnip, Catmint, Catnep

We have information from several sources:

Production of Catnip in North Carolina—J.M. Ferguson, W.W. Weeks, and W.T. Fike

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

New Crop FactSHEET

Cat's Claw

Contributors: Kerry Hughes and Tony Worth

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Common and Regional Names

Common:

Cat’s claw, uña de gato.

Regional:

Unicaria guianensis - garabato blanco (Loreto, Peru), uña de gato del bajo (Ucayali, Peru), uña de gavilán, garabato gavilán, garabato casha, auri huasca, tambor huasca, unganangui, ancajsillo, ancayacu, kugkuukjagki, jijyuwamyuúho.

Unicaria tomentosa - Garabato colorado (Loreto, Peru), uña de gato de altura (Ucayali, Peru), garabato amarillo (Inca), samento, tsachik, paotati-mösha, misho-mentis, jipotatsa, unganangui.

Both species- bejuco de agua (Ucayali, Peru), garabato (San Martin, Peru), garra gavilán (Inca), deixa paraguayo (Inca), torõn.


The head of the Yanesha cat's claw council, Walter Gabriel Camaña, stands next to a cultivated young cat's claw vine in traditional dress

Scientific Names

Species:

Uncaria guianensis (Aublet) Gmeliu

syn: *Ourouparia guianensis* (Aublet)

Uncaria tomentosa (Willdenow ex Roemer & Shultes) D.C.

syn: *Nauclea oculeata* H.B.K.; *Nauclea tomentosa* Willdenow ex Roemer & Shultes; *Ourouparia tomentosa* (Willdenow ex Roemer & Shultes) Shumann

Family: Rubiaceae

Uses

Cat’s claw is used commercially as a medicinal herb primarily for immune system stimulation. Other therapeutic applications for cat’s claw are many, which is a common trait of herbs with immune stimulatory activity, and include: disease prevention, cancer, recovery from chemotherapy side effects, recovery from childbirth, urinary tract infections, wounds, fevers, hemorrhages, and weakness. Applications for cat's claw which have had some clinical research include viral infections, pain and symptoms of Herpes infections, and for inflammatory conditions, such as Rheumatoid arthritis. Pharmacological activities that have been found in cat's claw are anti-inflammatory, immune system stimulation, cytoprotection and antioxidant. Recently, a couple new trademarked products have come into the dietary supplement market in the United States with new clinical research on new uses for cat's claw. One is called C-MED 100™, and it is a new proprietary extract which is standardized with much higher levels of carboxyl alkyl esters. In clinical studies, this extract has been found to have a greater normalizing effect on the immune system than a regular extract of cat's claw.

Products of Commerce

- Stem bark (most commonly)
- Root bark (rarely)

Origin

Cat's claw has been reported growing in the Western countries of the Central and South American continent as far North as Belize, and South into Paraguay. Marañao, Brazil, is the most Eastern area cat's claw has been reported to grow naturally.

Uncaria tomentosa is found between 02° 55' 00"–12° 50' 00" latitude S., and 69° 20' 00"–77° 00' 00" longitude W.; and *U. guianensis* is found between 00° 09' 00"–13° 06' 00" latitude S., and 69° 04' 00"–78° 19' 00" longitude W.

Crop Status

A perennial vine, or tropical liana; rarely cultivated, cat's claw is generally harvested from primary forest, secondary forest, or managed forest. These species are commonly called "cat's claw" (or uña de gato) because of their claw-like torns. Overwhelmingly, most of the commercial supply of cat's claw comes from Peru, although, other countries are now showing interest in producing cat's claw.

The product sold in international commerce is the bark of both the *U. tomentosa* and *U. guianensis*, although *U. tomentosa* is the most sought after. This is due to a general belief in the marketplace that *U. tomentosa* has a more favorable alkaloid profile, but this is not agreed upon, nor verified experimentally. There exists small local markets in Peru for furniture made from the lianas. The market for the bark has gone through a heavy increase in 1996, and then a large drop off (see **Table 1**), spurred by concerns in quality and lack of interest in the herb.

Table 1. Exportation of cat's claw, according to INRENA*, Peru.

Year	Volume (Kg)
1999†	64,457.20

1998	282,164.00
1997	275,562.00
1996	347,602.00
1995	726,685.00
1994	20,743.00

† values figured through March of that year.
* Instituto Nacional de Recursos Naturales (INRENA), Lima, Peru.

In Peru, INRENA, the natural resource department of the government of Peru, passed legislation in March of 1999 which banned the export of the raw material without the approval of management plans. This halted official trade of the raw material of cat's claw from Peru for several months until management plans began to achieve approval.

Regulatory Status

Cat's claw is permitted for use as a dietary supplement because it is an herb, as specified by the Definition of Certain Foods as Dietary Supplements, in Section 3 of DSHEA (The Dietary Supplement Health and Education Act; 1994) Furthermore, cat's claw is not a new ingredient in the United States dietary supplement market (it was introduced in the late 1980's), so no DSHEA section 8 filing on reasonable safety is required.

Toxicities

Cat's claw is listed as a class 4 herb by the American Herbal Products Association Botanical Safety Handbook, which means they believe the published data is insufficient thus far for them to establish toxicity. However, cat's claw is generally thought of as safe, with an LD_{50} of the aqueous extract in mice greater than 16 g/kg. Patients on immunosupressive therapy or other treatments with animal hormone, peptide, or protein products are urged to use caution with cat's claw due to its immune stimulating activity.

Traditional Medicinal Uses

The traditional use of cat's claw extends back through untold generations of several indigenous groups in tropical South America. Though several groups are familiar with cat's claw and its uses, two have received the most amount of attention for its ethnomedical use in Peru, the Ashaninka and the Yanesha. The medicinal uses of the stem and root bark that are most well-known to indigenous people are for inflammations (especially rheumatism), arthritis, urinary tract infections and gastric ulcers. Cat's claw has also been used for cleansing the kidneys, recovery from childbirth, as a wash for wounds to promote healing, skin "impurities", blood purifications, asthma, disease prevention, hemorrhages, menstrual irregularity, "loose" stomach, fevers, and for a normalizing effect on body systems. Cat's claw is also noted to be used in spiritual illness, to remove disturbances between the body and spirit which are the main cause of disease. In addition, as our modern understanding of cat’s claw has evolved, so has it evolved by indigenous peoples who report cat’s claw as good for cancer and for lessening side effects of antibiotics and chemotherapy. Some indigenous groups only use the water stored in the stem to quench thirst, and as a restorative drink.

Botany

Taxonomy

U. guianensis

A woody perennial vine or creeping shrub found mostly in secondary forest. External bark with superficial fissures; internal bark is fibrous and golden brown. The sap is watery with an astringent taste. Terminal branches are quadrangular, with a pale rosy green color; glabrous. Leaves are simple, opposite and distinct, elliptic to elliptic-oblong in shape; 7.8–18.5 cm in length, 4.6–9.5 cm in width. Leaf margins are entire with an acute apex, and an acute to acute-round base. Stipules are lanceolate shaped and 8–14 mm long and 3–5 mm wide. Spines are woody and strongly curved in the form of a hook, 4–26 mm long and 2–5 mm wide. Inflorescences are arranged in racemes or apexes of spherical umbels; terminal or axillary; 10–20 cm in length (inflorescences) and 1.5–4 cm in diameter (umbel), with glabrous peduncles. Flowers are bisexual and actinomorphic on 4 mm long pedicels. Calyx with jointed sepals, tubular to bell-shaped, 5–10 mm long and 3-5 mm in diameter. Corolla has jointed petals; 7–13 mm long and 3–5 mm in diameter; red-orange with a smooth interior and an exterior that is smooth on the bottom, with the top 1/3 with villous hairs. Adroecium has 5 subsessile stamens, adnate to the throat of the corolla. The pistil has an ellipsoid stigma, 1.5 mm. in length; inferior ovary. The fruits are dry and dehiscent, elliptical capsules; 10–12 mm long and 4–6 mm wide with numerous seeds, 6-8 mm long and 0.8-1.4 mm wide.

U. tomentosa

A large woody vine or creeping shrub, typical of primary forest, but also found in disturbed forest and rarely in secondary forest. The external bark has superficial longitudinal fissures, and the internal bark is fibrous, with the ground bark the color golden yellow. The sap is watery and astringent in taste. The terminal branchlets are quadrangular and yellow-green in color. The leaves are simple, opposite and distinct; oblong, oblong-ovate, or elliptic; 7.5–17 cm in length and 5–12 cm in width. The leaf margins are entire; apex is acute, or rarely acumate; base is round and/or cordate. The stipules are deltoid, 6–12 mm long and 4–8 mm wide. The spines are woody, occur in pairs, are slightly curved but straight, and pointy; 8–10 mm in length and 3–6 mm in width. The inflorescences occur in racemes or globular cymes, are axilarary and/or terminal, 7–18 cm in length, 1.5–2.5 cm in diameter. Flowers are bisexual, actinomorphic and sessil. The calyx is gamosepalous, tubular, 1–1.5 mm in length and 0.8–1 mm in diameter. The corolla is gamopetalous, 7–13 mm in length, 3–5 mm in diameter, with 5 round lobes; yellow. Stamens are sessil; 5-fused to the throat. The anthers are oblong with prolonged and divergent bases; 1–1.2 mm in length and 0.3–0.4 mm in width. The stigma is ellipsoid, 0.5 mm in length, with linear 4 mm long styles; inferior ovary. The fruits are dry and dehiscent; elliptic capsules; 5–8 mm long and 3–6 mm wide.

Crop Culture

Ecology

Cat’s claw is sometimes cultivated or managed in tropical forests of South America. *U. guianensis* may be cultivated in secondary forests with full sunlight, but *U. tomentosa* requires more shade, as it is found more often in primary forest. *U. tomentosa* primarily grows naturally in the following Holdridge life zones: tropical (bh-T and bmh-T), premontane tropical (bh-PT and bmh-PT), and the subtropical forest (bh-S). *U. tomentosa* prefers the following soil types: Ortic Acrisols, Distric Cambisols and Fluvisols; soil texture: 34–76% sand, 20–40% silt, and 4–38% clay; and a pH of 5.2–7.7. *U.guianensis* is primarily found in the following Holdridge life zones: tropical (bhT and bmh-T), premontane tropical (bh-PT and bmh-PT), and subtropical (bh-S, bmh-S and bp-S). It prefers Ortic Acrisols, Distric Cambisols and Fluvisols; soil textures of 34–78% sand, 8–48% silt, and 4–38% clay, and a pH of 4.4–6.2.

Cultivars and Chemotypes

There are no cultivars offered in agricultural trade; however, two chemotypes have been identified of Peruvian *U. tomentosa*: a tetracyclic oxindole alkaloid type (tetracyclica) and a pentacyclic oxindole alkaloid type (pentacyclica). It has been found that the pentacyclic alkaloid type is immunopotentiating; whereas, the tetraacyclic alkaloid type is immunosuppressing. In the traded product, these chemotypes have largely been ignored. The subject of which chemical profile is better, the stem vs. the root, is largely irrelevant due to the difficulty of trade in the root material of cat’s claw. The leaves have not been found useful commercially, however, there are groups in Lima who are researching this for possible commercial uses.

Guisella T. Brell of the Agrarian University of La Molina is involved in the micropropagation of cat’s claw (see selected experts). Transgenic cat’s claw root has been micropropagated in bioreactors, but this technology is still in the developmental stage, and is not yet commercially viable.

Production Practices

Generally, the propagation of the seed is difficult because viability rapidly declines after dehiscing, so cat’s claw is usually propagated asexually by cuttings. Eight-inch sections of the stem are cut for planting as cuttings. If the soil of the forest is moist enough, cuttings are said to be easy to reproduce by directly inserting them into the forest floor. If the conditions are right, the roots develop soon after transplant. However, others recommend reforesting cat’s claw through the use of natural regeneration. For natural regeneration, sufficient sunlight (canopy openings) is needed. In this case, the forest may be thinned to allow for easier natural regeneration, or cat’s claw may be allowed to grow in secondary forests where more sunlight gaps exist. Very few, if any, commercial plantations of cat’s claw exist. Most material is harvested in forests. Yield in managed forests depends on density, and densities that have been reported for *U. tomentosa* range from 2 to 8 individuals per hectare in natural forest, and 17 individuals per hectare in managed forest.

Sustainable management of cat’s claw is becoming an issue in Peru, due to the popularity of this botanical medicine. INRENA requires management plans for the harvest and trade of cat’s claw, and more studies on the effect of harvest to the natural ecosystem are needed to assure sustainability.

Harvesting

Today, the root is not normally harvested because of the destructiveness of this method of harvest. The primary product in trade comes from the stem bark. Although there are different chemotypes found in the field, there are no known morphological differences to distinguish them. Generally, it is recommended that the vine is cut at 8 inches to a meter above the ground and left to regenerate. Vines are only harvested at 8 or more years old, otherwise the diameter of the vine is not sufficient for bark removal. As a regular practice, the cut vine is stripped of its bark in the field due to the weight of carrying out the whole vine, and the inner stem is disgarded. In Iquitos, this practice is currently opposite due to local commercial use of the inner stem for furniture making. The stem bark is not harvested commercially in Iquitos because it is too expensive to transport cat’s claw to Lima.

Processing

The Association for the Conservation of the Patrimony of Cutivireni (ACPC) recommends the following processing procedure for a quality product: the damaged (infected or punctured) inner bark is disgarded, and the drying is conducted on clean raised surfaces to avoid molding. It is generally dried in the sun or shade, and it is then best packaged in waterproof sacks for shipping.

Germplasm

Collections

La Molina Agrarian University, Lima, Peru. Contact: Guisella T. Brell

Commercial Seed Sources

None known.

Selected Experts

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Typha ssp.

Typhaceae
Cattail

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Most species have been used in many ways by the local cultures, wherever they grow, and they are widely distributed. Rhizomes, in autumn, are rich in starch and constitute a good rootcrop. The pithy core, where rootstock and sprouting new stem join, is eaten roasted or boiled. Abenaki Indians used the juice from the roots; others extracted a jelly. Sprouts are often eaten raw or pickled (Fernald et al., 1958). Paiute ate the flower stalks, pre-pollen, raw or boiled or steamed. Fernald et al. suggest that the pre-pollen flowerstalks have a flavor suggesting both olives and artichokes. Asian Indians, like Amer-indians, are said to make bread from the pollen. The pollen is sometimes substituted for that of Lycopodium. Floss is a good kapok substitute. Leaves used in basketry.

Folk Medicine

According to Hartwell (1967–1971), the roots of *Typha angustifolia* are used in folk remedies for tumors in Chile and Argentina. Reported to be anodyne, anticoagulant, astringent, aphrodisiac, diuretic, emetic, hemostat, refrigerant, sedative, styptic, suppurative, tonic, uterotonic, vermifuge, and vulnerary, cattails are a folk remedy for amenorrhea, bruises, burns, cystitis, diarrhea, dropsy, dysentery, ecchymosis, epistaxis, erysipelas, fever, gonorrhea, hematochezia, hematemesis, hematuria, leucorrhea, measles, metroxenia, ophthalmia, piles, scalds, snakebite, sores, swellings, tumors, vaginitis, wounds, etc. (Duke and Wain, 1981).

Chemistry

Roots of *Typha latifolia contain* 30% starch, 7.8% crude protein, 1% crude sugar, 0.7% glucose, 0.7% oxalic acid. Aerial portions contain 1.5–3.5% fats, 7–12% crude protein, 38–48% carbohydrates. Leaves contain quercetin-3- neohesperidosid, quercetin- and kaempferol-3-glucoside, quercetin- and kaempferol-3-galactoside. The pollen, used both as a medicine and foodstuff, contains 19% crude protein, 17.8% carbohydrates (glucose, fructose, arabinose, rhamnose, xylose) and 1.1% lipids. In the seed oil, linolenic acid and glycerides predominate. The plant is said to be rich in vitamin B1, B2, and C.

Description

Typha latifolia is a perennial herb, from a creeping rhizome, 1–2.7 m tall; leaves flat, sheathing, pale or grayish-green, 6–23 mm wide; staminate (7–13 cm long) and dark brown pistillate (2.5–20 cm long) parts of the spike usually contiguous, in fruit 1.2–3.5 cm thick, its surface appearing minutely pebbled with crowned persistent stigmas and scarcely bristly, pistillate flowers without branchlets among the bristles; stigmas lance-ovate, fleshy, persistent; denuded axis of old spike retaining slender pedicles 1–2 mm long; fruit about 1 cm long, with copious white hairs arising near the base.

Germplasm

Reported from American, African, and Eurasian Centers of Diversity, cattail is reported to tolerate poor soil and waterlogging. ($2n = 30$)

Distribution

Typha latifolia is the common inland species in the USA, inhabiting marshes, shallow water, ditches, and wet wastes along river. It is said to be native throughout the United States, Eurasia, and North Africa. It has been classified as a serious weed in Hungary, a principal weed in Australia, Germany, Italy, Rhodesia, Spain, Tunisia, and a common weed in Argentina, Iran, Kenya, Portugal, and the US (Holm et al, 1979).

Ecology

Ranging from tropical to cool temperate life zones, cattails tolerate annual precipitation of 4 to 40 dm and annual temperature of 6 to 28° (estimated by J. Duke, too few data in computer).

Cultivation

Not currently cultivated, but could be considered as a cultivar for ornament, food, or medicine by those disposed to use the plant. Propagation is usually by division, but the minute reed can be planted in pots in water.

Harvesting

If the rhizomes are to be harvested for energy or food, it is suggested that fall might be the best time for harvesting.

Yields and Economics

According to the phytomass files (Duke, 1981b), annual productivity for *Typha latifolia* ranges from 6 to 20 MT/ha, other species reporting intermediate yields. In Britain, cattail swamps are said to produce 10.7 MT/ha/yr.

Energy

In Alcohol Week (October 20, 1980), there is a headline "DOE MAY FUND CATTAILS-TO-ETHANOL TECHNOLOGY: SEES LOWER COST, BIG YIELDS". The unsolicited proposal from a Florida Junior College suggests that one cattail crop will produce 1,000–1,500 gals/acre/year, while two crops would bring 2,100 to 3,100, and three crops 3,100–4,700 gals/acre, the higher figure representing more than 110 barrels ethanol per acre. While I believe these figures are extremely optimistic, I would endorse a serious study of cattails as a potential energy source. Douglas Pratt is quoted in the Washington Star to recommend several advantages to cattails. "Since they grow in wetlands, cattails do not compete for land that could be used for crops or forests, and drainage is unnecessary. Cattails use some pollutants as nutrients. Cattail farms near sewage treatment plants could clean troublesome nitrogen and phosphorus from effluent. Unlike nuclear power and fossil fuels, cattails do not add heat and carbon dioxide to the earth but recycle them. The plants use the sun's energy and the atmosphere's carbon dioxide to produce starches and sugars through photosynthesis. This heat and gas are returned to the cycle when the cattails are used as fuel. Wetlands are extensive and largely unused. According to one estimate, the United States has 140,000 square miles of wetlands from Alaska to the tip of Florida. Minnesota is estimated to have 10 million acres where cattail could grow, which theoretically could supply enough of them to meet the state's entire energy needs. Harvesting cattails in strips is compatible with preservation of wildlife and makes replanting unnecessary. Cattails spread with underwater stems called rhizomes and each year can recover the harvested strips. Cattails are an annually renewable resource, whereas coal, oil and peat take thousands or millions of years to form." (Washington Star, September 4, 1979).

Biotic Factors

The cucumber mosaic virus has been reported from *Typha angustifolia*, the wheat streak mosiac from *T. latifolia*. Among the fungus diseases on *Typha latifolia* are *Cladosporium*, *Cryptomela typhae*, *Didymosphaeria typhae*, *Gloeosporium* sp., *Guignardia* sp., *Hendersonia typhae*, *Heterosporium maculatum*, *Hymenopsis hydrophila*, *Leptosphaeria* spp., *Leptothyrium typhina*, *Lophodermium typhinum*, *Mycosphaerella typhae*, *Ophiobolus* sp., *Phoma orthosticha*, *Phyllosticta typhina*, *Pleospora typhae*, *Pythiogeton autossytum*, *Pythium helicoides*, *Sclerotium hydrophilum*, *Scolecotrichum typhae*, *Stagonospora typhoidearum*, and *Typhula latissima*. The nematode *Meloidogyne* sp. is also reported.

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 17.81 to 16.31 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the plant contained 71.57% volatiles, 7.90% ash, 20.53% fixed carbon, 42.99% C, 5.25% H, 42.47% O, 0.74% N, 0.04% S, 0.38% Cl, and undetermined residue.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Friday, January 9, 1998 by aw

Pennisetum glaucum (L.) R. Br.

Syn.: *Pennisetum typhoides* (Burm.) Stapf & Hubb. *Pennisetum americanum* (L.) Leeke

Poaceae, or Gramineae

Pearl millet, Bullrush millet, Cattail millet

We have information from several sources:

Pearl Millet: New Feed Grain Crop—David J. Andrews, John F. Rajewski, and K. Anand Kumar

The Use of Protogyny to Make Hybrids in Pearl Millet—David J. Andrews, Barnabas Kiula, and John F. Rajewski

Advances in Grain Pearl Millet: Utilization and Production Research—David J. Andrews, Wayne W. Hanna, John F. Rajewski, and Victoria P. Collins

Evaluation of Pearl Millet for Swine and Ducks—Olayiwola Adeola, Dale King, and Bradley V. Lawrence

Pearl Millet: A Potential Early Maturing Dryland Feed Grain Crop (Abstract)—William D. Stegmeier, B. Khaleeq, R.L. Vanderlip, and D.J. Andrews

Stand Establishment in Relation to Seedling Mesocotyl and Coleoptile Length in Pearl Millet (Abstract)—B. Khaleeq, W.D. Stegmeier, and R.L. Vanderlip

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Progress with Proso, Pearl and Other Millets—David D. Baltensperger

New Crops and the International Agricultural Research Centers—Robert B. Bertram

Pearl Millet: Double Crop for Northern Indiana—Carl Eiche

Pearl Millet: New Feed Grain for Indiana

Weed Control Studies in Pearl Millet—Steve Weller

Pearl Millet Alternative Crop Guide

Pearl Millet In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Pearl Millet from Lost Crops of Africa: Volume I: Grains

Kapok oil

Bombacaceae *Ceiba pentandra* (L.) Gaertn.

Source: Magness et al. 1971

Kapok oil is obtained from the seeds of the Kapok tree, which is a very large, deciduous tropical or semi-tropical tree, now grown in many tropical areas. The fruit is a pod, about 6 inches long and 2 in diameter, which is lined inside with hairs or lint - the kapok fiber of commerce, for which the tree is mainly grown. The seeds are free of lint, and are a byproduct of lint production. Seeds may be crushed for oil locally, or exported. The oil is suitable for the same purposes as cotton seed oil. The press cake and meal are used for cattle feed.

Last update June 31, 1996 by aw

Celandine

Chelidonium majus L.


Figure 37.—Celandine (*Chelidonium majus*)

Other common names.—Chelidonium, garden celandine, greater celandine, tetterwort, killwart, wart flower, wartweed, wartwort, felonwort, cockfoot, devil's-milk, Jacob's-ladder, swallowwort, wretweed.

Habitat and range.—Celandine is found in rich damp soil along fences and roadsides near towns from Maine to Ontario and southward. It is common from southern Maine to Pennsylvania.

Description.—This erect, branched, sparingly hairy herb is from 1 to 2 feet in height, with thin leaves 4 to 8 inches in length, which have a grayish-green appearance and are deeply and variously cleft. The small, sulphur-yellow flowers are produced from April to September, followed by smooth, slender capsules containing numerous seeds. The plant contains an acrid, yellow juice and when bruised has an unpleasant odor.

Part used.—The entire plant, collected when it is in flower.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Malkangni or Peng (*Celastrus paniculatus* Wild)

Pankaj Oudhia
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Scientific Name: *Celastrus paniculatus* Wild.
Family: Celastraceae
English Name: Black-Oil tree, Intellect tree, Climbing-staff plant.
Common Indian Names
Gujarati - Malkangana, Velo
Hindi - Malkakni, Malkamni, Malkangni
Canarese - Kangli, Kangodi, Kariganne
Marathi - Kangani, Malkangoni
Sanskrit - Jyotishmati, Kanguni, Sphutabandhani, Svarnalota
Telugu - Teegapalleru, Malaria teega
Bengali - Malkanjri
Malyalam - Polulavam
Tamil - Valuluvai

Botanical Description: It is an unarmed large woody climber; Leaves simple, alternate, very variable, elliptic, ovate, broadly, obovate or sub-orbicular, glabrous, sometimes pubescent beneath along the venation, up to 6 × 11 cm; base cuneate, obtuse or rounded, apex acute, acuminate or obtuse; panicles large, terminal, pubescent; Male flowers minute, Pale green; Calyx lobes suborbicular, toothed; Petals oblong or obovate-oblong, entire; Disk copular; Female flowers having sepals, petals and disk similar to those of male flowers; Capsule subglobose, bright yellow, trivalved, 3-6 seeded; Seeds ellipsoid, yellowish brown, enclosed in a red fleshy aril.

Useful Parts: Leaves and seeds

Medicinal Uses: According to Ayurveda, leaves are emmenagogue whereas seeds are acrid, bitter, hot, appetizer, laxative, emetic, aphrodisiac, powerful brain tonic, cause burning sensation. Oil enriches blood and cures abdominal complains. According on Unani system of medicine, seeds are bitter, expectorant, brain and liver tonic, cure joint-pains, paralysis and weakness. Oil stomachic, tonic, good for cough and asthma; used in leprosy, cures headache and leucoderma.

Internet Resources

Interactions with the traditional healers of Chhattisgarh, India specialised in treatment of Joint Pains
http://botanical.com/site/column_poudhia/126_jointpain.html

Traditional medicinal knowledge about common plants and animals : The results of recently conducted ethnobotanical surveys in Bastar region, Chhattisgarh, India.
http://botanical.com/site/column_poudhia/185_recent_bastar_surveys.html

Some less known traditional medicinal uses of common herbs used in treatment of Safed Daag (Leucoderma) in Chhattisgarh, India
http://botanical.com/site/column_poudhia/377_safed_daag.html

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Lindley, J. 1985. Flora Medica. Pbl. Ajay Book Service, New Delhi, India. p. 198.

Singh, U; Wadhwani, A.M. and Johri, B.M. 1996. Dictionary of Economical Plants of India. Pbl. Indian Council of Agricultural Research, New Delhi, India. p. 46.

Verma, D.M. Balakrishnan, N.P. and Dixit, R.D. 1993. Flora of Madhya Pradesh. Vol. I. Pbl. Botanical survey of India, Kolkata, India. p. 274.

	Celastrus paniculatus	*Celastrus maytenus*
Plant	Unarmed climbing shrub	Small tree
Leaves	Broadly oval or ovate or obovate, usually with a sudden short acumination, slightly serrated, glabrous	Alternate, simple, coriaceous, evergreen, ovate-lanceolate, tapering a little at the base and very much at the apex, serrated
Flowers	Racemes terminal, compound or supra-decompound, Calyx-lobed rounded, ciliated, margin of the disk thin, free	Axillary, fascicled, herbaceous minute
Capsule	Globose, 3-celled, 3-6 seeded	At the size of a pea, turbinate, cinerous, coriaceous, 2-valved, 2 seeded
Seed	With complete arillus	2, erect, with an orange-coloured aril

Celeriac

Celery root, Turnip-rooted celery, Knob celery

Umbelliferae *Apium graveolens* L. (Rapaceum group)

Source: Magness et al. 1971

Celeriac is a plant closely related to celery and like celery in growth habit and general appearance. However, it develops a thick, tuberous base and root, which is the edible portion, and is used as a salad and cooked vegetable. The leaves rise directly from this thickened base which may reach 3 to 4 inches in diameter and similar length. Plants are usually started in seed beds and transplanted to the field. Leaves are not utilized, and the bulbous root is covered with soil during growth. Celeriac is of minor importance in the U.S.

Season, field setting to harvest: 3.5 to 4 months.

Production in U.S.: No data, quantity limited.

Use: Pot vegetable, salad; not processed.

Part of plant consumed: Tuberous root.

Last update February 18, 1999 by ch

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Palada, M.C. and S.M.A. Crossman. 1999. Evaluation of tropical leaf vegetables in the Virgin Islands. p. 388–393. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Evaluation of Tropical Leaf Vegetables in the Virgin Islands

Manuel C. Palada and Stafford M.A. Crossman

Tropical leaf vegetables are grown in the tropics and are rich sources of nutrients, particularly minerals, and vitamins (Oomen and Grubben 1978). A number of species and cultivars have been introduced and grown in the continental US on a limited-scale, particularly in the southern region (Lamberts 1993). The US is a major market for tropical and specialty greens and most of the shipments come from the Caribbean and Latin America. For example, in 1998, total US imports for dasheen leaves (*Colocasia esculenta* L. Schott, Araceae) was over 90 t. From this total, 70% came from Jamaica and 30% from the Dominican Republic (Pearrow 1991). In the same year, the US imported amaranthus (*Amaranthus* spp. L., Amaranthaceae) at 27 t from the same countries. In 1988, shipments of Oriental, Mexican, tropical, and exotic produce, including specialty leafy greens, accounted for about 5% of fresh vegetable shipments, whereas in previous years the volumes have been too low to track (Cook 1990; Lamberts 1990, 1993).

There are several reasons for the increasing demand of tropical and specialty leafy greens in the US. Growth in ethnic populations contributes to demand for product diversity within the produce section (Cook 1990) and food, previously considered ethnic or regional in nature is increasingly being consumed by a broader portion of the population. This trend will likely continue as the ethnic population continues to grow and more Americans become familiar with and develop the taste for the new crops.

This research study is undertaken with the following objectives: (1) collect and describe growth characteristics of minor tropical leaf vegetables; and (2) evaluate yield performance and commercial potentials in the Virgin Islands and the Caribbean.

AMARANTHACEAE

Amaranth

Amaranthus spp. are common, short-lived annuals, the leaves of which are used as potherb. Some species are cultivated in home gardens and for marketing. Several species exist depending on the region in the tropics. For example, *A. tricolor* L. is mostly found in East Asia, while *A. cruentus* (L.) Sauer is common in Africa and *A. dubius* Mart. ex Thell. in the Caribbean. Amaranths are probably the most important leaf vegetables of the lowland tropics of Africa and Asia, but scarcely known in South America. The nutritional value is high where vitamins A and C, and calcium and iron are found in good quantity. However, the high oxalic acid content may decrease the availability of calcium (Oomen and Grubben 1978; Martin and Ruberte 1979). Boiling produces a very acceptable spinach. Some Indian cultivars are markedly short-day plants, so market growers plant them in the beginning of the summer and harvest over several months by repeated pruning until plants flower at the end of the season.

Amaranths are upright and branch sparsely. The leaves are relatively small (5–10 cm long) but quite variable among cultivars. The flowers are small, and are borne in abundance in terminal or axillary spikes. The seeds are born in large numbers, small and edible. The flowers are not edible. The leaves, petioles, and young tips are used in salads and as potherb.

Amaranth is a suitable plant in crop rotation. It is not affected by common soil diseases such as nematodes, fungal, and bacterial wilt. Serious pests and diseases are damping off, wet rot, caterpillars, and stemborers. Early flowering may occur as a consequence of a short daylength or as a result of a short period of water stress.

Considerable differences exist between the three main species. The African cultivars of *A. cruentus* are originally grain-amaranths. They have a long stem and a high dry matter content in the leaves and bear large inflorescence. *A. dubius* and *A. tricolor* cultivars have a much lower seed production and their habit is similar to spinach, with a short stem and succulent leaves. Commercial cultivars exist in India, Taiwan, the Caribbean, and the US.

Eight cultivars were evaluated at the experiment station during the summer-fall season of 1997. The cultivars consisted mainly of *A. tricolor* compared against the local amaranth (*A. dubius*). Most of them performed well in terms of plant establishment, but differed in seedling or plant vigor. Most of the *A. tricolor* cultivars had poor plant vigor and were susceptible to damage by cutworms and leafrollers (Lepidoptera: *Pyralidae*). They also produced seed head (bolting) early before producing considerable leaf area. The number of days from planting to first harvest ranged from 40 to 47 days (Table 1). Edible leaf fresh yield was highest (1158 g/m^2) for amaranth cv. Callaloo and lowest (240 g/m) for amaranth cv. Greenleaf. It appears that 'Callaloo' is suitable for production in the Virgin Islands.

Table 1. Yield and productivity of warm season tropical leaf vegetables in the Virgin Islands, Summer-Fall, 1997.

Common name	Botanical name	Days to first harvest	Edible leaf fresh wt. ±SE (g/m^2)	Daily productivity ±SE (g/m^2)
Amaranth				
Local	*Amaranthus dubius*	42	365±2.5	8.70±0.2
Tigerleaf	*Amaranthus tricolor*	41	455±2	11.1±0.1
Callallo	*Amaranthus cruentus*	40	1158±15	29.0±0.4
Greenleaf	*Amaranthus tricolor*	47	240±7	5.1±0.2
Gangeticus	*Amaranthus tricolor*	41	295±12	7.2±0.3
Merah	*Amaranthus tricolor*	41	432±8.5	10.5±0.2
Pinang	*Amaranthus tricolor*	42	430±3	10.2±0.1
Puteh	*Amaranthus tricolor*	42	367±14	8.7±0.3
Celosia				
USA	*Celosia argentia*	41	1604±584	39.1±14.2
India	*Celosia argentia*	41	650±17	15.9±0.4
Quailgrass	*Celosia argentia*	42	615±8	14.6±0.2
Bush Okra	*Corchorus olitorius*	43	735±18	17.1±0.4
Malabar				
Green	*Basella alba*	57	344±4.5	6.04±0.1
Red	*Basella rubra*	57	385±81.5	6.75±1.43
Sweet potato	*Ipomoea batatas*	42	821±98.0	14.7±1.8
Water spinach	*Ipomoea reptans*	57	412±68.0	7.23±1.2

Celosia

Celosia (*Celosia argentia* L.) is present in Africa and Asia both as a weed and as a cultivated leaf vegetable resembling amaranth. Some species and cultivars with a wide variation in leaf color are grown as ornamental plants. The vegetable type celosia is the most important leaf vegetable of Southern Nigeria and is popular in Benin, Zaire, and Indonesia. It is grown in home gardens and small farms both for home consumption and marketing. The plants are vigorous annuals that grow rapidly from seed. They are upright with alternate leaves and few branches until near flowering time. The flowers are borne in dense heads that yield large numbers of edible seeds. The flowers are often brilliantly colored, and the green foliage may contain large amounts of anthocyanin pigments. The leaves, young stems, and young flowers are eaten as a pot herb. Much of the pigment is lost on cooking, but the leaves retain a pleasant green color.

Three cultivars were evaluated during the 1997 spring season. *Celosia argentia* cv. USA produced the highest yield and productivity (Table 1). *C. argentia* cv. India and *C. argentia* cv. Quailgrass have similar yield of edible leaves. All cultivars were resistant to pest and diseases. Celosia appears to be a good alternative leaf vegetable to local amaranth which is very susceptible to many insect pests.

BRASSICACEAE

Arugula

Arugula (*Eruca sativa* Mill.) is a low growing, annual leaf vegetable with dull green, deeply cut, compound leaves. The edible leaves are characterized by a distinctive spicy, pungent flavor resembling horseradish. The leaves are used in a young tender stage for salads and sometimes cooked as a potherb. The plant was considered by early writers as a good salad herb, but not to be eaten alone. Ancient Egyptians and Romans both have considered the leaves in salads to be an aphrodisiac. Arugula is a very minor crop in the US. In Florida, it is grown to a limited extent commercially and in home gardens where it seems to do quite well (Stephens 1988).

In the Virgin Islands, arugula grows best during fall planting, where it takes 61 days from planting to first harvest. Average edible fresh yield is 840 g/m^2 (Table 2). When grown during the hot summer months, arugula tends to produce flower heads (bolting) and susceptible to insect pest damage. It is a suitable leaf vegetable for the Virgin Islands where there is demand from local food stores, restaurants, and hotels.

Table 2. Yield and productivity of cool season tropical leaf vegetables in the Virgin Islands, fall, 1997.

Common name	Botanical name	Days to first harvest	Edible leaf fresh wt. ±SE (g/m^2)	Daily productivity ±SE (g/m^2)
Arugula	*Eruca sativa*	61	840±14	9.2±0.2

Chinese mustard	*Brassica juncea*	38	451±42	12.9±1.2
Mustard				
Florida	*Brassica juncea*	33	2118±141	176.5±11.5
Savanna	*Brassica juncea*	34	4169±1612	720.5±105
Pak choi	*Brassica rapa* var. *chinensis*	38	3577±400	32.3±4.3
Komatsuna	*Brassica rapa* var. *perviridis*	51	3843±131	19.5±0.3

Chinese Mustard

Chinese mustard [*Brassica juncea* (L.) Czern.], is a popular leaf vegetable in the Far East. In contrast to Chinese cabbage the petioles of mustard have no wings and are not swollen, instead the dented leaf blades are thin and crispy, and the taste is sharp. Some cultivars have a strong pungent taste. Leaves of Chinese mustard are deeply notched, narrow, and feathery. A single plant may have as many as 20–50 leaves clustered together in a compact bunch. Local mustard cultivars are used as leaf vegetables in tropical Asia. The leaves may be eaten raw, as in a salad. As a potherb it is prepared in many ways: as a steamed or boiled well-seasoned green, stir-fried, in soups, or mixed with other vegetables. Like other mustard, Chinese mustard is rich in vitamins and minerals.

Chinese mustard grows well when planted in the fall season in Virgin Islands. However, it is not as productive as the common mustard greens. Average edible leaf yield is only 5–10% of common mustard greens cvs. Florida Broadleaf and Savanna (Table 2). Nevertheless, Chinese mustard is a promising specialty crop in the Virgin Islands.

Pak Choi

Pak choi (*Brassica rapa* L. var. *chinensis*) is a very popular tropical leaf vegetable. It is a non-heading Chinese cabbage with prominent white, fleshy petioles and upstanding glabrous leaves forming a loose rosette as in swiss chard. The large leaves are glossy and dark green. Pak choi flowers and sets seed very easily at high temperatures and long days are favorable for flower development (bolting). It is a quick maturing plant which can be harvested 30 to 45 days after planting. Individual leaves or entire heads are harvested, used raw or cooked. The popularity of pak choi as a summer vegetable in temperate zones and as an all-year leaf vegetable in the humid tropics is increasing. In the Virgin Islands, it is one of the most productive leaf vegetables grown during the fall season with average edible leaf yield of 3577 g/m^2 (Table 2). It is being grown by many home gardeners in St. Croix and St. Thomas. It is seen in local markets and on farmers' market.

Komatsuna

Otherwise known as Japanese mustard, komatsuna (*Brassica rapa* L. var. *perviridis*) is an annual cool season leaf vegetable. The plant appears similar to common mustard, but grows faster and bigger than mustard. Leaves are broad and oval in shape with dark green color. It has the combined flavor of mustard and spinach and remains tender in dry and hot weather. It can be grown year-round and tolerates cold weather. It is the most productive leaf vegetable in the evaluation trial at the experiment station. It matures in 51 days after planting with average edible leaf yield of 3843 g/m^2 (Table 2).

BASELLACEAE

Malabar Spinach

Malabar spinach (*Basella* spp. L.) is also known as Ceylon spinach, vine spinach or Malabar nightshade. It is a climbing perennial plant, mostly cultivated as an annual vegetable against a support in home gardens but in some areas as a vine like market vegetable without staking. There are two common species of Malabar spinach, the red stem and leaves (*Basella rubra* L.) and the green leaves and white stem (*Basella alba* L.). Malabar spinach is not a true spinach (*Spinacia oleracea* L., chenopodiaceae), but its leaves, which form on a vine, resemble spinach, and are used in the same way. The plant is a native of the East Indies, and found its way to the New World from China. It has spread throughout the tropical world and it is one of the best tropical spinach widely adapted to a variety of soils and climates. It is particularly abundant in India, Malaysia, and the Philippines, but it is also seen throughout tropical Africa, the Caribbean, and tropical South America.

Malabar spinach has thick tender stems and the leaves are almost circular to ovate, alternate, and short petioled. They are thick, rugose, succulent, and colored from green to purple. The flowers, borne on axillary spikes or branching peduncles are bisexual and inconspicuous. The fruits are fleshy and purplish black and the juice is sometimes used as a dye.

The succulent young and mature leaves, and the stems are eaten. The most common method of cooking is as a pot herb, mixed with stew or other vegetables. On cooking, the green stem/leaf species retains its fresh green color. The red species loses much pigment to the water and is less attractive. The leaves have mild flavor or are almost tasteless. The stems may be somewhat bitter, and become gelatinous or mucilaginous especially when overcooked. Malabar spinach is a good source of vitamins A and C, calcium, and iron.

Malabar spinach is a perennial that tends to extend itself over time. Seeds can be sown directly or vines may be established directly from stem cuttings. These need a little shade on transplanting, but root readily. Malabar spinach can thrive under conditions of moderate soil fertility, but is quite responsive to nitrogen fertilizer. Evaluation trial at the experiment station indicated that plants can be harvested at 57 days after planting. The red species is slightly more productive than the green species (Table 1). Edible leaf yield was
385 g/m^2 for the red species compared to 344 g/m^2 for the green species. Malabar spinach is one of the rapidly growing tropical leaf vegetables in the Virgin Islands, responds well to pruning and nitrogen fertilizer. In addition, it is tolerant to insect pests and diseases. It is definitely one of the minor tropical leaf vegetables with market potential in the Virgin Islands.

CONVOLVULACEAE

Note on US import restrictions

Water Spinach

Water spinach, kangkong, swamp cabbage, or water convolvulus (*Ipomoea aquatica* Forsk., or *Ipomoea reptans* Poir) is an important green leaf vegetable in most of Southeast Asia. It is a trailing tropical lowland plant, related to sweet potato. Two main cultivar groups can be distinguished: var. *aquatica* and var. *reptans*. The first is an aquatic plant or paddy vegetable in the Southern part of India and Southeast Asia, propagated by cuttings and growing in the wild or cultivated in fish ponds and water courses. The second is an upland vegetable, cultivated on dry or marshy land and propagated by cutting or seeds. Both types are an important market vegetable in Malaysia, Indonesia, and other Southeast Asian countries. Several cultivars are known, but the most important distinction is between upland (dry) forms and paddy (swamp) forms.

Water spinach develops a trailing vine that spreads rapidly by rooting at the nodes. Vertical branches arise from the leaf axils. It is quite glabrous, with sagitate, alternate leaves. The leaves are somewhat succulent, particularly in the wet land form, and has a pleasant light green color. A white flower is produced which matures into a 4-seeded pod.

Almost all parts of the young plant are eaten. Older stems, especially from plants cultivated on dry land, contain considerable fiber. Therefore, cultural methods emphasize the production of young succulent tips. These can be eaten fresh in salads. Often they are cooked as spinach. The flavor is bland and some spicy ingredients or salt are added to enhance flavor. The leaves maintain much of their green color, but the stems are yellowish when cooked (Martin and Ruberte 1979).

Water spinach is planted either from seed or from cuttings. Seeds do not germinate well under water, but can be direct seeded. Plants are normally grown in nursery beds for later transplanting in the field. In evaluation trial conducted at the experiment station, the upland type of water spinach was harvested 57 days after planting. The average edible leaf yield was 412 g/m^2 (Table 1). Productivity was about similar with Malabar spinach. Under Virgin Islands climatic conditions, water spinach grows well during summer-fall season and is a suitable leafy green vegetable with market potential.

Sweet Potato

The leaves of sweet potato (*Ipomoea batatas* L.) are used as a potherb in Southeast Asia, the Pacific, and locally in Latin America. It is an important foodstuff for the highland population of New Guinea. Sweet potato leaves are considered as a cheap and coarse vegetable. Stems and leaves are used as forage. Often considered a poor man's food, sweet potato leaf has a rich protein content that helps fill the nutritional gap left by eating principally the protein-poor tubers. Sweet potato leaves are particularly important, and cultivars have been developed that are used only for the leaves. These cultivars are rich in calcium. However, cultivars differ in general appearance, flavor, and bitterness. Many cultivars have a resinous flavor that is acceptable unless quite strong.

Sweet potato merits a place in tropical gardens because it is easy to culture and yields edible tubers as well as leaves. Leaves and tubers can be produced year round and plants are adapted to a wide range in climatic conditions. Most soils are suitable for sweet potato, but soils rich in organic matter promote lush growth of leaves. Sweet potato is adapted to calcareous soils of the Virgin Islands. Leaves and young shoots can be harvested in 42 days after planting (Table 1). It is more productive than amaranth, Malabar spinach, and water spinach. Frequent harvest stimulates development of side shoots and vines. Although it is a perennial, its succulent nature restricts its cultivation to relatively short growing seasons of 3 to 5 months. It is definitely a suitable leaf vegetable for the Virgin Islands and a good alternative to local spinach.

TILIACEAE

Bush Okra

Bush okra, jew's mallow, or jute mallow (*Corchorus olitorius* L.) is primarily known as a fiber crop, however, special types with shorter and more branched stems are frequently cultivated as a mucilaginous tropical leaf vegetable. Bush okra is one of the popular tropical leaf vegetables in Africa, Asia, and some parts of the Middle East. The plant belongs to the Tiliaceae and is characterized as an annual upright, branching, glabrous, slightly woody herb. Leaves are narrow and serrate, about 5–13 cm in length. Flowers are small, yellow-petioled, and borne in small clusters in the leaf axils. The cylindrical capsules of 2–5 cm are produced in large numbers, especially during the short days (Martin and Ruberte 1979). Seeds are dark bluish-green, angular, and about 2 mm long.

Bush okra is one of the leading leaf vegetables in West Africa and is often stored dry. It is also commonly used in Malaysia, the Philippines, and parts of Latin America. It is the most important leaf vegetable in Egypt, where it is cultivated from March to Nov. (Oomen and Grubben 1978). The nutritional value of bush okra compares very well with other common tropical leaf vegetables. It is high in protein, fiber, calcium, iron, and carotene. The edible shoot tips and leaves are always eaten and cooked as a potherb. Their edible qualities are widely appreciated in West Africa where the shoots and leaves are combined in stews to be eaten as a starchy paste. In India the shoots are cooked with rice.

Although bush okra is a popular leaf vegetable in many countries of the tropics, little research and development work have been done to improve its culture and production. According to Oomen and Grubben (1978) seed yields of bush okra are low, and germination is often very poor due to dormancy which can be overcome by soaking in hot water. Leaf production is also low compared to other tropical leaf vegetables, but dry matter content is high. Trials at the experiment showed that bush okra can be harvested in 33 days after planting, however, edible leaf yield is very low (Table 1). Yield and productivity can be increased by increasing planting density. Studies by Palada and Crossman (1998) indicated that a planting density of 98,522 plants/ha or a plant spacing of 50 × 20 cm was optimum for maximum yield of bush okra. Bush okra is resistant to damage by pests and diseases. It is one of the most suitable leaf vegetables for growing in the Virgin Islands.

SUMMARY

The germplasm evaluation trials indicate that under Virgin Islands conditions, most of the cool season *Brassica* spp., including the Oriental greens show potentials for adaptability and higher productivity. The warm season species such as the Malabar spinach, celosia, and sweet potato performed better than amaranth, bush okra, and water spinach. Planting density study with bush okra indicated that yield and productivity can be increased with closer spacing. Crop management trials involving plant spacing and fertilizer application are on-going to improve the yield of the common species including amaranth, Malabar spinach, celosia, and water spinach. When outstanding species and cultivars are identified and improved cultural management practices are developed, local growers will be able to adopt these recommendations to enhance production of tropical leaf vegetables. Future efforts will be focused on product development and marketing of these specialty vegetables.

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Ipomoea aquatica is a federal noxious weed. Under authority of the Federal Noxious Weed Act, the Animal and Plant Health Inspection Service prohibits the importation and interstate movement of this species, except under USDA-issued noxious weed permit. Although *I. aquatica* is prized as a vegetable, it is also an agricultural and environmental pest, reducing yields of rice and sugarcane in other parts of the world, and affecting aquatic ecosystems, irrigation systems, reservoirs, and navigation and recreation on fresh waterways.

APHIS (Animal and Plant Health Inspection Service) encourages importers to be aware of import restrictions meant to protect American agriculture and natural areas. Please refer to the APHIS web site for more information: http://www.aphis.usda.gov/ppq/ss/permits.html

Centipedegrass

Gramineae *Eremochloa ophiuroides* (Munro) Hack.

Source: Magness et al. 1971

This grass, native to Asia, was introduced into the United States in 1919. It is a low-growing perennial, spreading by stolons. It makes a dense mat of stems and leaves. It is of very low nutritive value, so is of little value for pastures, but is useful for lawns and erosion control. It is not hardy, but is grown in the Coastal Plain from North Carolina to Texas. Propagation is by planting stolons or from seed.

Last update February 18, 1999 by ch

Monstera deliciosa L.

Araceae

Ceriman

We have information from several sources:

Ceriman—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Tuesday, January 26, 1999 by ch

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Ceriops tagal (Perr.) C.B. Rob.

Syn.: *Ceriops candolliana* Arn.
Rhizophoraceae
Tagal mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Andamese are said to sometimes eat the fruit. Asians may use the astringent bark or the old calyx with their betel quid (Hou, 1958). Bent branches are used (as are the knees) for boats, the trunks for housebuilding. Regarded as the most durable of the mangroves. (Burkill, 1966). In Indonesia the wood is used for mine timbers and pit props. Bark used for tanning matter and as a source of a black dye. Treating nets and sails with the bark extract is said to preserve them from decay (C.S.I.R., 1948–1976).

Folk Medicine

Reported to be astringent and hemostat, tagal mangrove is a folk remedy for malaria and sores (Duke and Wain, 1981). The shoot decoction, used as a hemostat, has served as a quinine substitute (Kirtikar and Basu, 1975). The bark is also used in lotions for malignant ulcers (C.S.I.R., 1948–1976). Malays give the bark infusion to women in confinement with abdominal ailments. Filipinos used the bark to cure diabetes during the Japanese occupation (Perry, 1980).

Chemistry

Bark contains 23–40% tannin. Leaves contain 15.45%, twig bark 25.89%, and bole bark 41.22% tannin (C.S.I.R., 1948–1976). Twig bark may contain up to 1.77% NaCl.

Description

Evergreen tree 5–15(-25) m high and 20–40 cm in diameter, of ten with unbranched stilt roots and thin knees 20–30 cm high. Bark light gray or reddish-brown, smooth or irregularly fissured; inner bark orange or reddish. Leaves opposite, clustered at end of twigs, obovate to elliptical, 5–10 cm long, 2–6 cm wide, rounded and emarginate at tip, acute at base, entire, thick, leathery, glabrous, without visible veins. Petiole 1–3.5 cm long, stipules paired, narrow, ca 2 cm long. Cymes single and short-stalked in leaf axils. Flowers 4–10, short stalked, ca 6 mm long. Calyx yellow-green with 5–6 narrow pointed lobes turned back on fruit; petals 5–6, white, united at base, 2-lobed and ending in 2–4 bristles, stamens 10–12; pistil with conical, partly inferior 3-celled ovary and short style. Berry drooping, ovoid, 1.5–2.5 cm long, leathery. Seed 1, viviparous, becoming cigar-shaped or club-shaped, sharply angled, 15–25(-35) cm long (Little, 1983).

Germplasm

Reported from the African, Australian, Hindustani, and Indonesia -Indochina Centers of Diversity, tagal mangrove, or cvs thereof, is reported to tolerate diseases, insects, pests, salt, and waterlogging (NAS, 1980; Little, 1983).

Distribution

South and East Africa to Madagascar, Seychelles, Sri Lanka, India, Burma, Andamans, Thailand, Cambodia, Vietnam, southern China, Taiwan, through Malaysia to Micronesia, northern Australia, and Melanesia to New Caledonia. Rare and local in South Africa. Not widely introduced.

Ecology

Estimated to range from Tropical Moist to Rain through Subtropical Moist to Rain Forest Life Zones, tagal mangrove is estimated to tolerate annual precipitation of 10 to 80 dm, annual temperature of 20 to 26°C, and pH of 6 to 8.5. Usually on well drained soils, within the reach of occasional tides in the inner mangrove. Sometimes occurs under Rhizophora or Bruguiera forest, but may form dense monospecific stands.

Cultivation

According to the NAS (1980a), planting is usually not needed because natural regeneration is so successful. In Avicennia and Rhizophora, direct seeding results in ca 90% survival.

Harvesting

Species of Rhizophoraceae, growing only from the tips of the branches, are often killed by indiscriminate lopping of branches (NAS, 1980a).

Yields and Economics

Cannell (1982) cites data on a mangrove forest dominated by Rhizophora, Ceriops, and Sonneratia, averaging 11 m tall, with an LAI of 3.7–4.2. The stemwood and bark on a DM basis weighed 74.4 MT/ha, the prop roots 61.2 MT/ha, the branches 15.8, the foliage 7.4, the fruits 0.3, for a total standing aerial biomass of 157 MT/ha. The CAI (current annual increment) of stem wood, bark, and branches was 20 MT/ha/yr , foliage 6.7, fruits 0.3. These data, taken from a mangrove on Phuket Island, Thailand, regenerated following clear felling, suggest annual productivity may attain 20 MT/ha/yr in Asian mangroves.

Energy

According to the data in the phytomass files (Duke, 1981b), annual productivity of mangroves is estimated to range from 5 to 25 MT/ha. Tagal mangrove has a very high fuel value, "certainly one of the best of firewoods" (Burkill, 1966). With calorific value of 5,150 cals, or 9,272 Btu, the wood is used directly as fuel, or converted to charcoal, described as excellent (C.S.I.R., 1948–1976; Little, 1983).

Biotic Factors

No data available.

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Chaenomeles: Potential New Fruit Crop for Northern Europe

Kimmo Rumpunen

INTRODUCTION

A number of plant species, that have only rarely been cultivated in the past, are now being investigated for possible domestication in northern Europe. Species within the Rosaceous genus *Chaenomeles* (also referred to as the common name of these species) have received increased attention because of their high yield of fruits, which are rich in juice, aroma, and dietary fiber, and because of their presumed potential for cultivation with organic production methods. In the Baltic region, development of Japanese quince (*C. japonica*) started in Latvia 1951. In 1993, the interest for growing Japanese quince reached a peak. Plantations in Latvia and Lithuania at that time comprised more than 400 ha. However, the seed propagated plants were very variable in several traits, including important fruit characters. This heterogeneity made field management difficult, cultivation less profitable and prevented the development of high quality products. At the same time the shift in economical system in the independent Baltic countries contributed to a strong competition on the market from import of exotic juice concentrates. Consequently the interest in growing Japanese quince dropped drastically. The need for improved plant material became obvious and a joint Latvian-Lithuanian-Swedish plant breeding program was therefore initiated. In this paper, the genus *Chaenomeles* is introduced, and its potential and utilization as a fruit crop is reviewed.

THE GENUS *CHAENOMELES*

Systematic Position

The genus *Chaenomeles* Lindley (chaenomeles) is assigned to the subfamily Maloideae of the ecologically and economically important Rosaceae (Phipps et al. 1990). Within Maloideae, *Chaenomeles* is most closely related to the genera *Cydonia* (quince), *Docynia*, *Malus* (apple) and *Pyrus* (pear). *Chaenomeles* has obtained its name from the Greek chaino, “to gape,” and melon “apple,” based on Thunberg’s 1784 description of the type species for the genus: *C. japonica* (Thunb.) Lindl. ex Spach (Weber 1964). This description is not considered correct, since the fruit very seldom splits (Weber 1964), but is a phenomenon that has been noticed occasionally.

Taxonomy

Four species, *C. cathayensis* (Hemsl.) Schneider (Chinese quince), *C. japonica* (Thunb.) Lindl. (Japanese quince or dwarf Japanese quince), *C. speciosa* (Sweet) Nakai (flowering quince), and *C. thibetica* Yü (Tibetan quince) are now recognized in Chaenomeles (Phipps et al. 1990). Four hybridogenous taxa, resulting from successful ornamental plant breeding, are also discriminated (Weber 1964): *C.* ×*superba* (Frahm) Rehder (*C. japonica* × *C. speciosa*, Superba group), *C.* ×*clarkiana* Weber (*C. cathayensis* × *C. japonica*, Clarkiana group), *C.* ×*vilmoriniana* Weber (*C. cathayensis* × *C. speciosa*, Vilmoriniana group), and *C.* ×*californica* Clarke ex Weber [*C. cathayensis* × (*C.* ×*superba*), Californica group].

Taxonomic confusion has throughout the history been extensive for the genus *Chaenomeles*. The separation of the four chaenomeles species from the two quince species (*Cydonia oblonga* and *Cydonia sinensis*) is now supported by morphological studies of the fruits (Rataru and Ponomarenko 1993) and by molecular studies (Campbell et al. 1995; Kaneko et al. 2000). The taxonomic confusion and the fact that not all *Chaenomeles* species had been thoroughly studied were two reasons to re-investigate the genus by morphology and by various molecular markers (Rumpunen 2001). A large collection of wild Chinese and Japanese *Chaenomeles* accessions was therefore assembled and studied. In agreement with previous studies on cultivated Chaenomeles material (Bartish et al. 1999; Garkava et al. 2000) *C. japonica* was clearly differentiated from *C. speciosa* and *C. cathayensis* (Bartish et al. 2000a). The recently recognized species *C. thibetica* appeared to be rather closely related to *C. cathayensis*. Populations of *C. japonica* and *C. speciosa* were considerably more diverse than populations of *C. cathayensis* and *C. thibetica*. Correspondingly, most of the total variability could be attributed to within-population differentiation in the case of *C. japonica* and *C. speciosa*, and to between-population differentiation in the case of *C. cathayensis*. Differences in mating systems among the species was suggested as a possible explanation for these results (Bartish et al. 2000a). Furthermore, analysis of diagnostic RAPD markers and of chloroplast DNA haplotypes supported the notion of spontaneous hybridization between *C. cathayensis* and *C. speciosa* in some wild populations (Bartish et al. 2000b).

Cytogenetics, Mating System, and Patterns of Inheritance

The basic chromosome number of $x = 17$, and the diploid count $2n = 34$ for *C. cathayensis, C. japonica,* and *C. speciosa* was reported by Moffett (1931) and has later been confirmed (Weber 1964; Saito and Kaneko 1975; Singhal 1990). The same chromosome number has recently been obtained for *C. thibetica* (S. Kauppinen, unpubl. data). Tetraploidy has been reported only in one cultivar with very large flowers (Weber 1964). A large number of *C. japonica* polyploids have however been developed within the ongoing plant breeding program (unpubl. results).

Distribution and Ecology

Chaenomeles japonica is a dwarf shrub (0.6–1.2 m) which occurs in central and south Japan at elevations from 100–2100 m on hillsides, and on riverbanks and lakeshores (Weber 1964). The other three species are mainly distributed in China, with a presumed center of origin in Yunnan and Tibet, but their precise distribution and ecology is not yet fully known. *Chaenomeles thibetica* is a large shrub (1.5–3 m) and wild-growing populations have been reported from 2700 m. It has, however, been reported in cultivation at the remarkable altitude of 3760 m (Yü and Kuan 1963). *Chaenomeles cathayensis* is a large shrub or a small tree (up to 6 m) which grows at 900–2500 m, and *C. speciosa* is a large shrub (2–5 m) which grows at 200–1700 m (Weber 1964). The Chinese species grow on hillsides, in open thickets, on rocky slopes, in ravines, and in forests. From the distribution of the species and from their performance in cultivation, it may be concluded that the Chinese species are mainly continental and the Japanese species is coastal. All species normally have abundant thorns, terminating short or long shoots. However, mass selection has considerably reduced the frequency of thorns in the plant material presently cultivated in Latvia and Lithuania. A few thornless cultivars of *C. japonica*, *C. speciosa*, and *C.* ×*superba* are also known (Buchter-Weisbrodt 1992; Weber 1964).

Floral Biology

On plants of *C. cathayensis*, *C. japonica*, and *C. speciosa* (*C. thibetica* not yet thoroughly studied), 1 to 6 flower buds occur in clusters, on two-year-old or older branches. The flower buds are normally formed during late summer and autumn, but may develop as either short shoot type (in the spring and in the late autumn) or long shoot type (from late spring to late autumn).

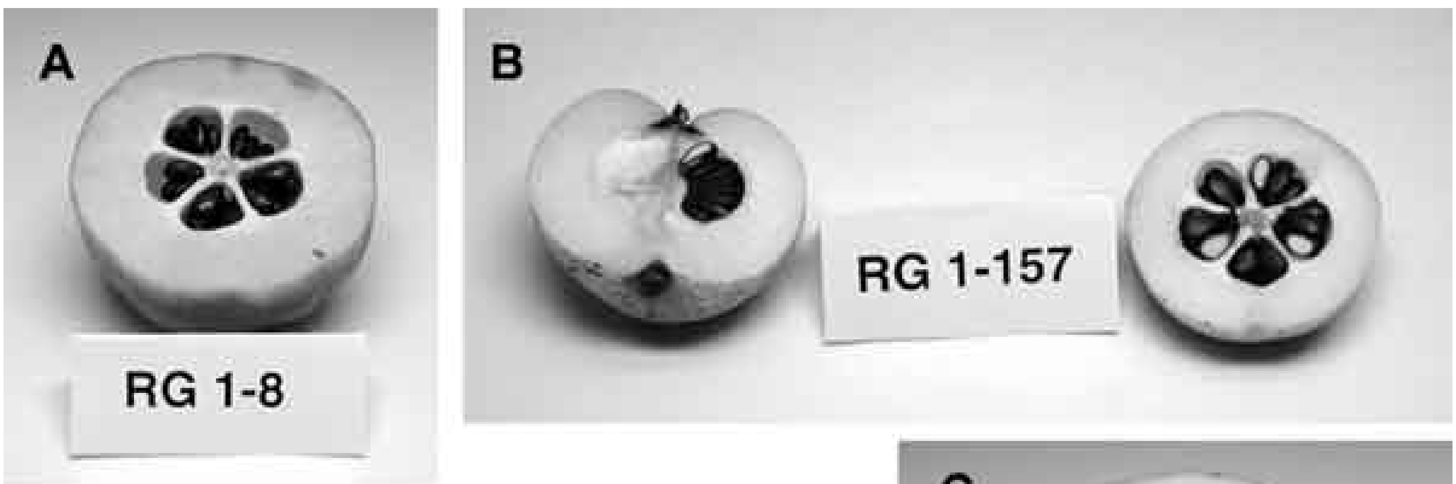
The showy flowers of *Chaenomeles* are usually classified as perfect and homomorphic (Kaufmane and Rumpunen 2002a). Nevertheless, when screening collections and breeding populations, it was noticed that almost every plant also had several “imperfect” flowers with stunted, sterile pistils. This is in agreement with previous observations (Weber 1964) where every studied species were reported to also form unisexual flowers (female and male, respectively). The size and shape of the hypanthium forming the base of the flowers may be used to distinguish unisexual flowers, a short cup-shaped hypanthium being typical for functionally male flowers (Weber 1964; Kaufmane and Rumpunen 2002a).

The flowers of all species within the genus *Chaenomeles* normally have five sepals and five petals. The petals can vary from white to darkest red through pink, orange, and scarlet, and bi-colored petals are frequent (Weber 1964). The number of stamens is usually large, 40–60. The stamens are of somewhat varying length, and are placed in two circles. The female gametophyte develops in the deeply inferior ovary at the base of the pistil (Kaufmane and Rumpunen 2002b). In general 5 styles are fused for 1/3 to 2/3 of their length and the column formed by the styles is characteristic for the genus *Chaenomeles* (Weber 1964). The stigma is of the wet type, group III, following the classification of Heslop-Harrison and Shivanna (1977) and is receptive at anthesis (Kaufmane and Rumpunen 2002a). Pollinating vectors are honeybees and bumblebees, which are attracted to the nectar-rich but scentless flowers. Each locule in the ovary contains up to about 20 ovules (arranged horizontally in two rows), of which about 6–10 functional ovules develop in *C. japonica*. Within Maloideae, multiovulate carpels are also found in *Cydonia* and *Docynia* (Rohrer et al. 1994), which results in the development of numerous seeds in each fruit.

Fruit Morphology

The fruits of *Chaenomeles* are pomes and very diverse in shape (Weber 1964; Mezhenskij 1996; Yü and Kuan 1963) (Fig. 1). The fruit of *C. japonica* is usually the smallest in the genus. It is apple-shaped, about 4 cm in diameter, with a weight below 50 g. By contrast, *C. cathayensis* has the largest fruit in the genus. It is ovoid, up to 15 cm long and 8 cm broad, with a weight of about 180 g, occasionally up to 600 g or more (Shao and Lu 1995). The fruit of *C. thibetica* is oblong and pear-shaped, typically 6–11 cm long and 5–9 cm in diameter. The fruit of *C. speciosa* vary in size and shape. It is typically 4–7 cm long and 3–6 cm in diameter, with a weight of up to 140 g but usually smaller. Typically up to 80 seeds develop in the fruit of *C. japonica*, up to 100 in *C. speciosa* and up to 120 in *C. cathayensis* (no information yet available for *C. thibetica*) (Fig. 2).

Fig. 1. Typical fruit of *C. speciosa* (flowering quince), *C. japonica* (Japanese quince), and *C. cathayensis* (Chinese quince), respectively.



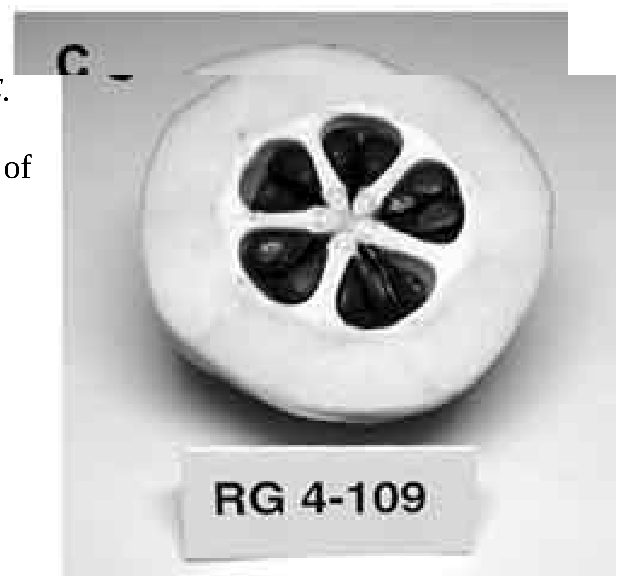


Fig. 2. Dissected fruit of A) *C. speciosa* (flowering quince), B) *C. japonica* (Japanese quince), and C) *C. cathayensis* (Chinese quince), revealing the numerous seeds in each locule. The length of the paper strip is 5 cm.

The sticky cuticle of *C. japonica* fruit, and some of its interspecific hybrids, is a sign of maturity, as are brown seeds (Weber 1964). The fruit of *C. japonica* is usually the earliest ripening (at the end of August in the Baltic climate). The fruit of *C. speciosa*, and especially *C. cathayensis*, needs more heat to develop the typical yellow color (sometimes yellowish green and somewhat red) and does not normally ripen in the Baltic climate. Fruits of all *Chaenomeles* species become more or less fragrant during ripening, but do not soften, and must therefore be processed before consumption.

Utilization as a Fruit Crop

The high content of organic acids in the juice, distinctive aroma, and high amount of dietary fiber, make the fruits of *C. japonica* well suited for industrial processing (Lesinska 1986, 1987, 1988). Furthermore, the fruit is not sensitive to oxidative browning during processing, and the juice contains a high level of vitamin C and phenolic compounds (Lesinska and Kraus 1996) that act as antioxidants. The antioxidant activity of flavonoids in *C. japonica* is just somewhat lower than the antioxidant activity of flavonoids in *R. rugosa* (Gabrielska et al. 1997). The phenotypic variation in content of organic acids, soluble solids, and total antioxidant activity is large (Rumpunen and Kviklys 2001). The flavor components of *C. japonica* are considered partly similar to apples and quince, and partly similar to citrus fruits (Lesinska and Kraus 1996; Lesinska 1988). Based on the chemical composition and characteristics of the fruit, several products have been proposed and developed (Lesinska 1986; Lesinska and Kraus 1996). It is for instance possible to produce juice, wine, purée, aroma-extracts, pectin, dietary fiber, etc. Syrup, liqueur, carbonated soft drinks, marmalades, and candies are the main products that have been available in Latvian and Lithuanian markets (Ruisa 1996). Furthermore, a sugar-juice aroma extract has recently proven to provide excellent flavor in ice cream and yogurt.

Propagation

Chaenomeles species can easily be generatively propagated. Germination rates between 95% and 100% are frequently obtained, provided that seeds are not allowed to dry out before being properly stratified. A month at 2° to 4°C in moist substrate is sufficient (Tiits 1989) but in commercial propagation a period of 2–3 months or longer is commonly used. Cultivars must be vegetatively propagated. Whereas chaenomeles cultivars can be grafted, as well as propagated by root pieces, by layering or by hardwood cuttings, softwood cuttings are preferred for commercial scale enterprises. There is, however, much variation in rooting ability among genotypes (Wells 1955; Eley 1970; Kviklys and Rumpunen 1996). Rooting percentage can be strongly increased by use of growth regulators (typically 30 ppm IBA for 18 h, or a quick dip in 1000 ppm IBA) but size of the cutting is also important. Large cuttings (above 20 cm) root rapidly, produce more roots, and show better winter survival (Wells 1955; Kviklys 1998). Etiolation of shoots may retard rooting (Blain and Dixon 1984) and should therefore be avoided. Protocols for micropropagation have also been successfully developed (Panavas 1994; Stanys 1996, unpubl. data). Due to high costs, micropropagation may be limited to production of stock material for later propagation of cuttings.

Diseases

There are only few reports of plant pathogens and pests attacking chaenomeles plants. Diseases caused by *Monilinia* species (syn. *Sclerotinia*, conidial state: *Monilia*) are the most frequently reported (Creelman 1962; Eliade and Barbu 1963; Heaton 1979; Penrose et al. 1976). Leaf spots may be caused by *Coryneum foliicola* and *Phyllosticta chaenomelina* (Eliade and Barbu 1963), *P. chaenomelesicola* (Yu and Bai 1995), and *Entomosporium eriobotryae* (Horie and Kobayashi 1979). Grey mould, *Botrytis cinerea*, has been reported on flowers (Eliade and Barbu 1963) and on twigs causing cankers (Moore 1949). Eliade and Barbu (1963) also reported fruit fungi: *Septoria cydoniae* and *Cytospora piricola*, and a leaf rust fungus, *Gymnosporangium confusum*. The fire blight bacteria, *Erwinia amylovora* (Zeller 1979), and a virus, apple chlorotic leaf spot virus (Sweet 1980), have also been reported. Among known pests are *Grapholita (Cydia) dimorpha* (Oku et al. 1988), *Caliroa cerasi* (Raffa and Lintereur 1988) and in China the root-knot nematode *Meloidogyne incognita* (Ying et al. 1994).

In Sweden symptoms of several fungi, causing leaf spots, fruit spots, and rotting of fruits, have been noticed (I. Norin, unpubl. data). On fruits *Septoria cydoniae*, *Phlyctaena vagabunda*, *Phoma glomerata*, *Phoma exigua*, *Alternaria tenuissima*, *Alternaria alternata*, and *B. cinerea* have been isolated. In addition, common storage fungi of apple, *Penicillium* sp., *Phlyctaena vagabunda*, and *B. cinerea* have been found on stored fruits, and *Monilia fructigena* has been found on fruit in the field. Die back of shoots, and sometimes of whole plants, has also been noticed, possibly caused by *B. cinerea*. *Botrytis cinerea* has been observed to sporulate on flower parts, on fruits in all stages, and on twigs. Furthermore, a severe attack of grey mold occurred on seedlings in a greenhouse, when the fungus infected and even killed young plants of all *Chaenomeles* species. Among pests, leaf weevils (*Phyllobius* sp.), larvae of *Yponomeuta* sp., and *Operophtera* sp. have been noticed feeding on the plants during spring and early summer. Later in the season, larvae of *Orgyia antiqua* and red spider mites (possibly *Panonychus ulmi*) were found on some plants.

Among diseases and pests, fungal diseases appear to predominate. Nevertheless, *Chaenomeles* is a genus with comparatively healthy plants, amenable to organic growing systems. Despite that chaenomeles fruits are attacked by some fungi which also cause serious storage diseases on apple, the plants seem not susceptible to scab or powdery mildew. Unless field resistant genotypes are selected, fungal diseases may, however, become a problem if clones of various chaenomeles species and hybrids are more widely cultivated.

DOMESTICATION

Chaenomeles species have long been appreciated because of their ornamental value. In Japan, to which *C. speciosa* was introduced from China around 1550, several ornamental cultivars, and cultivars of hybrid origin (also with the endemic *C. japonica*), were soon selected because of the showy and variable flowers (Weber 1964; Kaneko et al. 2000). Chaenomeles speciosa was introduced to Europe (England) in 1796, *C. japonica* in 1869, and *C. cathayensis* in 1880. Through intra- and interspecific crosses, more than 500 ornamental cultivars have been developed (Weber 1963). *Chaenomeles thibetica* was not described until 1963 (Yü and Kuan 1963) and has not been used in breeding, and not until recently become introduced to Europe.

Fruits collected in native populations of *C. speciosa* (and possibly also of *C. cathayensis* and *C. thibetica*) have for a long time been used for medicinal purposes in China (Anon. 1989; Weber 1964; Yü and Kuan 1963). These species have also been cultivated in gardens in China but only recently has research aimed at developing *C. speciosa* into a fruit crop been reported (Wang et al. 1997, 1998). Attempts to grow *C. cathayensis* for production of pectin and malic acid have previously been made in Geneva, New York (Slate 1941). However, two cold winters destroyed the plantation and no more trials were conducted. Later research and development of *C. japonica* as a fruit crop has instead taken place in some European countries, as described below.

In Poland, research was initiated in 1978 (Lesinska 1986). The studies focused on biochemical composition, processing and potential products. Fruits of *C. japonica* and *C. speciosa* were considered most useful for processing, however, lack of sufficient fruit quantities hampered further development (Lesinska and Kraus 1996, pers. commun.).

In Finland, a breeding project was initiated in 1979 with the primary objective to select high yielding and winter hardy cultivars of *C. japonica*. Selected genotypes have been propagated by tissue culture and are presently being compared in clone tests (Tigerstedt 1996, pers. commun.).

In Ukraine, domestication of chaenomeles began in 1913, which resulted in the first industrial plantation in 1937. However the crop never became very popular, and in 1981 a new project was started for reintroduction of chaenomeles. In this new project, variability was measured for several fruit morphological and chemical characters, and possibilities for early selection were estimated through calculation of correlation coefficients between characters and years (Mezhenskij 1989, 1996). Besides studies on interspecific (*C. japonica*, *C. speciosa*, and *C. cathayensis*) and intergeneric hybridization (*Pyrus*), research was conducted on propagation and marketable products. The crop was considered promising but so far this has not resulted in any new commercial plantations (Mezhenskij 1996, pers. commun.).

In Moldavia, research on intraspecific variation in morphological characters and in some fruit biochemistry characters of *C. japonica* was initiated in the 1980s. Correlation coefficients and variability coefficients were estimated and it was concluded that *C. japonica* had good possibilities for improvement through breeding (Ponomarenko 1996, pers. commun.). So far no commercial plantations have, however, been established.

In Latvia, research on *C. japonica* was initiated in 1951 (Tiits 1989; Tics 1992) and the first large plantations were established in the 1970s. In 1993 the plantations in Latvia covered approximately 300 ha, with a maximum yield of 20–30 t/ha (Ruisa 1996) and an average yield of 12–15 t/ha. The interest in *C. japonica* as a fruit crop had also spread to Lithuania (Ratomskyte 1996; Rumpunen and Kviklys 1996). The plant material used in the Baltic countries was propagated only by seed and very heterogeneous. A few generations of mass-selection, however, succeeded in reducing the frequency of plants with thorns (to about 4%), promoting early ripening, and increasing the yield (Ruisa 1996). Nevertheless, fruit quality was not sufficient to enable production of high quality and competitive products. The need for improved plant material became obvious, and a joint Latvian-Lithuanian-Swedish plant breeding program was initiated in 1992 (Rumpunen et al. 1998). A link between the Swedish-Latvian-Lithuanian program and the Finnish plant breeding project was established in 1998, and multidisciplinary research was at the same time started, aimed at studying the potential of *C. japonica* as a fruit crop (Rumpunen et al. 2000).

In the current plant breeding program, selection has taken place in orchards, the selected plants have been micropropagated, and clone trials have been established in Finland, Italy, Latvia, Lithuania, and Sweden. In addition, breeding populations have been created, including offspring from interspecific and intergeneric crossings. Floral biology (development of micro- and macrogametophytes, pollen viability, pollen germination, pollen tube growth, embryo sac viability, fertilization, the effective pollination period, period of flowering, functionality of flowers with stunted pistils, fruit set following self-pollination, the effect of emasculation, and bagging on fruit set) has been studied (Kaufmane and Rumpunen 2002a,b). The content and composition of dietary fiber of the fruit of *C. japonica* has been investigated (Thomas et al. 2000), and a method for screening of pectin in chaenomeles fruits has been developed (Rumpunen et al. 2002). The chemical composition of the fruit fragrance and flavor, and the characteristics of the fruit juice, have been investigated during development and storage. In addition, consumer preferences have been evaluated for a number of products based on chaenomeles fruits. Furthermore, an ideotype has been defined for the fruit crop *C. japonica*, and breeding strategies have been developed (Rumpunen 2001). Important traits to be specifically considered during selection and breeding of *C. japonica* are: adaptation and hardiness, disease resistance, thorns, suckering, growth, rooting of cuttings, time of ripening, yield, amenability for mechanical harvesting, and fruit quality.

FUTURE PROSPECTS

The large phenotypic and genetic diversity in the genus *Chaenomeles*, as inferred from morphological and biochemical traits, and from molecular markers, is advantageous for crop improvement through breeding and selection. The high content of dietary fiber and pectin in the fruit makes *C. japonica* a promising candidate for the manufacture of dietary fiber-containing food products and pectin. The pleasant flavor and high acidity of the fruit, make the crop interesting as raw material for development of a range of sweetened food products. At present, the absence of selected cultivars limits the possibility for large-scale product development. The first cultivars should be available for marketing within a few years. It will then be possible to establish pilot plantations, yielding high quality fruits for further product development and marketing of this new crop.

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Chaerophyllum bulbosum L.

Umbelliferae, Apiaceae

Turnip-rooted Chervil

We have information from several sources:

Tuberous-rooted Chervil: A New Root Vegetable for Temperate Climates—Jean-Yves Péron

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update October 13, 1997 by aw

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Mirabilis expansa Ruíz & Pavón

Nyctaginaceae

Mauka, Chago

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Mauka, *Mirabilis expansa* can be found in Lost Crops of the Incas from National Academy Press

Chamaelirium

Chamaelirium luteum (L.) A. Gray.

Chamaelirium

Figure 38.—Chamaelirium (*Chamaelirium luteum*)

Other common names.—Helonias, unicorn root, false unicorn root, blazing-star drooping starwort, starwort, devil's-bit, unicorn's-horn. This plant is frequently confused with *Aletris farinosa* L., not because it bears much resemblance to the latter but probably on account of a similarity in some of the common names by which they are sometimes designated. In the drug trade it is perhaps best known as Helonias, but the use of that name is likely to lead to confusion because the plant has no relation to the genus *Helonias*.

Habitat and range.—This native plant is found in open woods from Massachusetts to Michigan and south to Florida and Arkansas.

Description.—Chamaelirium is an erect, fleshy herb. The male and female flowers are borne on separate plants. The male plants grow to a height of 1 1/2 to 2 1/2 feet, while the female plant is sometimes 4 feet tall and is more leafy. The leaves which are from 2 to 8 inches long, are spoon shaped, being wider at the top than at the base. The white starry flowers are produced from June to July. The flowers of the male plant are borne on plumelike spikes from 3 to 9 inches long and those of the female plant in erect spikes. The rootstock is from one-half to 2 inches in length and usually curved upward at one end in the form of a horn. The rootlets penetrate to the center of the rootstock. This and its disagreeable bitter taste distinguish it from Aletris root.

Part used.—The rootstock. collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Chamaemelum nobile (L.) All.

Asteraceae (Compositae)

Chamomile, Camomile

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Nitrogen Application Affects Yield and Content of the Active Substances in Camomile Genotypes—Wudeneh Letchamo

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

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Chrysothamnus nauseosus (Pallas) Britt.

Asteraceae, or Compositae

Rubber Rabbitbrush, Chamisa

NewCROP has Rubber Rabbitbrush information at:

Chrysothamnus: A Rubber-Producing Semi-Arid Shrub—D.J. Weber, W.M. Hess, R.B. Bhat, and J. Huang

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside links

Stinky Rabbitbrush (Chrysothamnus nauseosus) Native Wildflowers of the North Dakota Grasslands.

Ayerza, R. (h) and W. Coates. 1996. New industrial crops: Northwestern Argentina Regional Project. p. 45-51. In: J. Janick (ed.), Progress in new crops. ASHS Press, Alexandria, VA.

New Industrial Crops: Northwestern Argentina Regional Project

Ricardo Ayerza (h) and Wayne Coates

The goal of the Northwestern Argentina Regional Project is to identify and bring into commercial production new industrial crops which can help diversify agricultural production and increase profits for farmers in northwestern Argentina. Both private and government organizations in the United States and Argentina have been working cooperatively on this project since its inception.

The project started in 1991 with an agreement between Partners of the Americas Inc., a non-profit organization headquartered in Washington DC, and Agropecuaria El Valle S.A., an agricultural enterprise with offices in Buenos Aires and Catamarca, Argentina. This technical cooperation was made possible through the Farmer to Farmer program, financed by the Congress of the United States as a part of the 1990-95 Farm Bill (Public Law 480), and the Agency for International Development (USAID).

Subsequently, The University of Arizona, the University of California, the National University of Catamarca, the Rural Group Pulares, and the government of the province of Salta joined the project. In 1995 four grower organizations from the province of Jujuy also joined. These are CREA Los Lapachos, Union Caneros Independientes de Jujuy and Salta, Cooperativa de Tabacaleros de Jujuy, and La Camara del Tabaco de Jujuy.

NEW CROP COMMERCIALIZATION

The development of any new crop goes through four distinct phases: (1) market assessment; (2) identification of the most appropriate species; (3) domestication of the species; (4) commercial production.

Growers, processors and marketing agencies must be involved and share the risks in all four phases of this development process for it to be the most effective. Under these conditions all of the involved parties are unified through contracts, a common information base, and personal involvement. Because this concept of widespread involvement and responsibility is an integral part of the Northwestern Argentina Regional project, the growers, processors and marketing agencies have all assumed a degree of the cost, and hence risk, with it.

Ecosystems

Northwestern Argentina consists of five provinces: Salta, Jujuy, Tucuman, Santiago del Estero, and Catamarca. The region can be divided into three general ecosystems which run parallel to each other in a north and south direction. The eastern most ecosystem is called Chaco, and is a wide plateau approximately 300 to 700 m in elevation. The climate is warm and dry, and naturally supports an open woodland ecosystem. Directly to the west is a long sloping region which rises from 200 to 4000 m in elevation, over a distance of 50 to 100 km. This center ecosystem is called the Yungas, is frost free in most years, and receives more than 1200 mm of rainfall annually. This area is suitable for tropical fruit production. The western ecosystem is a high plateau called Puna, and is at an elevation of 4000 m or more. It is a cold and dry grassland, having no naturally occurring tree species.

The work reported in this manuscript took place in the Yungas and Chaco ecosystems, within the provinces of Catamarca, Jujuy, Salta, and Tucuman. The project began in 1991 and is planned for continuation at least through 1996, with the objective being to evaluate potential industrial crops and then bring them into production. Ancillary objectives are to bring about a better public understanding of how new crops can improve the economic situation in northwestern Argentina, and to promote closer cooperation between northwestern Argentina and the southwestern United States.

Education and Information Exchange

Establishing research plots, providing on-farm technical advice, and conducting workshops, conferences, and seminars for growers, university faculty, and technical personnel have all been part of the program. During 1995 alone, 12 different topics were presented in a series of workshops, conferences, and seminars held at various locations in northwestern Argentina.

Seventeen scientists, growers and company managers have been brought from the U.S. to Argentina to provide technical assistance. Areas of expertise have included agronomy, genetics, plant physiology, mechanization, processing, economics, and marketing.

Nineteen professors from the National University of Catamarca and three from the University of La Rioja travelled to the U.S. for specialized training programs lasting from 2 to 3 months. The time was spent at either the University of Arizona, or the University of California. In 1994, two members of a women's agricultural cooperative from Catamarca participated in the exchange program and spent time in California, Arizona and Northern Mexico, where they were able to exchange ideas on new crop production with growers and researchers.

IDENTIFICATION OF SUITABLE NEW CROPS

The research plots, as well as the demonstration plantings, have been located on private farms, thus directly involving the farming public in the project. The tests have been conducted in the four provinces of Catamarca, Jujuy, Salta, and Tucuman, (Table 1) providing wide public exposure to the project.

Through the trials, six species have been identified which appear to hold significant potential for the region. These are: chia, lesquerella, vernonia, and chan which are sources of industrial oil; guayule, a source of rubber, resins, and latex; and kenaf, a raw material for paper and newsprint. Of these crops, only lesquerella and chia have been grown commercially. For the others, trials are continuing to evaluate cultivars and/or sites in order to identify those crops and locations which hold the greatest commercial potential for northwestern Argentina. Some of the results are presented here.

Chan (*Hyptis suaveolens*, Labiatae)

This plant is native to southern Mexico and Central America, and was used as a food by pre-columbian people in the region. The seed contain 77%-80% linoleic acid, and little or no linolenic acid. Yields in Argentina have reached 1770 kg/ha (Coates and Ayerza 1995). The data in Table 2 summarize the results obtained from four-row plots which were harvested in June 1995. No statistically significant difference between sites, either in terms of total biomass or amount of seed harvested, was detected. This tends to indicate that either site would be equally suited for growing chan. Table 2 also shows that total oil content as well as percent alpha-linoleic fatty acid in the seed were similar at both locations. This also indicates that either site would prove equally suitable for growing chan.

The total oil yield is very low compared to other commercially grown oil seed crops. Because this is a new crop, it is necessary to conduct further tests and examine the analysis techniques which were used in the laboratory to determine oil quantity and distribution. Environmental factors which might have affected the results also need to be investigated before a sound conclusion can be drawn regarding the quantity and quality of oil contained in the seed.

Kenaf (*Hibiscus cannabinus*, Malvaceae)

Kenaf, a native of tropical Africa, is a fast-growing annual which is grown for its fiber. It can reach heights of 4 to 6 m in one growing season, and has yielded up to 17.5 t/ha of dry matter in Argentina (Ayerza and Cook 1996). Table 3 presents results from a series of kenaf trials that were conducted over a number of years, at five sites. Sumalao and Pichanal were both irrigated, while the other sites were not. Dry matter yields ranged from 4.3 to 13.3 t/ha, with the yields being quite variable. Yields have been influenced by both location and climate. One cultivar has not proven superior to the others at all locations, indicating that site influences are significant and will need to be taken into account when selecting cultivars for commercial production. These tests clearly indicate the need for additional cultivar and location trials, and consequently these are underway.

Kenaf was first planted in Argentina on a commercial scale in late 1995. Plans called for planting 25 ha using three cultivars, with the idea being to use the plantings not only to determine the production potential of the three cultivars which had demonstrated the best performance in the plots, but also to evaluate alternative harvesting technologies and determine which might be the most appropriate for the region. After harvest, the material was to be sent to a commercial operation to be pulped, and was then to be blended with bagasse pulp and made into paper. Unfortunately early 1996 was one of the driest summers on record in northwestern Argentina, and the extended trial had to be abandoned. As a consequence only two hectares were sown. Plans still call for this field to be used to test alternative harvesting methodologies, although in a more limited scale. Pulping will take place provided that a commercial entity can be located that is willing to work with a limited amount of material.

Vernonia (*Vernonia galamensis*, Asteraceae)

Vernonia, a member of the sunflower family, is native to tropical Africa. Its seed contain an unusual oil which, because of its low viscosity, can be used as a solvent in paint. Over 70 other potential uses for the oil have been identified. Table 4 presents the results from the vernonia trials conducted in 1995 at Pichanal and Yuto. At Pichanal significant differences in seed yield were detected among the cultivars, with more than a ten fold difference being found between the most and least productive. No statistically significant differences in 1000 seed weight were detected, and some cultivars had significantly lower oil content than others. As insufficient seed was available to plant a replicated trial at Yuto, only one block was sown. As a consequence only mean seed yields are presented in Table 4, and no statistical analysis of the data was conducted. The mean values, however, indicate that this site may be the best of the two for growing vernonia.

In general the vernonia yields are low, on a per hectare basis, as compared to other oilseed crops. The values were determined for rows planted 1 m on center. This spacing conforms to USDA test plots, and allows comparison with their data. In a commercial situation, row spacing would be on the order of 150-200 mm, significantly increasing yields. Pest and disease problems at both sites also decreased yield.

Guayule (*Parthenium argentatum* Gray, Asteraceae)

Guayule, a plant native to the Chihuahuan desert of Mexico, produces rubber that is almost identical to that from the rubber tree. It also produces several co-products, including resins, low-molecular weight rubber, and bagasse, each of which have potential uses. The rubber (or latex) from guayule can be used where synthetic materials are not satisfactory. Table 5 presents the analysis which was conducted on two year old guayule harvested in Catamarca in 1995. Significant differences in biomass yields were detected among varieties, however no differences in rubber yield were found on a dry matter basis. When the biomass yields are combined with the rubber content, rubber production ranged from 17 to 60 g per plant. Thus although percentage of rubber in a plant can influence processing costs, total rubber production on an area basis would probably be the governing factor used to select the best varieties.

Results of this study show that additional trials are required to determine not only the highest producing varieties, but also to assess yields as influenced by time of harvest. Plans call for these tests to be undertaken starting in June 1996.

Jojoba [*Simmondsia chinensis* (Link) Schneid., Simmondsiaceae]

Jojoba, which is native to the southwestern United States and northern Mexico, produces seeds which contain a liquid wax that has uses in the cosmetic industry, and it also serves as high quality lubricant. Jojoba has been grown commercially for a number of years in La Rioja and Catamarca provinces. The development of equipment to mechanize its production has been an integral part of the Northwestern Argentina Regional Project. Equipment has already been developed for transplanting cuttings, pruning the plants, and preparing the soil surface for harvest. A new type of jojoba harvester is under development, with a prototype having been built and tested.

Lesquerella (*Lesquerella fendleri*, Brassicaceae)

Lesquerella is an annual plant native to the southwestern United States. The seed of lesquerella contain an unusual fatty acid which is similar to that of castor bean. This fatty acid can be converted to many products which have both industrial and cosmetic potential. The meal remaining after the oil is removed contains a good amino acid balance, and can be used in livestock feed.

Chia (*Salvia hispanica*, Labiatae)

Like chan, chia is native to southern Mexico and has been used by pre-columbian inhabitants of Central America as a food source and a medicine. Oil from chia was also used in paints. The seed contain the highest known natural source of linolenic acid (60%), with linolenic acid having many uses in industry and cosmetics. The meal remaining after the oil is expressed is high in protein and fiber, and can be used for human and animal food. Seed yields in plots of up to 1602 kg/ha, and oil contents as high as 38.6% have been reported in Argentine trials (Ayerza, 1995).

Chia and lesquerella have been commercially produced in the provinces of Catamarca, Salta, and Tucuman. The seed produced has been exported to the United States, with contracts for its production being signed between the growers and commercial enterprises from Argentina and the U.S. Table 6 lists the sites and number of growers that have been involved in the commercial production of these crops.

From Table 6 it can be seen that the number of farms and growers involved in the production of chia and lesquerella on a commercial basis has varied. The reasons for this have been the degree of success realized by each grower, and the level of satisfaction arising from being involved with the introduction of a new crop.

The commercial yields of both chia and lesquerella have varied from year to year, and from location to location. This is due to a number of factors including cultural practices, climate, weed infestations and harvesting techniques used. Cultural practices purposely have not been standardized across farms, as it is the intent of the project to allow farmers to use those cultural practices with which they are familiar to grow the new crops, while providing them with overall guidance as to how best to produce each crop.

Analyses of the chia seed which was commercially harvested in 1995 showed viability to range from 78% to 87%. Purity ranged from 84% to 97.5%. This is considered excellent, especially given the small size of the seed and the difficulties which were encountered with the harvesting and cleaning processes. These data demonstrate that chia can be commercially produced in northwestern Argentina.

Table 7 provides a comparison of the returns that can be realized from chia production, as compared to two traditional crops found in the region. The higher returns from chia have in large part prompted a significant increase in acreage planted in 1996.

LONG RANGE OUTLOOK

Over-production of traditional crops continues worldwide. It is therefore likely that prices and profit margins for these will remain very low, except when shortages arise because of war or climatic disasters. Furthermore, the consumption of many non-renewable resources continues, and environmental policies are already beginning to favor markets for many new industrial crops.

The success of the program is clearly demonstrated by the increasing numbers of hectares of chia being grown in northwestern Argentina. It is anticipated that this trend will continue and that the same thing will occur for lesquerella and kenaf. Such success is possible because the program is dynamic. Many organizations and growers are already a part of this project and they expect to take advantage of the conditions which exist to benefit their own enterprises. Others in the community benefit as a result of improved economics. The dynamic, open nature of the Northwest Argentina Regional Project means that other organizations and growers interested in the benefits of new industrial crops, including diversification of their cropping practices, are welcome to join the program at any time.

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Table 1. Locations where the new industrial crops have been evaluated or commercially grown.

Location	Province	South latitude	Elevation (m)	Rainfall (mm)
C. de Valle	Catamarca	28° 36'	454	437
Sumalao	Catamarca	28° 28'	546	394
Perico	Jujuy	24° 23'	936	600
Yuto	Jujuy	23° 35'	349	802
Chiocoana	Salta	25° 06'	1270	715
El Carril	Salta	25° 03'	1069	624
Metan	Salta	25° 30'	858	841
Pichanal	Salta	23° 17'	300	618
Pulares	Salta	25° 04'	1240	825
Guemes	Salta	24° 40'	734	507
Alberdi	Tucuman	27° 36'	369	1092

Table 2. Biomass, seed yield, oil content and composition of chan seed as affected by location.

Location	Biomass (kg/ha)	Seed (kg/ha)	Total oil (%)	Palmitic (%)	Palmitoleic (%)	Stearic (%)	Oleic (%)	Linoleic (%)	Linolenic (%)
Pichanal	2188a[z]	638a	11	8.4	0.0	2.5	7.8	81.9	0.4
Yuto	2125a	725a	12	8.9	0.0	1.8	8.6	80.4	0.3

[z]Mean separation in columns by Ryan-Einot-Gabriel-Welsch multiple range test, 5% level.

Table 3. Production of kenaf at five locations in northwestern Argentina.

	Location (no. of years)				
Cultivar	Sumalao[z] (t/ha)	Alberdi (t/ha)	Metan (t/ha)	Yuto[y] (t/ha)	Pichanal[z] (t/ha)
Tainung 2	13.3 (3 yr)	9.4 (2 yr)	7.7 (2 yr)	11.3 (1 yr)	6.0 (2 yr)

Cubano	10.9 (3 yr)	7.1 (2 yr)	7.2 (2 yr)	7.7 (1 yr)	5.9 (2 yr)
Cuba 108	10.0 (3 yr)	11.4 (1 yr)	6.9 (1 yr)	--	4.3 (1 yr)
Tainung 1	9.9 (3 yr)	6.8 (2 yr)	7.4 (2 yr)	8.4 (1 yr)	4.9 (2 yr)
15-2	9.5 (3 yr)	7.2 (1 yr)	9.8 (1 yr)	--	8.0 (1 yr)
Everglades 41	8.9 (3 yr)	8.28 (2 yr)	7.3 (2 yr)	9.8 (1 yr)	5.6 (2 yr)
SF 45-9	8.9 (3 yr)	6.4 (2 yr)	7.5 (2 yr)	10.6 (1 yr)	8.4 (2 yr)
Everglades 71	8.3 (3 yr)	7.5 (2 yr)	8.1 (2 yr)	10.4 (1 yr)	7.3 (2 yr)
SF-192	--	8.2 (2 yr)	8.2 (2 yr)	7.5 (1 yr)	7.7 (2 yr)
N-7	--	7.0 (2 yr)	5.6 (2 yr)	8.4 (1 yr)	5.2 (2 yr)
19-117-2	10.9 (2 yr)	--	--	--	--
Guatemala 51	11.6 (2 yr)	--	--	--	--
78-18 RS 10	7.8 (2 yr)	--	--	--	--

[z]Irrigated
[y]Two sites

Table 4. Yield of vernonia grown at Pichanal and Yuto.

	Pichanal			Yuto
Cultivar	Seed yield (kg/ha)	Oil (%)	1000 seed wt (g)	Seed yield (kg/ha)
29E-OR2-14	229a[z]	43.8a	3.23a	457
35A-2-9	188ab	42.0a	3.19a	186
72A-1-2	158abc	42.6a	3.17a	257
48A-10	154abc	41.9a	3.17a	143
66C-1-9	139abcd	41.3ab	3.62a	193
15D-10-12	128abcd	41.2ab	3.68a	150
A0399	100bcd	42.7a	3.22a	186
14D-2-5	82bcd	43.2a	3.18a	157
AO382	81bcd	41.0ab	3.32a	NA[y]
35A-2-10	37d	36.6bc	3.12a	150

[z]Mean separation in columns by Ryan-Einot-Gabriel-Welsch multiple range test, 5% level.
[y]Not available; did not mature sufficiently prior to frost to permit harvesting.

Table 5. Guayule biomass and rubber content found in two year old plants grown in Catamarca.

Line	Biomass (g/plant)	Rubber content (%)
AZR1	1103a[z]	6.1a
O16-1	401b	8.8a
AZ-R2	368bc	8.0a

N9-5	337bcd	5.8a
N6-5	301cd	10.6a
P3-1	273d	14.1a
O16-3	268d	12.8a
AZ-R3	171e	11.0a

[z]Mean separation in columns by Ryan-Einot-Gabriel-Welsch multiple range test, 5% level.

Table 6. Number of growers and area commercially sown to chia and lesquerella in Northwestern Argentina.

Year	Location	Province	Growers (no.)	Area planted (ha)	Average size (ha)	Yearly total (ha)
Chia						
1992	C. del Valle	Catamarca	1	14	14	14
1993	C. del Valle	Catamarca	1	70	70	
	Alberdi	Tucuman	1	4	4	74
1994	C. del Valle	Catamarca	2	3	1.5	
	Sumalao	Catamarca	1	20	20	
	Alberdi	Tucuman	1	5	5	
	V. de Lerma[z]	Salta	1	3	3	31
1995	C. del Valle	Catamarca	2	3	1.5	
	Alberdi	Tucuman	1	5	5	
	V. de Lerma	Salta	5	40	8	
	Metan	Salta	1	10	10	58
1996	V. de Lerma	Salta	6	120	20	
	Guemes	Salta	1	5	5	
	Perico	Jujuy	2	20	10	145
Lesquerella						
1992	C. del Valle	Catamarca	1	12	12	12
1993	C. del Valle	Catamarca	1	2	2	2
1994	Sumalao	Catamarca	1	1	1	1
1995	Pulares	Salta	4	20	5	20

[z]Valle de Lerma: Includes Pulares, Chiocoana and El Carril

Table 7. Economic comparison of chia production to black and white bean production.

Crop	Yield (kg/ha)	Price ($/t)	Gross income ($/ha)	Production cost ($/ha)	Gross margin ($/ha)
Chia	1,000	800	800	220	580
Black beans	1,500	400	600	320	280
White beans	1,100	700	700	380	390

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Potential Nutritional and Health Benefits of Tree Spinach*

Joseph O. Kuti and Eliseo S. Torres

The tree spinach (*Cnidoscolus chayamansa* McVaughn, Euphorbiaceae), called "chaya" in south Texas, is popular in Mexico and Central America and has been introduced into the United States (mainly South Texas and Florida) for potential uses as a leafy vegetable and/or as a medicinal plant. The plant is an attractive shrub, 3 to 5 m tall (Breckon 1979). The leaves are broad and may consist of 3 or more lobes with fleshy petioles (Fig. 1). The white-colored flowers, which are usually borne on cyme-branched inflorescences, may contain 3-forked arrangements in which the pistillate flowers are located on the basal fork. The staminate flowers are expanded distally from the base of the lobes. Mature seeds and fruit are rare and unknown (McVaugh 1944).

The young shoots and tender leaves of chaya are cooked and eaten like spinach. They comprise part of the staple diet and are the main dietary source of leafy vegetable for the indigenous people of Yucatan peninsula of Mexico and Kekchi people of Alta Verapaz in Guatemala (Harris and Munsell 1950; Booth et al. 1992). There are many underexploited native leafy plants with potential as a traditional food source (NAS 1975). With current renewal of interest in household gardens, attention is being focused on promoting some of these plants as leafy green vegetables among populations in the developing countries (FAO 1987). The edible parts of chaya plant, which taste like spinach when cooked, provide important nutritional sources for protein, vitamins (A and C), minerals (calcium, iron, phosphorus), niacin, riboflavin, and thiamine among populations that cannot afford expensive foods rich in these nutrients (Yang 1979). The plant may also constitute a potentially valuable leafy green vegetable here in the United States and elsewhere.

Chaya traditionally has been recommended for a number of ailments including diabetes, obesity, kidney stones, hemorrhoids, acne, and eye problems (Diaz-Bolio 1975). Chaya shoots and leaves have been taken as a laxative, diuretic, circulation stimulant, to improve digestion, to stimulate lactation, and to harden the fingernails (Rowe 1994). Like most food plants such as lima beans, cassava, and many leafy vegetables, the leaves contain hydrocyanic glycosides, a toxic compound easily destroyed by cooking. Even though some people tend to eat raw chaya leaves, it is unwise to do so.

While the nutritional value of chaya has been demonstrated (Martin and Ruberte 1978; Booth et al. 1992), none of the purported therapeutic values of chaya leaves has been substantiated with scientific experimentation. Therefore, the present study reports on nutritional composition of raw and cooked chaya leaves and the results compared with the nutritional composition of spinach leaves. Also a possible antidiabetic effect of the aqueous leaf extracts or chaya tea, administered through drinking water to streptozotocin-induced diabetic rabbits, was evaluated.

METHODOLOGY

Nutritional Composition

Young leaves and shoots of *C. chayamansa* were collected from greenhouse-grown plants. Raw and cooked (in microwave oven for 5 min) samples of the leaves and shoot were analyzed for their moisture content, crude fiber, fat, and ß-carotene using the AOAC standard methods (1984), for the protein content (N_2 content multiplied by 6.25) using modified semi micro-kjeldahl method of Searle (1974), for mineral contents using an atomic absorption spectrohotometer and for total carbohydrate using gas chromatography. All samples were analyzed in triplicate. Nutritional components and average nutritive value (ANV) of chaya leaves were compared to spinach leaves. The ANV was calculated using the empirical formula proposed by Grubben (1978): ANV/100g = g protein/5 + g fiber + mg Ca^{++}/100 + mg Fe^{++}/2 + mg carotene + mg vit C/40

Possible Antidiabetic Effect

The experimental animals (rabbits) for this study were supplied by Dr. Steven Lukefahr of the Department of Animal and Wildlife Sciences, Texas A&M University-Kingsville. All animals were housed and maintained in compliance with Texas A&M University-Kingsville IACUC policy on animal care and use. The rabbits were fed with standard rabbit chow and given water *ad libitum*. Diabetes was induced by a single subcuteanous injection of 60 mg/kg streptozotocin (STZ), after fasting for 18 h, according to the method described by Bonner-Weir et al. (1981). The rabbits exhibited post-STZ blood glucose levels that were at least double that of the pre-STZ levels one week after diabetes had been induced.

The leaves of *C. chayamansa* were collected from plants grown in the greenhouse. About 10 g of the leaves was extracted with boiling water (1000 mL) for 30 min until the volume of the water had been reduced to 90% of the original. The tea (900 mL) was filtered and used in the subsequent experiments. Two groups of 8 rabbits each were used. The first group of 8 rabbits were normoglycemic (non-diabetic). Four of the normoglycemic rabbits recieved water (control) only and the remaining 4 received chaya tea treatment only. The second group of 8 rabbits were hyperglycemic (diabetic). Four of the diabetic rabbits received water only and the remaining 4 received chaya tea only.

Before administering the tea or water (control), blood samples were obtained from the ears of 18 h fasted nondiabetic and diabetic rabbits using a capillary tube. Then the tea or water was administered orally through drinking water bottles *ad libitum*. Blood sampling was repeated at hourly intervals for 6 h after the oral administration. Blood glucose was determined using a blood glucometer (Miles Inc., Diagnostic Division, Elkhart, IN, U.S.). The mean blood glucose values ±SE were determined and the significance of the difference between the means of treated and control groups was established by Student's *t*-test.

RESULTS

Nutritional Composition

The nutritional analysis of chaya (*C. chayamansa*) leaves and spinach (*Spinacia oleracea* L.) are presented in Table 1 for comparison. Chaya leaves were found to contain substantially greater amounts of nutrients than the spinach leaves. The chaya leaf is especially high in protein (5.7%), crude fiber (1.9%), calcium (199.4 mg/100 g), potassium (217.2 mg/100 g), iron (11.4 mg/100 g), vitamin C (164.7 mg/100 g), and carotene (0.085 mg/100 g). The levels of chaya leaf nutrients, in this study, agree with published reports (Martin and Ruberte 1978; Munsell et al. 1949; Booth et al. 1992) and are two to threefold greater than most edible leafy green vegetables. In terms of the average nutritive value, chaya leaves [14.9] is by far superior to other leafy green vegetables such as spinach [6.4], amaranth [11.3], Chinese cabbage [7.0], and lettuce [5.4] (Grubben 1978). While some edible leafy green vegetables are usually good sources of mineral macronutrients (Levander 1990), chaya leaf furnishes appreciable quantities of several of the essential mineral macronutrients necessary for human health maintenance. For example, potassium has been shown to be an important mineral nutrient in the control of hypertension and in the reduction of risks of stroke (NRC 1989), calcium is important for ossification and iron is necessary for normal hematopoiesis (Hodges et al. 1978). Brise and Hallberg (1962) reported that vegetables, such as chaya, with high vitamin C content may enhance absorption of nonheme iron.

Analysis of raw and cooked samples of chaya leaves revealed that cooking may increase the relative composition of carbohydrate and fat and decrease relative composition of crude fiber and protein (Fig. 2). On the other hand, cooked samples of chaya leaves were considerably higher in calcium, phosphorus and iron while the potassium content was relatively lower than in the raw samples (Fig. 3). The increase in some of the mineral nutrients may be due to the cooking process, which allows extraction of the nutrients from the tissues, therefore increasing the percentage of mineral elements while decreasing moisture content (Booth et al. 1992).

Possible Antidiabetic Effect

Following the oral administration of chaya tea, the blood glucose levels of the diabetic rabbits were gradually lowered from a high of 118 (baseline at 0.0 h) to 87 six hours after administration. The blood glucose level of 87 is similar to blood glucose levels of normoglycemic rabbits on drinking water (Table 2). The blood glucose levels of non-diabetic control rabbits that were given chaya tea showed a slight increase (i.e. hyperglycemia) above the baseline 85 at 1 to 2 h after administration, but rapidly stabilized thereafter (Table 2). The reason for this transient hyperglycemia is unknown and needs to be investigated. The results obtained in this study suggest that in STZ-induced diabetic rabbits, aqueous leaf extracts of *C. chayamansa* may be effective for treatment of non-insulin dependent diabete mellitus (NIDDM) symptomatology. This is a first report on hypoglycemic effect of chaya plants. The present report is preliminary in nature and additional studies will be needed to properly characterize the antidiabetic potential of chaya in diabetic animals. Also further studies will be necessary to determine the effective dosage, mechanism of the hypoglycemic activity and the active hypoglycemic principle present in the leaves of *C. chayamansa*.

CONCLUSION

The potential of *C. chayamansa* for human food and health has a significant implication for the plant as a horticultural crop. Although demand for chaya, as a medicinal plant, has recently increased among the Hispanic population in the United States, the plant has the potential to make a significant nuritional contribution to the vegetable diet as well, because of its high nutrient content. The development of chaya as a new horticultural crop would transcend the ethnic popularity and create a worldwide market for the plant and its products, whether as a leafy green vegetable and/or as a therapeutic herbal tea.

It is noteworthy that the chaya plant is drought resistant, which is of a particular value in areas with short seasonal rainfall and shortage of green vegetables (Peregrine 1983). Growth of the plant is rapid and edible leaves and shoots could be produced within a short period (8 to 10 weeks). Propagation by cutting is easy and the woody stem sections readily root. Few pests and diseases are known to be of any significance in the cultivation of chaya plants. One disadvantage is the presence of toxic hydrocyanic glucosides in the leaves. However, cooking, which is essential, inactivates the toxic compound. Other *Cnidoscolus* (chaya) species are being examined in our laboratory at Texas A&M University-Kingsville to genetically select species with high leaf and shoot biomass yield and lower hydrocyanic glycoside content. Additionally, we are conducting research on genetic improvement, propagation, field production, potential for processing and marketing of chaya and its products in south Texas.

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Table 1. Comparisons of nutritional compositions of leaves of "chaya" (*Cnidoscolus chayamansa* McVaughn) and spinach (*Spinacia oleraceae* L.) per 100 g fresh weight.

Component	chaya	spinach[z]
Water (%)	85.3	90.7
Protein (%)	5.7	3.2
Fat (%)	0.4	0.3
Crude fiber (%)	1.9	0.9
Total CHO (%)	4.2	3.8
Ash (%)	2.2	1.8
Calcium (mg/100g)	199.4	101.3
Phosphorus (mg/100g)	39.0	30.0
Potassium (mg/100g)	217.2	146.5
Iiron (mg/100g)	11.4	5.7
Ascorbic acid (mg/100g)	164.7	48.1
Carotenoids (mg/100g)	0.085	0.014
Average nutritive value[y]	14.94	6.38

[z]Data for spinach were obtained from the USDA (1984).

[y]Average nutritive value according to Grubben emprical formula (1978).

Table 2. Effect of *Cnidoscolus chayamansa* leaf extract ("chaya" tea) on blood glucose levels of non-diabetic and streptozoctocin-induced diabetic rabbits.

	Blood glucose level (mg/dL)[z]			
	Non-diabetic		Diabetic	
Time (h)	water	"chaya"	water	"chaya"
0.0	87±3.1	85±2.5	112±8.3	118±13.2
1.0	86±2.7	91±3.9	138±4.6	114±7.3

2.0	87±2.6	99±4.3	143±6.4	103±8.7
3.0	87±3.1	82±1.6	139±8.0	96±9.3
4.0	88±3.0	85±2.1	153±6.3	92±5.8
5.0	87±4.7	84±4.2	158±7.4	89±3.6
6.0	87±3.1	82±2.7	162±9.0	87±2.7

[z]Mean±SE.

Fig. 1. A potted chaya plant. The young leaves and shoots are edible after being boiled in water.

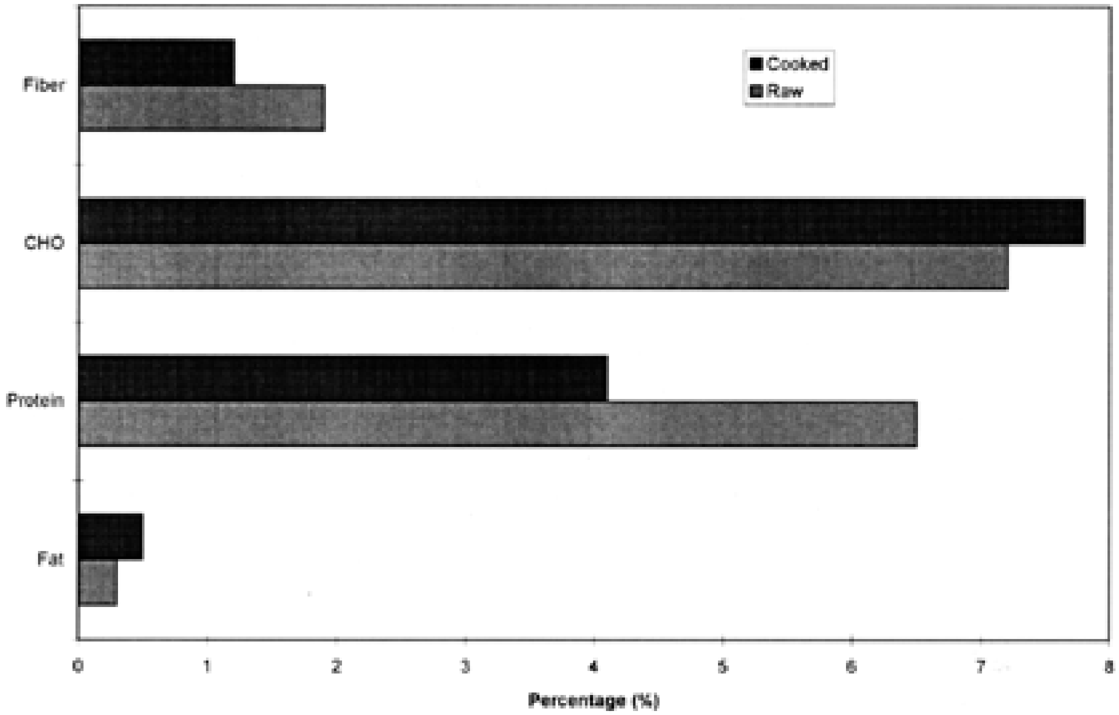

Fig. 2. Proximate fat, protein, carbohydrate and crude fiber compositions of raw and cooked chaya leaves.

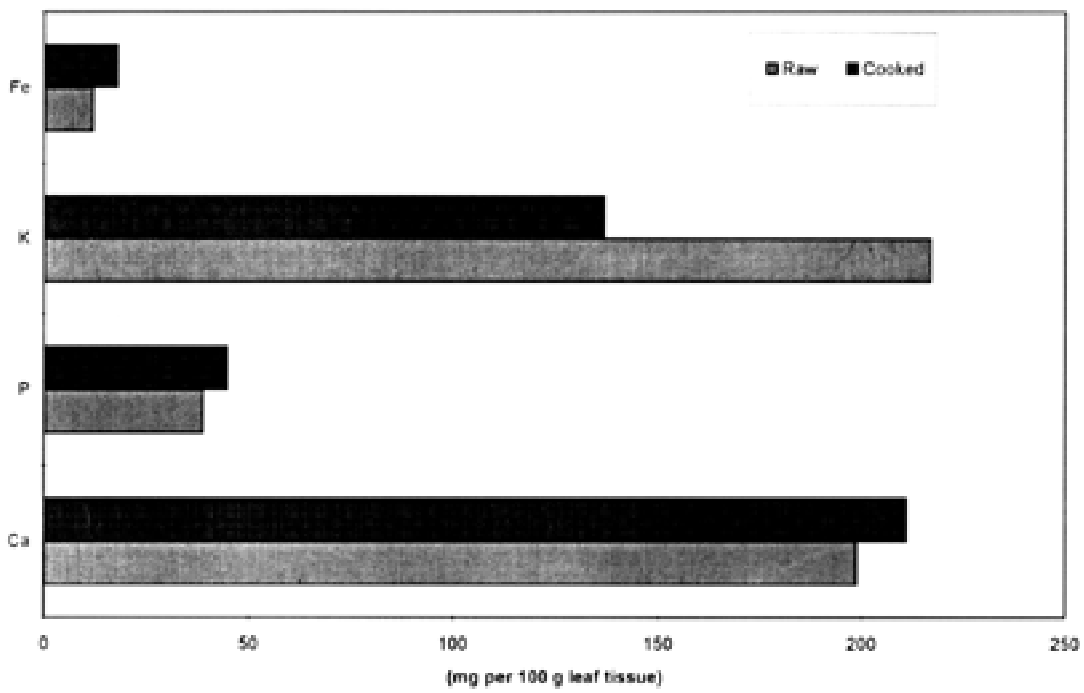

Fig. 3. Proximate mineral macronutrient (calcium, phosphorus, potassium and iron) compositions of raw and cooked chaya leaves.

Last update August 24, 1997 aw

Sechium edule (Jacq.) Sw.

Cucurbitaceae

Chayote, Buddha's-hand, *Chaco, Chayotli, Chinchayote, Chocho, Choko*, Christophene, Christophine, *Chuchu*, Custard Marrow, *Guispui*, Mango Squash, Mirliton, *Pepinella, Sousous, Tallon, Tallote*, Vegetable Pear, *Xuxu*

We have information from several sources:

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Neglected Crops : 1492 from a Different Perspective.—1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 47-62.

Outside Links

Chayote—by Rafael Lira Saade from the International Plant Genetic Resources Institute

Cudrania tricuspidata (Carr.) Bur. ex Lavallee

Moraceae

Cudrania, Chinese Mulberry, Che, Cudrang, Mandarin Melon Berry, Silkworm Thorn, Storehousebush

Note: Intergeneric hybrids exist between *Cudrania tricupidata* and *Maclura pomifera* (osage orange) = *Macludrania hybrida*

NewCROP has outside links to Cudrania information at:

Cudrania California Fruit Facts - from the California Rare Fruit Growers Inc.

Turtlehead

Chelone glabra L.

Figure 109.—Turtlehead (*Chelone glabra*)

Other common names.—Balmony, white turtlehead, turtle bloom, fishmouth codhead, salt-rheum weed snakehead, bitter herb, shellflower.

Habitat and range.—This native plant grows in swamps and along streams from Newfoundland to Manitoba and south to Florida and Kansas.

Description.—Turtlehead is an erect, slender herb with a 4-angled stem 1 to 4 feet in height and short-stemmed, sharp-toothed leaves from 3 to 6 inches in length. The flower clusters, which are produced in late summer or early fall consist of showy, whitish or pinkish flowers about an inch in length, resembling in form the head of a turtle or a snake.

Part used.—The herb, especially the leaves, collected during the flowering period.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Wormseed

Chenopodium ambrosioides anthelminticum (L.) A. Gray.

Synonym.—*Chenopodium anthelminticum* L.

Other common names.—Chenopodium, American wormseed, Jerusalem-oak.

Habitat and range.—Wormseed occurs in waste places from New England to Florida and westward to California.

Description.—This common weed has a much-branched stem from 2 to 3 feet in height and numerous, lance-shaped leaves, the lower ones 1 to 3 inches in length and the upper ones much smaller. The greenish flowers are produced from July to September in closely crowded spikes mixed with leaves and are followed by small, green, roundish fruits each of which contains a very small black seed. The entire plant has a strong, disagreeable odor due to the volatile oil which is present.

Figure 123.—Wormseed (*Chenopodium ambrosioides anthelminticum*)

Part used.—The fruit, collected when ripe, and the volatile oil distilled from the fruit or from the entire plant. Wormseed is grown commercially mainly in central Maryland for the production of the oil.*

Information on the extraction of volatile oils from plants is contained in the following publication: Sievers, A.F. Methods of extracting volatile oils from plant material and the production of such oils in the United States. U.S. Dept. Agr. Tech. Bul. 16, 36 p. illus. 1928.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Good King Henry

Mercury, Markery, Fathen, Wild spinach

Chenopodiaceae *Chenopodium bonus-henricus* L.

Source: Magness et al. 1971

The plant is a stout, erect herb, up to 2.5 feet, with broad, triangular or ovate leaves. Leaves have wide spreading basal points, and are entire or undulate. Plants are sparingly cultivated for the leaves, used as pot herbs. The plant is similar to spinach both in general growth habit and use.

Season, seeding to first harvest: about 2 months.

Production in U.S.: No data. Apparently not commercial.

Use: As pot herb.

Part of plant consumed: Leaves and young stems.

Last update February 18, 1999 by ch

Chenopodium quinoa Willd.

Chenopodiaceae

Goosefoot, *Huauzontle*, Inca wheat, Pigweed, *Quihuicha*, Quinoa, Quinua

NewCROP has Quinoa information at:

Quinoa—Duane L. Johnson and Sarah M. Ward

New Grains and Pseudograins—Duane L. Johnson

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

New Crops In The UK: From Concept to Bottom Line Profits—Francis H. Nicholls

Quinoa: A Potential New Oil Crop—Michael J. Koziol

Blue Corn and Quinoa: New Grain for the Southwest

Quinoa: Candidate Crop for NASA's Controlled Ecological Life Support Systems—Greg Schlick and David L. Bubenheim

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Quinoa: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

New Crops for Canadian Agriculture—Ernest Small

Quinoa Saponins: Concentration and Composition Analysis—José Bernardo Solíz-Guerrero, Diana Jasso de Rodríguez, Raúl Rodríguez-García, José Luis Angulo-Sánchez, and Guadalupe

Méndez-Padilla

And outside links to more Quinoa info:

Quinoa can be found in Lost Crops of the Incas from National Academy Press

Quinoa facts from Waltonfeeds

Chenopodiums A Modern Herbal by Mrs. M. Grieve

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Prunus cerasus L.

Rosaceae

Sour cherry

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Exploration and Exploitation of New Fruit and Nut Germplasm—Maxine M. Thompson

Growing Cherries in Indiana—Cooperative Extension Service, Purdue University, West Lafayette, Indiana

Cherry—from Mark Reiger, Dept of Horticulture, University of Georgia.

Sour cherry kernel oil
Plum oil

Rosaceae *Prunus* sp.

Source: Magness et al. 1971

The pits of sour cherries contain about 28 percent of kernel, and the kernel contains 32 to 40 percent of a semi-drying oil. Pits from cherry processing plants are cracked, and kernels and shells separated mechanically. The expressed oil, after refining, is used as a salad oil and in the manufacture of cosmetics. There is some extraction of cherry kernel oil in the U.S.

Plum kernel oil is extracted and used in Europe in ways similar to those for cherry oil, but appears not to be extracted in the U.S. Plum and prune kernels contain 30 to 40 percent of semi-drying oil.

Last update February 18, 1999 by ch

Cherry, Sweet

Rosaceae *Prunus avium* L.

Source: Magness et al. 1971

The sweet cherry tree is an upright grower, medium in size, up to 40 or more feet, but usually held to 20 feet or less by pruning. The deciduous leaves are oblong-ovate. Fruits have smooth, thin skins which adhere to the fleshy pulp. They are globose to heart shaped, depressed at the stem, 0.75 to an inch in diameter. They are borne on 1 to 3 inch stems, in groups of 1 to 5. Color varies in different varieties from light red to near black, a few yellow.

Season, bloom to harvest: 80 to 100 days.

Production in U.S.: About 90,000 tons.

Use: Fresh eating, canned, maraschino.

Part consumed: All except pit.

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Red fescue

Gramineae *Festuca rubra* L.

Chewing's fescue

***F. rubra* var. *commutata* Gaud.**

Source: Magness et al. 1971

Red fescue was introduced from Europe. It differs from sheep fescue in that it creeps by underground stems and forms a sod rather than growing in tufts. It is extensively used for lawns and erosion control in northern parts of the United States. Plants are hardy and vigorous. It is not highly palatable and is not generally used for pastures or hay. Chewing's fescue is a closely related kind but grows in clumps instead of forming a dense sod. It is also used for lawns and general purpose turf in shaded areas.

Last update February 18, 1999 by ch

Chhui-Mui or Lajwanti (*Mimosa pudica* Linn.)

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Scientific Name: *Mimosa pudica* Linn.
Family: Mimosoideae
English Name: Sensitive Plant, Bashful Mimosa, Humble Plant, Touch-me-not
Hindi Name: Chhui-Mui, Lajwanti, Lajjawati, Lajalu, Lajak

Botanical differences among the major species of *Mimosa*.

Characters	*M. pudica*	*M. himalayana* syn. *M. rubicaulis*	*M. hamata*
Plant	Small woody herbs or low-spreading undershrub with hairy and prickly branches, hairs glandular	A large straggling shrub, studded with straw-coloured, hooked prickels	A much branched, armed shrub, branches downy, with numerous straw-coloured, curced or straight prickles
Leaves	Bipinnate, sensitive to touch, pinnae 1-2 pairs, leaflets 10-20 pairs, linear, glabrous	Bipinnate, main rachis with hooked prickles, pinnae 5-11 pairs, linear-oblong	2-pinante, main rachis pubescent, some timely prickly, leaflets 6-10 pairs
Flowers	Heads small, peduncled, globose, axilalry, pink-purple, Calyx campanulate, Petals crenate towards base	Numerous, in globose heads, peduncles crowded at the ends of branchlets	4-merous in globose heads, peduncles axillary, crowded at the end of branches
Pods	1.5-2.5 cm long, closely prickly on the sutures	7-10 cm long, falcate, glabrous, one seeded joints, persistant but not prickly	5-7 cm long, falcate, consisting 4-8 one seeded joints, pubescent

Flowering and Fruiting time	Sept.-March in Indian conditions	August-Sept. and October in Indian conditions	Aug.-Nov. and Dec.-Feb. in Indian conditions

Useful Parts: Roots, leaves and flower heads.

Traditional Medicinal Uses: According to Ayurveda, root is bitter, acrid, cooling, vulnerary, alexipharmic and used in treatment of biliousness, leprosy, dysentery, vaginal and uterine complaints, inflammations, burning sensation, fatigue, asthma, leucoderma, blood diseases etc. According to the Unani system of medicine, root is resolvent, alternative, useful in diseases arising from blood impurities and bile, bilious fevers, piles, jaundice, leprosy etc.

Chemical Constituent: Contains an alkaloid Mimosine. Roots contain tannin, ash, calcium oxalate crystals and mimosin.

Other Uses
Grown as garden herb
Useful for green manuring
Fixes nitrogen
Can be used as fodder.
Suitable for growing in wastelands
Seed yield an oil like Soybean oil with similar properties

Internet Resources
Interactions with the natives of Tilda (Chhattisgarh, India) region having rich traditional medicinal knowledge about common herbs http://botanical.com/site/column_poudhia/55_tilda.html
Interactions with the natives and traditional healers of Dhamtari region, Chhattisgarh, India having rich traditional medicinal knowledge about common herbs
http://botanical.com/site/column_poudhia/229_dhamtari.html
Traditional Medicinal Knowledge about common herbs used in treatment of Dast (Diarrhoea) in Chhattisgarh, India http://botanical.com/site/column_poudhia/76_dast.html

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Bhandari, M.M. (1990). Flora of the Indian Desert. Pbl. MPS Repros, Jodhpur, India: 136.
Caius, J.F. (1980). Medicinal and poisonous Legumes of India. Pbl. Scientific Publishers, Jodhpur, India.: 174-177.
Paranjpe, P. (1999). Indian medicinal plants: Forgotten healers. Pbl. Chaukhamba Sanskrit Pratisthan, Delhi, India.: 155-156.
Singh, U., Wadhwani, A.M. and Johri, B.M. (1996). Dictionary of Economic plants of India. Pbl. Indian Council of Agricultural Research, New Delhi, India: 142.
Verma, D.M. Balakrishnan, H.P. and Dixit, R.D. (1993). Flora of Madhya Pradesh (Vol.I), Pbl. Botanical survey of India, Calcutta, India.: 440-441

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Salvia spp.

Labiatae, or Lamiaceae

Sage, Chia, California Chia, Common sage, Garden sage, Ghia, Mexican Chia, Rubbed sage

We have information from several sources:

Monograph on Clary sage from J.E. Simon, A.F. Chadwick and L.E. Craker

Monograph on Sage from J.E. Simon, A.F. Chadwick and L.E. Craker

New Bedding Plants—Lowell C. Ewart

Photoperiodic Control of Flowering of *Salvia leucantha* L. (Abstract)—Allan M. Armitage, J.M. Laushman, and F. Vogel

New Herbaceous Ornamental Crops Research—Allan M. Armitage

Introduction of Chia and Gum Tragacanth in the U.S.—Howard S. Gentry, Marc Mittleman, and Peter R. McCrohan

New Industrial Crops: Northwestern Argentina Regional Project—Ricardo Ayerza (h) and Wayne Coates

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.
Sage

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and Feed Crops of the United States.
Salvia officinalis
Salvia sclerea

Chicken corn

Gramineae *Sorghum drummondii* (Steud.) Millsp. & Chase

Source: Magness et al. 1971

Chicken corn was apparently introduced by chance and became naturalized on black soils of Alabama around the middle of the last century. Later it largely disappeared as a naturalized plant. A selection has been increased recently, primarily for use in wild life plantings. It is a sweet sorghum of medium size. The seed shatters in late summer, remains dormant over winter, and germinates the following spring. Seed is in limited commercial production.

Cicer arietinum L.

Leguminosae

Bengal gram, Calvance Pea, *Ceci*, Chestnut Bean, Chich, Chich-pea, Chickpea, Dwarf Pea, Garavance, Garbanza, *Garbanzo*, Gram, Gram Pea, *Grão do bico*, Hommes, Hamaz, Nohud, Lablabi, Pulse, Shimbra, Yellow Gram

We have information from several sources:

FactSHEET—contributed by F.J. Muehlbauer and Abebe Tullu

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Food and Grain Legumes—Fredrick J. Muehlbauer

Generation Mean Analysis of Agronomic Traits in Chickpea (Abstract)—Saranga P. Kidambi, Tarlochan S. Sandhu, and Balwant S. Bhullar

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark

New Crops for Canadian Agriculture—Ernest Small

Chickpea, Faba Bean, Lupin, Mungbean, and Pigeonpea: Potential New Crops for the Mid-Atlantic Region of the United States—Harbans L. Bhardwaj, Muddappa Rangappa, and Anwar A. Hamama

Chickpea: A Potential Crop for Southwestern Colorado—Abdel Berrada, Mark W. Stack, Bruce Riddell, Mark A. Brick, and Duane L. Johnson

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Chickpea—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Growing Beans In The Home Vegetable Garden—HO-175 Purdue University Cooperative Extension Service

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Cichorium endivia L.

Cichorium intybus L.

Asteraceae (Compositae)

Asparagus Chicory, *Barbe de capucin*, Batavian endive, Belgian Endive, Broad-leafed endive, Chiccory, Chickory, *Chicorée*, Curly endive, Endive, *Escariola, Frisée,* Radicchio, *Radicchio de castelfranco, Radicchio de chiogga, Radicchio de treviso, Radicchio de Verona, Radicchio rosso*, Red Chicory, Red-leafed Chicory, Red Treviso Chicory, Red Verona Chicory, *Rosso di Verona, Scariole*, Succory, *Witloef, Witloof*

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Witloof Chicory: A New Vegetable Crop in the United States—Kenneth A. Corey, David J. Merchant, and Lester F. Whitney

Midwest Vegetable Production Guide for Commercial Growers 2000

Lettuce and Endive production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Endive
Chicory

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

An outside source for cultivation information on Belgium Endive, Chicory or Witloof from Belgium!

Pipsissewa

(1) *Chimaphila umbellata* (L.) Barton; (2) *C. maculata* (L.) Pursh.

Synonyms.—(1) *Pyrola umbellata* L., *Chimaphila corymbosa* Pursh; (2) P. *maculata* L.

Pipsissewa

Figure 84.—Pipsissewa (A, *Chimaphila umbellata* B, *C. maculata*)

Other common names.—(1) Common pipsissewa, prince's pine pyrola, rheumatism weed, bitter wintergreen, ground holly, king's-cure, love-in-winter, noble pine, pine tulip; (2) striped pipsissewa, spotted pipsissewa, spotted wintergreen, spotted piperidge, ratsbane, dragon's-tongue.

Habitat and range.—Common pipsissewa is found in dry, shady woods, especially in pine forests, from New Brunswick to British Columbia and south to Georgia, Mexico, and California. Spotted pipsissewa occurs in similar places, but its range extends only to Minnesota and south to Georgia and Mississippi.

Description.—Common pipsissewa is a small herb a foot or less in height with a long, running, partly underground stem and shining, dark-green, evergreen, somewhat leathery leaves, 1 to 2 inches long, rather crowded toward the top of the stem. From about June to August its handsome, waxy-white or pinkish fragrant flowers are borne in nodding clusters from the top of the erect stem.

The spotted pipsissewa is readily distinguished from the former by its leaves, which are olive green marked with white along the midrib and veins

Part used.—The leaves and the herb of both species.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Chinese artichoke

Chorogi, Knotroot

Labiatae *Stachys sieboldii* Miq.

Source: Magness et al. 1971

The plant is mint-like, up to 18 inches, with ovate to lanceolate leaves. It produces numerous small, slender tubers, the edible part, just under the soil surface. These tubers are white, with crisp flesh which can be eaten raw or cooked. The plant and edible parts are comparable to potatoes, both in culture and exposure to pesticides. The tubers do not store well. Chinese artichoke is not grown commercially in the United States, but may be found occasionally in home gardens.

Last update February 18, 1999 by ch

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Cabbage, Chinese

Celery cabbage, Wong Bok, Pe-Tsai, Bok Choy, Repollo chino, Peking cabbage, Kim chee

Cruciferae *Brassica campestris* L. (Pekinensis group)

Source: Magness et al. 1971

The general growth habit of Chinese cabbage is similar to cabbage, but both leaves and heads are elongated and relatively narrow. Heads are less densely packed, and leaves are much thinner than in cabbage. Heads range from densely packed (Wong Bok or Chee-foo) to semi- or loose-heading (Shantung or Santo) varieties. As with cabbage, initial leaves are somewhat spreading. These, as well as leaves immediately surrounding the edible portion, are usually discarded. The Wong Bok type head is up to 20 inches long and 4 inches wide and is quite dense. The Chinese word "Bok Choy" refers to all leaf-heading vegetables.

Production in U.S.: 1,200 acres reported 1959 census. Possibly 10,000 tons.

Use: Fresh, as salad or as pot herb.

Parts of plant consumed: Inner leaves.

Last update February 18, 1999 by ch

Jujube

Ber, Chinese date

Rhamnaceae *Ziziphus jujuba* Mill.

Source: Magness et al. 1971

The jujube or Chinese date, introduced into this country from China, is a medium size tree, up to 25 or more feet, with glossy green, deciduous foliage.

It thrives best in warm, dry climates; but will withstand winter temperatures down to -20 F. Fruit is generally dark brown when ripe, oval to pyriform in shape, 1 to 2 inches diameter, with a single stone. Fruit will dry if left on tree, similar to figs. Skin is smooth and thin until drying of fruit occurs, then becomes wrinkled. Pulp is dryer than in most fruits.

Season, bloom to mature: 2 to 4 months, depending on kind and climate.

Production in U.S.: Not commercial. Scattered trees, mostly home gardens.

Use: Some fresh eating, confections.

Part of fruit consumed: All except stone.

Last update June 31, 1996 by aw

Sapium sebiferum (L.) Roxb.

Euphorbiaaceae

Chinese tallow tree, Chinese vegetable tallow,
Tallow tree, Vegetable tallow, White wax berry, Stillingia Oil Tree

NewCROP has Chinese tallow tree information at:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Chinese Tallow: Multipurpose Tree Crop (Abstract)—Edward Glumac and Joe Cowles

Fringetree

Chionanthus virginica L.

Other common names.—American fringetree, white fringe, flowering ash, poison ash, graybeard tree, old-man's-beard, shavings, snowdrop tree, snowflower.

Figure 53.—Fringetree (*Chionanthus virginica*)

Habitat and range.—The fringetree is found in moist thickets and along streams from Delaware to Florida and Texas.

Description.—The fringetree is from 6 to 20 feet in height, with the trunk covered with a light-colored bark. It has smooth entire leaves. The white flowers, which from their drooping character give a fringelike appearance, are produced in May and June, are borne in dense clusters, and are followed by fleshy, bluish-black fruits containing a 1-seeded nut.

Part used.—The bark of the root.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Chloris gayana Kunth

Poacea

Rhodesgrass

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update July 8, 1996 by aw

Safed Moosli (*Chlorophytum borivilianum* L.): Medicinal and Wonder Crop

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India is bestowed with a wealth of medicinal plants, most of which have been used in *Ayurveda*, *Unani* systems of medicines, and by tribal healers. Safed moosli (*Chlorophytum borivilianum* L., Liliaceae) holds an important position in Indian herbal medicine. The roots are widely used as a natural "sex tonic" and is an integral part of more than 100 herbal drug formulations (Oudhia 2001a). Although Indian forests are rich in *safed moosli* demand is increasing rapidly in Indian and international drug markets. Foreign demand has been estimated as 300-700 tonnes annually (Bordia et al. 1995), a quantity that Indian forests cannot sustain. This has created a pressure on Indian forests and if steps for timely conservation are not taken, the Indian forests will lose this valuable plant (Oudhia 2001b). At present the availability of *Chlorophytum* is decreasing and obnoxious weeds like *Parthenium hysterophons* and *Lantana* are taking its place (Oudhia 1996).

Dried roots of *Chlorophytum* contain 42% carbohydrate, 80–9% protein, 3–4% fiber and 2–17% saponin (Bordia et al. 1995). Research studies on *Chlorophytum* conducted in India and elsewhere indicate that saponins are responsible for medicinal properties. Saponins are thought to be highest in roots of forest origin.

More than 175 species of *Chlorophytum* have been reported in the world. *Chloophytum comosum* is widely used as ornamental plant where it is commonly known as spider ivy, spider plant, aeroplane plant, or walking anthericum. Thirteen species of *Chlorophytum* have been been reported in India. All these species differ in appearance, native species are sold as *sufed moosli* in the Indian drug market. *Chlorophytum boriviliahum* produces the highest yield and highest saponin content. Other native Indian *Chlorophytum* species (Table 1) include *C. arundinaceum, C. tuberosu, C. laxum,* and *C. breviscapum* (Oudhia 2000a).

Table 1. Different species of *Chlorophytum* available in India.

Species	Distribution
C. arundinaceum Baker	All districts of Chota Nagpur, Vindhya, Satpura and Aravali Hills, parts of Central India. Taria region of N-E Himalayas in Assam. West Bengal and Bihar.
C. attenuatum Baker	Western Ghats, southwards to Comibatore, West Peninsula.
C. borivilianum	Dangs Forests (Gujarat). Aravali Hills
C. laxum R.Br.	Katki Hills, Belgaum, Dharwar, North and South Kanara, Deccan peninsula in India.
C. tuberosum (Rox b.) Baker	Parts of Konkan to Travancore in Kerala, Eastern Himalaya, Bihar and West Bengal.
C. hreviscapum	Sikkim Himalaya, Belgaum and South Peninsula.

In nature, Moosli propagates vegetatively through its fleshy roots., rarely by seed. The black angular seed is similar to onion seed in appearance. Seed have poor germination and low viability. Seed rates of 3 quintals/hectare is considered optimum for growers.

Chlorophytum is found in soils rich in organic matter. It requires bright sunlight for good growth (Oudhia and Tripathi 2001). Many tribal communities of India use the fresh leaves of Safed Moosli as potherb. (Oudhia and Joshi 2000) but the roots are the useful part of the plant for medicinal purposes. Once the root is harvested reseeding rarely occurs.

Innovative Indian farmers have initiated commercial cultivation of safed moosli. The crop is a popular rainy season (kharif crop) in India and a commercial root harvest can be obtained in 3–4 months. Spacing 30 × 15 cm is optimum. The crop seems adapted to a wide range of conditions. Few insect pests have been reported (Oiudhia 2000b, 2001e). Saponin content may be affected by fungicides and synthetic phyrethroides. Many moosli farms have started selection of cultivars.

There is now a heavy demand of organically grown safed moosli with high saponin content in national and international drug market. In India moosli-based products are coming regularly to the market. The area under this crop is increasing rapidly in India.

References

Bordia, P.C., A. Joshi, and M.M. Simlot. 1995. Safed moosli. p. 429ö451. In:. K.L. Chadha and Rajendra Gupta (eds.), Advances in horticulture Vol. II. Medicinal and aromatic plants. Malhotra Publ. House, New Delhi.

Oudhia, P. 1996. *Parthenium*: A curse for the bio-diversity of Chhattisgarh Plains. National Reen.

R.D. Govt. P.G. College, Mandla, Indian, 30ö32 July. p. 26.

Oudhia, P. 2000a. Can we save the endangered medicinal plant Safed Moosli (*Chlorophytum borivilianum*) in Indian forests? http://www.herb.com/poudl.html, July–August, 2000.

Oudhia, P. 2000b. Record of Orange Banded Blister Beetle *Zonabris pustulata* Thunb (Coleoptera: Meloidae) on Safed Moodli (*Chlorophytum borivilianum* L.). Insect Environment, 6(3):138.

Oudhia, P. 2001a : My experiences with wonder crop Safed Moosli. In: Souvenir. International Seminar on Medicinal Plants and Quality Standardization, VHERDS, Chennai, India, 9–10 June.

Oudhia, P. 2001 b. Problems perceived by Safed Moosli (*Chlorophytum borivilianum*) growers of Chhattisgarh (India) region: A study. J. Medicinal and Aromatic Plant Sci. 22/4A & 23/1A:396–399.

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Internet Resources

My experiments with the wonder crop Safed Musli (*Chlorophytum borivilianum*): Some useful observations of recently completed experiments at SAMPDA'S research farm http://botanical.com/site/column_poudhia/146_musli.html

Are two crops of Safed Musli (*Chlorophytum borivilianum*) possible in a year? http://botanical.com/site/column_poudhia/300_multiple_musli_crops.html

Selection of Safed Musli (*Chlorophytum borivilianum*) planting material: Are we in right direction? http://botanical.com/site/column_poudhia/230_rightdirection.html

My experiments and experiences with wonder crop Safed Musli (*Chlorophytum borivilianum*): Recent visit to leading Musli farm of India http://botanical.com/site/column_poudhia/174_muslifarms.html

Planting technique of Safed Musli (*Chlorophytum borivilianum*) tubers: Some useful tips
http://botanical.com/site/column_poudhia/232_technique.html

Possible uses of wonder crop Safed Musli (*Chlorophylum boriviliamum*).
http://botanical.com/site/column_poudhia/201_safed.html

New record of Swarming caterpillar *Spodoptera mauritia* Boisd. (Lepidoptera; Noctuidae) on Safed Musli (*Chlorohytum* sp.) In Chhattisgarh, India
http://botanical.com/site/column_poudhia/222_catapillar.html

My experiences and experiments with wonder crop Safed Musli (*Chlorophytum borivilianum*): The details of recent visits to Safed Musli fields of different parts of India
http://botanical.com/site/column_poudhia/297_recent_musli_visits.html

National Workshop on Indian Medicinal and Aromatic Plants with special emphasis on Safed Musli, the Millennium Crop: My observations and views
http://botanical.com/site/column_poudhia/194_workshop.html

Harvesting, Processing and Trading of wonder crop Safed Musli (*Chlorophytum borivilianum*): My research and experience
http://www.botanical.com/site/column_poudhia/112_harvestingmoosli.html

The possibilities of establishing Safed Musli (*Chlorophytum borivilianum*) as Indoor ornamental plant http://botanical.com/site/column_poudhia/323_safed_indoors.html

My Experiences and Experiments with the wonder crop Safed Musli (*Chlorophytum borivilianum*)
http://botanical.com/site/column_poudhia/110_experiements.html

Allelopathic potential of Safed Musli (*Chlorophytum* species): Some preliminary observations
http://botanical.com/site/column_poudhia/419_potential.html

Potential markets of wonder crop Safed Musli (*Chorophytum borivilianum*): Some new observations http://botanical.com/site/column_poudhia/390_safed.html

Weed management in commercial cultivation of wonder crop Safed Musli (*Chlorophytum borivilianum*): My experiences http://botanical.com/site/column_poudhia/414_cultivation.html

Interactions with the traditional healers and natives of Bhopalpatnam region, Chhattisgarh, India having rich traditional medicinal knowledge about common herbs insects and other animals
http://botanical.com/site/column_poudhia/121_bhopalpatnam.html

Importance of Standard Agronomical practices in commercial cultivation of wonder crop Safed Musli (*Chlorophytum borivilianum*): My experiences.
http://botanical.com/site/column_poudhia/408_standardpractice.html

Possibilities of utilizing Fly Ash in commercial cultivation of medicinal and aromatic crops: My experiences and experiments http://botanical.com/site/column_poudhia/307_fly_ash.html

Traditional medicinal knowledge about specific soil on which wonder herb Safed Musli

(*Chlorophytum* sp.) Grows, in Chhattisgarh, India
http://botanical.com/site/column_poudhia/319_ricesoils.html

http://www.botanical.com/site/column_poudhia/gallery/slides/094.html

http://www.botanical.com/site/column_poudhia/gallery/slides/122.html

http://www.botanical.com/site/column_poudhia/gallery/slides/165.html

http://www.botanical.com/site/column_poudhia/gallery/slides/135.html

http://www.botanical.com/site/column_poudhia/gallery/slides/150.html

http://www.botanical.com/site/column_poudhia/gallery/slides/149.html

http://www.botanical.com/site/column_poudhia/gallery/slides/151.html

http://www.botanical.com/site/column_poudhia/gallery/slides/141.html

http://www.botanical.com/site/column_poudhia/gallery/slides/136.html

http://www.botanical.com/site/column_poudhia/gallery/slides/157.html

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Xanthium strumarium

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Chotagokhru or Kuthua, *Xanthium strumarium* L.

Xanthium strumarium L., Compositae, is a common weed found in India (Oudhia 2001; Oudhia and Dixit 1994). In different Indian languages *Xanthium* is known as banokra, chotadhatura, chotagokhru, kuthua (Hindi) godrian (Gujrati), aristha, itara, kambu-vanamalini, sarpakshi (Sanskrit), dumundi, dutundi (Marathi), maruloomatham (Tamil), maruluummatti (Kanarese), and marulam athangi (Telugu). The reason behind its common name chotagokhru is the shape of its fruit, which look likes the cow's toe (chota - small; go - cow; khuru - toe). In many parts of India, it is known as adhasisi (in English adhasisi means hemicrania; as this weed is used for the treatment of this common disease). In English, *Xanthium* is known as cocklebur or burweed. The genus *Xanthium* includes 25 species, all of American origin *X. spinosum* Linn and *X. strumarium* Linn are used medicinally in Europe, North America and Brazil; *X. canadens* Mill. is used in North America and Brazil and *X. strumarium* Linn in China, India and Malaya (Caius 1986). Two species of *Xanthium*, *X. indicum* and *X. strumarium* have been reported in India. The origin of *X. strumarium* is North America. It was introduced in India and spread like weed. It commonly grows in wasteplaces and along river banks in warmer parts.

X. strumarium is an annual herb with a short, stout, hairy stem. Leaves broadly triangular-ovate or suborbicular; flower heads in terminal and axillary racemes; white or green; numerous; male upper most; female ovoid, covered with hooked bristles; Fruit obovoid, enclosed in the hardened involucre, with 2 hooked beaks and hooked bristles. Flowering time in India is August-September. It can be propagated through seeds. This weed is easily dispersed through animals as the fruits have hooked bristles and 2 strong hooked beaks (Agharkar 1991).

The whole plant, specially root and fruit, is used as medicine. According to Ayurveda, *X. strumarium* is cooling, laxative, fattening, anthelmintic, alexiteric, tonic, digestive, antipyretic, and improves appetite, voice, complexion, and memory. It cures leucoderma, biliousness, poisonous bites of insects, epilepsy, salivation and fever. The plant of *Xanthium* yields xanthinin which acts as a plant growth regulator. Antibacterial activity of xanthinin has also been reported. Seed yields a semi-drying edible oil (30-35%) which resembles sunflower oil and used in bladder infection, herpes, and erysipelas. Cake can be used as manure whereas shell can be used as activated carbon (Oudhia and Tripathi 1998; Sastry and Kavathekar 1990). The plant has been reported as fatal to cattle and pigs.

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Simon, J.E., N. Beaubaire, S.C. Weller, and J. Janick. 1990. Borage: A source of gamma linolenic acid. p. 528. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Borage: A Source of Gamma Linolenic Acid

James E. Simon, Nancy Beaubaire, Stephen C. Weller, and Jules Janick

Borage (*Borago officinalis* L.) is an annual herb of recent interest because the seeds are a rich source of gamma linolenic acid (GLA; gamma-18:3Δ6,9,12). As an intermediate fatty acid in the biosynthesis of prostaglandins, GLA, an unusual fatty acid, is of medicinal value. The oil also appears promising in treating atopic eczema. GLA is obtained principally from seeds of the evening primrose (*Oenothera biennis*) and selected *Ribes* spp., although borage seed appears to be the highest known plant source of GLA (17-25% gamma-18:3 from a total seed oil content of 28-38%).

Large-scale commercial production of this crop presents unique challenges because of the plants indeterminate vegetative growth, lack of concentrated flowering and seed set and non-uniform seed maturation. Since 1984, we have investigated borage seed production and GLA metabolism. Field studies were conducted to determine the optimum plant population and nitrogen levels and a prototype mechanical harvester to vacuum seed from the soil surface was built. Experimental seed yields of 753 kg/ha were obtained when multiple nondestructive harvests of seeds were periodically collected from the soil surface, plus a single destructive harvest where plants were cut and seeds harvested. Simulation of a single destructive harvest yielded only 35-40% of the total potential seed yield because of significant seed loss due to seed shattering.

Borage is susceptible to a wide range of insects and disease pests, and is a weak competitor with weeds. Supporting weed control studies identified several promising preemergent herbicides and other compounds that could eradicate the plant No satisfactory postemergent herbicides were identified.

Studies on the genetic variation of seed lines indicated a wide range of total fatty acids and GLA content. Nonshattering types were not found among the more than 50 accessions evaluated. The development of nonshattering seed fines high in fatty acid and GLA would overcome the present production limitations. However, in the interim, the refinement of a seed harvesting unit which can follow a mechanical combine could make the commercial production of borage a more attractive enterprise.

McDaniel, R.G. 1990. Breeding arid-adapted pyrethrum for insecticide production in the desert

southwest. p. 529. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Breeding Arid-adapted Pyrethrum for Insecticide Production in the Desert Southwest

Robert G. McDaniel

Dried pyrethrum flowers are a source of biorational insecticides called pyrethrins which show minimal mammalian toxicity and biodegrade rapidly in the environment. In combination with synergists, pyrethrins are extremely effective for control of insects in human habitations, dairy and horse barns, and food manufacture. At present, all pyrethrins used in the United States are imported. Most are supplied in bulk by East African Countries including Kenya. These sources can be very unreliable, which in turn precipitates wide swings in supply and price. This limits the utility of pyrethrins in domestic pesticides.

Following an eight year breeding program we have, developed pyrethrum (*Chrysanthemum cinerariaefolium*) germplasm adapted to environmental stresses inherent to desert irrigated agriculture. Moderate winters, combined with wide differences in day/night temperatures (a result of the dry desert climate) somewhat mimic the high elevation equatorial environments of East Africa and Equador where high pyrethrin contents are achieved. Arid adapted, stress-resistant pyrethrum clones have been bred which show a good balance of pyrethrins and which yield greater than 2% pyrethrins (dry weight basis) analyzed by HPLC. At Arizona latitude, pyrethrum behaves as a perennial showing a single flush of blooming in April. Simultaneous flowering makes mechanized harvesting feasible. Favorable climatic conditions coupled with intensive irrigated agriculture technology of the American Southwest make it probable that *C. cinerariaefolium* will become a viable perennial crop in Arizona. It is hoped that our work will promote new domestic production of this high value insecticide crop.

Last update March 31, 1997 aw

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Japanese greens

Chopsuey greens, Skungiku, Edible-leaved chrysanthemum

Compositae *Chrysanthemum coronarium* L.

Crown Daisy

Garland chrysanthemum

C. *spatiosum* Bail.

Source: Magness et al. 1971

These two species are used sparingly as pot herbs. For that purpose young plants are harvested when 4 to 6 inches high. Leaves are glabrous, lobed, and grow as a rosette. They are aromatic and are cooked like spinach. In exposure of edible parts they are comparable to spinach.

Last update February 18, 1999 by ch

Chrysanthemum majus (Desf.) Asch.

syn: *Chrysanthemum balsamita* L.

Compositae

Costmary, Alecost, Balsam herb, Bible leaf, Bible-leaf mace, Mace, Mint geranium

We have information from several sources:

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Chrysophyllum cainito L.

Sapotaceae

Star Apple

We have information from several sources:

Star Apple—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Chufa

Ground almond, Edible rush, Rush nut

Cyperaceae *Cyperus esculentus* L.

Source: Magness et al. 1971

Chufa plants are grown for the edible tubers. The top is grass-like, with simple leaves and flower stalk rising from the ground surface, up to 3 feet. Tubers are small, 1/2 to 3/4 of an inch long, cylindrical and hard, produced entirely underground. They are eaten raw or baked. Plants are propagated by planting the tubers, similar to potatoes. They are a minor crop, grown mainly in the southern states.

See chufa oil.

Season, planting to harvest: 5 to 6 months.

Production in U.S.: No data. Mainly home gardens, a minor crop.

Use: Tubers eaten raw or baked. Sometimes used as coffee substitute.

Part of plant consumed: Tubers only.

Last update February 18, 1999 by ch

Chufa oil

Cyperaceae *Cyperus esculentus* L.

Source: Magness et al. 1971

The tubers of Chufa contain 20 to 28 percent of a non-drying oil. The oil is obtained by pressing the cleaned tubers and has a mild, pleasant flavor. The separated emulsion of oil and juice, obtained by pressing, is consumed in quantity in Europe, especially Spain, as a drink (Horchata de Chufas).

Last update February 18, 1999 by ch

Coriandrum sativum L.

Apiaceae (Umbelliferae)

Coriander, Cilantro, Chinese parsley, *Cilantrillo*, Culantro, Mexican parsley, *Yuen sai*

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Coriander Under Irrigation in Argentina—Gustavo Luayza, Roberto Brevedan, and Rosana Palomo

Greenhouse Production of Garlic Chives and Cilantro—Robert G. Anderson and Wenwei Jia

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Midwest Vegetable Production Guide for Commercial Growers 1998

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside Links

Coriander—by Axel Diederichson—Link to the International Plant Genetic Resources Institute

Cinnamon

Canela

Lauraceae *Cinnamonium zeylanicum* Garc. ex Blume

Source: Magness et al. 1971

This is a small semi-tropical tree, 20 to 30 feet high, with thick ovate to lanceolate leaves 4 to 7 inches long. It is hardy in the Gulf States of the U.S. Most of the cinnamon of commerce comes from Ceylon. It is the ground bark of the tree. The best quality of bark is from branches at least 2 years old. Cinnamon is widely used in cookery and confections. The flavor is due to a volatile oil contained in the bark. The cinnamon oil of commerce is extracted from inferior bark, not suitable for grinding.

Last update February 18, 1999 by ch

Ciruela de Madagascar

Governor's plum

Flacourtiaceae *Flacourtia indica* (Burm. f.) Merr.

Source: Magness et al. 1971

Tropical shrub or small tree, sometimes sparsely armed with sharp, stout thorns. Fruits are subglobose and may be slightly over 1 inch in diameter. The fruits are purplish red or blackish, and are surmounted by the remains of the pistils. The reddish juicy pulp encloses 8 to 10 small seeds. The fruits may be eaten fresh or used in jams and jellies.

Last update February 18, 1999 by ch

Hadjod or Hadjora [*Cissus quadrangula* (L.)]

Contributor: Pankaj Oudhia

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Scientific Name: *Cissus quadrangula* L.
syn. *Vitis quadrangula* (L.) Wallich ex Wight & Arn.

English Names: edible-stemmed vine

Common (Indian) Names
Sanskrit: asthisonhara; vajravalli Hindi: hadjod; hadjora; harsankari
Bengali: hasjora; harbhanga
Marathi: chaudhari; kandavela
Gujrati: chadhuri; vedhari
Telugu: nalleru
Tamil: pirandai
Canarese: mangaroli

Family: Vitaceae

Related Species
The genus *Cissus* include over 350 species. Some important species are:
Cissus adnata Roxb. syn. *Vitis adnata* Wall. ex. Wight. (Malyalam: nadena; Telugu: kokkita yaralu)
Cissus discolor Blume syn. *Vitis discolor* Dalz.
Cissus pallida Planch. syn. *Vitis pallida* W & A. (Canarese: kondage; Telugu: nalltige; Oriya: takuonoil)
Cissus repanda Vahl. syn. *Vitis repanda* W & A.
Cissus repens Lan. syn. *Vitis repens* W & A.
Cissus setosa syn. *Vitis setosa* Wall.

Distibution: In India, it grow as wild plant. Also under cultivation in fairly large areas.

Botany: Climbing herb, tendrils simple, opposite to the leaves, leaves simple or lobbed, sometimes 3-folialate, dentate. Flowers bisexual, tetramerous, in umbellate cymes, opposite to the leaves, Calyx cup-shaped, obscurely 4-lobed. Fruit globose or obovoid fleshy berries, one seeded, dark purple to black; seeds ellipsoid or pyriform. Flowering and fruiting time May-June.

Medicinal Properties and Uses: It is mainly used as healer of bone fractures. It is one of the very frequently used herb by traditional bone setters of India. (In Hindi Hadj=bone; Jod=to fix). It is also used for piles, asthma, digestive troubles, cough, and loss of appetite.

Ayurvedic formulations: Asthisamharaka juice, powder and decoction of dried stalks.

Chemical constituents: Stem isolates include 3- keto steroids, onocer-7-en-3α, 21β-diol (I) and onecer-7-en-3α, 21α-diol (II).

Other Uses: Stems and roots yield strong fiber. Young shoots are used in curries.

Cultivation: In India, it is mainly grown in fence and in between tree plantations. The fence wire and trees act as support to this climbing herbs. In many parts, it is grown as field crop and given support with the help of Bamboo sticks.

Climate: It requires warm tropical climate.

Soils: It can be grown in various soils but prefers loamy soils.

Planting Season: Kharif (after commence of monsoon rains in June-July in India).

Propagation: Stem cuttings.

Spacing: 30 × 30 cm.

Nutrients: In general it is grown organically. Initially, farm yard manure is applied (10-12 tonnes/ha.)

Pest Infestation: No major insects or diseases have been reported.

Harvest: It is a perennial crop. Stems are cut and air dried 11 months after sowing. Fresh stem cuttings are sold as planting material.

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Phone: 91-771-253243
Mobile: 91-98271-15642
Fax: 91-771-536312

Citrus medica Linn.

Rutaceae

Citron, Citron melon, Corsican citron, Diamante citron, Esrog, Ethrog, Etrog, Leghorn citron, Preserving melon, Stock melon

We have information from several sources:

Citron—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Citron

Stock melon, Preserving melon

Cucurbitaceae *Citrullus lanatus* var. *citrioides* (Bailey) Mansf.

Source: Magness et al. 1971

Citron is a plant of the same species as watermelon, but the fruit flesh is white, hard and inedible in the raw state. The plant is prostrate growing. The fruits are round to oval, up to 6 inches long, with smooth surface, resembling small watermelons. The flesh is used for making conserves and pickles. Citrons are sometimes used as feed for hogs.

Season, planting to harvest: 4 to 5 months.

Production in U.S.: No data. Very minor.

Use: Conserves, pickling, stock feed.

Part of plant consumed: White flesh

Last update February 18, 1999 by ch

Citronella Horsebalm

Collinsonia canadensis L.

Other common names.—Stoneroot, Collinsonia, knob-root, knob glass, knobweed, knotroot, horseweed, richweed, richleaf, ox balm.

Habitat and range.—Citronella horsebalm is found in moist shady woods from Maine to Wisconsin and south to Florida and Kansas.

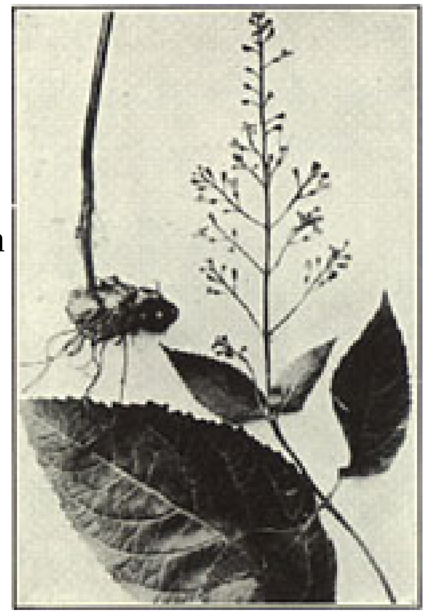

Figure 39.—Citronella horsebalm (*Collinsonia canadensis*)

Description.—This plant is a tall herb growing as high as 5 feet with a stout, erect, branched stem, smooth or the upper part hairy. The leaves are from 3 to 8 inches long, pointed, sometimes heart-shaped at the base, and coarsely toothed. From July to October the plant produces large, loose panicles of small pale-yellow, lemon-scented flowers. The entire flowering herb possesses a pleasant, lemonlike odor. The root, even when fresh, is very hard, hence the name stoneroot. It is horizontal, large, thick, and woody, the upper side rough, knotty, and irregularly branched. It has a rather disagreeable odor and a spicy, pungent taste.

Part used.—The root, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Citrullus lanatus (Thunb.) Matsun & Nakai

Cucurbitaceae

Watermelon, American watermelon, Jubilee, seeded watermelon, seedless watermelon

We have information from several sources:

Specialty Melons for the Fresh Market—James E. Simon, Mario R. Morales, and Denys Charles

Watermelon production links

Cucurbit Resources in Namibia—Vassilios Sarafis

Watermelon In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Midwest Vegetable Production Guide for Commercial Growers 2000

Watermelon: Marketing and Production Opportunities for Indiana —Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

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Citrus aurantifolia Swingle

C. acida Roxb.

C. lima Lunan

C. medica var.*acida* Brandis

Limonia aurantifolia Christm.

Rutaceae

Mexican Lime

We have information from several sources:

Mexican Lime—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus aurantium L.

Rutaceae

Sour Orange

We have information from several sources:

Sour Orange—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus limon B.

Rutaceae

Bearss, Bergamot lemon, *Citron* (archaic), Eureka lemon, Lemon, *Limão, Limón, Limou amarillo*, Lisbon lemon, Meyer lemon

We have information from several sources:

Lemon—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus maxima Merr.

syn. *Citrus grandis* Osbeck, *Citrus decumana* L.

Rutaceae

Pummelo

We have information from several sources:

Pummelo—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside links:

Germplasm Catalogue of Pummelo in Nepal from Fruits for a Future

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus paradisi M.

Rutaceae

Grapefruit, Marsh grapefruit, Ruby Red, Shaddock, Thompson grapefruit, Webb grapefruit

We have information from several sources:

Grapefruit—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus reticulata L.

Rutaceae

Clementine, Dancy tangerine, Mandarin, *Satsuma*, Tangelo, Tangerine

We have information from several sources:

Mandarin Orange—Julia Morton, Fruits of warm climates

Mediterranean Fruits—Joan Tous and Louise Ferguson

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus paradisi × Citrus reticulata

Citrus × tangelo

Rutaceae

Tangelo

We have information from several sources:

Tangelo—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus sinensis L.

Rutaceae

Orange

We have information from several sources:

Orange—Julia Morton, Fruits of warm climates

Sweet Orange—Food and feed crops of the United States, Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus sp.

Rutaceae

Hybrids

We have information from several sources:

Sundry Hybrids and Rootstocks—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Citrus—Descriptors for Citrus—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—FAO/IBPGR Technical Guidelines for the Safe Movement of Citrus Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Citrus—from Mark Reiger, Dept of Horticulture, University of Georgia.

Citrus Information from the University of California Fruit & Nut Research and Information Center

Rubus chamaemorus L.

Rosaceae

Bakeberry, Baked-apple berry, Cloudberry, *Malka, Moltebeere*, Salmonberry, *Torfbeere*, Yellowberry

We have information from several sources:

FactSHEET contributed by Kåre Rapp

Commercialization of the Cloudberry (*Rubus chamaemorus* L.) in Norway—Kåre Rapp, S. Kristine Næss, and Harry Jan Swartz

Temperate Berry Crops—Chad Finn

Cloves, Clove Tree, Clavos

Syzygium aromaticum (L.) Merr. & Perry

syn. *Eugenia caryophyllus* (Spreng.) Bullock & Harrison.

syn. *E. aromatica* (L.) Baill.

syn. *Jambosa Caryophyllus* (Spreng. Niedenzu)

Myrtaceae Source: Magness et al. 1971

The clove tree is a small, tropical evergreen, up to 20 feet tall, with oblong leaves, 5 to 10 inches long and 2 to 4 inches wide. It is native in the Philippines and nearby islands, but has been introduced into all tropical countries. Zanzibar and Pemba are the principal producers of cloves and clove oil. The tree is not hardy in continental U.S. The cloves of commerce are the dried flower buds, which grow in clusters at the ends of branches and are harvested and dried before they open. Cloves are widely used in cookery and confections. The extracted clove oil is widely used in cosmetics and confections. By oxidation, it produces vanillin.

(pictures: Ben Alkire)
Last update June 24, 1997 by aw

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Sainfoin

Esparcet, Holy clover

Leguminosae *Onobrychio viriaefolia* Scop.

Source: Magness et al. 1971

Sainfoin was introduced from Turkey recently and is showing promise as a hay and pasture crop for the Northern Plains, particularly Montana and Western North Dakota. It is a perennial legume, growing to three to four feet, with pinnate-compound leaves. Under tests in the above area it has out-yielded alfalfa and has not caused bloat in cattle. It appears to be about equal to alfalfa in palatability and nutritive value. It does not compete well with weeds as regrowth after mowing is limited.

Last update July 1, 1996 bha

Alsike clover

Swedish clover

Leguminosae*Trifolium hybridum* L.

Source: Magness et al. 1971

Alsike clover is believeed native to northerrn Europe. It was introduced into the United States about 1839 and is now mainly grown in states bordering on the Great Lakes, in northerrn California and in Oregon. Its special merit is its adaptation to wet soils, even tolerating some flooding. It is more tolerant to both acid and alkaline soils than other clovers. The stems are quite slender, up to 3 feet long, and tend to be prostrate except in dense stands. The trifoliate leaves are long stemmed with obovate leaflets. Flower heads are not at the terminal of the main stem but are at the terminals of branch stems. They are white or pink in color. Both stems and leaves are smooth. Alsike clover is valuable both for pasture and hay on soils too wet or too acid for other clovers.

Last update June 26, 1996

Sweet clovers

Leguminosae, Fabaceae *Melilotits* sp.

Source: Magness et al. 1971

The sweet clovers are native to temperate Europe and Asia. Although reported as found in Virginia as early as 1739, it was not until the present century that their great value for soil improvement, pasture, hay and silage became recognized. During the decade 1948-57, seed production in the United States averaged about 46,000,000 pounds annually with near 16,000,000 additional pounds imported - sufficient to seed more than 5,000,000 acres. Since 1960, however, seed production has declined in this country to an annual average of about 21,600,000 pounds. Most of the sweet clovers grown here are biennial, although some annual kinds are grown. They are adapted only to soils that are near neutral in acidity. Major production is in a belt from the Great Lakes west to Montana and south to the Gulf of Mexico in areas baving 17 inches or more annual precipitation. All the biennial sweet clovers fix large amounts of atmospheric nitrogen. The deep-penetrating tap roots decompose after the second year, so the crops are very useful for opening up subsoil. They are therefore probably the best of the crops for soil improvement.

The sweet clovers have a high content of coumarin which reduces palatability. More important, in hay spoiled due to excess moisture when stored or in improperly prepared silage, dicoumarol, which reduces the clotting of blood, is formed. Animals fed such hay or silage are subject to excessive external or internal bleeding.

The species of *Melilotus* of most value agriculturally are described as follows.

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White sweet clover

Leguminosae *Melilotus alba* Desr.

Source: Magness et al. 1971 In general, the white-flowered forms of sweet clover are somewhat ranker growing, heavier yielding, and have coarser stems than the yellow-flowered. They are later maturing so are generally preferred for pastures in areas of ample moisture. The more vigorous growth and heavier yields make them somewhat superior for soil improvement. In growth habit and appearance the two are similar except for flower color. Most of the *M. alba* grown is so-called common white. Two selected varieties in addition to common are in the trade. Spanish is leafier and somewhat more productive than common and is recommended for higher rainfall grain areas of the Pacific Northwest, as well as the Great Plains. Evergreen is late maturing, providing long grazing and heavy forage yields. It is generally adapted in the Corn Belt. Penta is a low-coumarin variety, bred in Wisconsin. Annual forms of *M. alba* are also in the trade. Hubam, Floranna, and Israel are such kinds. They are most useful in the central and southern regions where the growing season is relatively long.

Last update June 26, 1996

Yellow-flowered sweet clover

Leguminosae *Melilotus officinalis* (L.) Lam.

Source: Magness et al. 1971

The yellow-flowered sweet clovers grown in the United States are all biennial. As compared to white-flowered *M. alba*, the yellow-flowered is finer stemmed, matures earlier in summer, is more tolerant to drought and competition with companion crops, and gives a better quality but lower yield of hay. Because of better drought tolerance the yellow-flowered is better adapted to the Great Plains. The first season, a central much-branched stem is produced with a deep tap root which becomes fleshy in the fall. The second year, crown buds start growth early with vigorous, rather coarse stems. Leaves are trifoliate, the leaflets being long-oval in shape. For hay, the second season crop should be cut early. Several varieties are in the trade. Madrid makes strong seedling growth, is leafy and later maturing the second year, well adapted to the Great Plains. Gold Top is vigorous and late maturing, giving longer pasture. Erector, developed in Canada, makes good growth in the Northeastern Great Plains.

Last update June 26, 1996 bha

Leung, A.Y. 1990. Chinese medicinals. p. 499-510. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Chinese Medicinals

Albert Y. Leung

INTRODUCTION

Natural products have been used for medicinal purposes since ancient times. These include materials from plant, animal, and mineral sources, with the majority derived from plants.

Traditions of materia medica differ among different cultures. Some are rudimentary and primarily verbal while others are extremely extensive and well documented. Examples of the former include medicine as practiced in the jungles and remote regions of Asia, Africa, Australia, and tropical America. This form of medical practice still incorporates a sizable amount of magic or witchcraft but is the one that has captured and continues to capture a major part of our attention. This is due to a number of reasons, including the following two. One, it satisfies the pioneering American spirit where one goes after something exciting that can produce headlines; the end result, which is to seek leads to effective drugs, often appears to be secondary. Two, due to the lack of easy access to non-English or non-European medicinal records, jungle medicine seems to be the only alternative for most American or Western researchers.

In contrast to the primitive practice of herbal medicine and its verbal tradition as currently found in the jungles, there are some very extensively documented medical traditions that are out of reach of most Western researchers. This is not due to a separation by physical distance, but rather by the language barrier. The most extensive and best documented source of materia medica can be found in traditional Chinese medicine. I hope this paper can serve as an introduction to this so far largely untapped resource.

HISTORY

Although Chinese materia medica may not have as long a history as those of Egypt or India, it is the most well-documented and enjoys the most continuous use. Today, the majority of Chinese sill depend on it regularly for their health care and so far little of it has been "rationalized" out of existence by modern science, a contrast to traditional medicinals of some other cultures. It is extremely tempting for us to rationalize the effects of an herb or herbal preparation based on the often limited chemical or biological data on it. When we cannot capsulize our rationalization in a familiar mold, we often tend to label the herb as worthless. Conversely, if our rationalization fits a preset mold that we can understand, we tend to consider the problem solved and pronounce the medicines either "active" or "inactive." Examples of such medicinals include rhubarb, aconite, and cinnabar.

When we see the word rhubarb (root/rhizome), we instinctively think of it as a cathartic because we in America tend to judge the value of a plant drug by its best known chemical components which in this case happen to be cathartic anthraglycosides. We also associate aconite and cinnabar with strong poisons because of the toxic chemicals they normally contain (aconitine and mercuric sulfide). Yet in Chinese medicine, all three are commonly used for purposes other than those most Westerners know. For example, rhubarb is one of the most used medicinals for upper gastrointestinal bleeding in China, as evidenced by the large number of clinical reports on this use (Jiao et al. 1980, Jiao et al. 1988, Sun et al. 1986); processed aconite is an ingredient in some Chinese tonics; and cinnabar is a commonly used sedative, although we normally would consider it an antiseptic for external applications only.

Chinese herbal medicine is empirically based. It is the accumulated knowledge of more than four thousand years of practical experience. Based on ancient literary records, we now know that back in 1100 BC during the West Zhou era, Chinese medicine had already developed into different branches, including disease therapy, ulcer therapy, diet therapy and veterinarian medicine.

The following are some of the most well-known documents on Chinese medicinal plant use:

Wu Shi Er Bing Fang (Prescriptions for Fifty-two Diseases)

The first written record exclusively devoted to disease treatment was compiled sometime between 1065 and 771 BC (Sun 1986). It is the *Wu Shi Er Bing Fang (Prescriptions for Fifty-two Diseases)*, which was only discovered in 1973 during the excavation of the Ma Wang Dui tomb at Changsha, Hunan. Prior to that discovery, the *Shen Nong Ben Cao Jing (Shennong Herbal)*, compiled sometime between the 1st century BC and the 2nd century AD, had been the earliest record of Chinese materia medica.

During the excavation of the *Ma Wang Dui* tomb (dated 168 BC), numerous drugs were found in sachets, two of which were clutched in the hand of a skeleton. The drugs positively identified include cassia or Chinese cinnamon, magnolia flower bud (*xinyi*, *Magnolia* spp.), sour date kernel (*suanzaoren*, seeds of *Ziziphus* spp.), ginger [*ganjiang*, *Zingiber officinalis* (Willd.) Rosc.], *gaoben* (rhizome of *Ligusticum* spp.), eupatorium herb [*peilan*, *Eupatorium fortunei* Turcz.], and Sichuan peppercorn [*huajiao*, fruit of *Zanthoxylum bungeanum* Maxim.]. Among other finds were some well-known Chinese classics and the silk scroll copy of the *Prescriptions for Fifty-two Diseases.*

The Prescriptions lists 52 diseases, with 283 known prescriptions for their treatment; over two-thirds of the prescriptions contained two or more components (Chen 1987b). Some of the identified diseases along with the number of prescriptions indicated for each disease are given below:

Disease	No. of prescriptions
Skin ulcers and carbuncles	42
Urinary problems	29
Hernia	24
Wounds and injuries	17
Frostbite	14
Snake bites	13
Warts/tumors	10
Internal hemorrhoids	9
External hemorrhoids	4
Poison arrow wounds	7
Lacquer sores (dermatitis)	7
Convulsions from wounds	6
Male sexual disease(s)	5

Mad dog bites	3
Infantile convulsions	2
Malaria	2

Based on preliminary studies, there are 247 drugs listed, many of which have not been identified or found in later herbals such as the *Shennong Herbal*. One third are derived from mineral or animal sources. Among the identified plant drugs are the following:

Qinghao [herb of *Artemisia annua* L.]
Magnolia flower bud [*Magnolia* spp.]
Licorice [root of *Glycyrrhiza* spp.]
Baizhi [root of *Angelica dahurica* (Fisch. ex Hoffm.) Benth. et Hook. f.]
Fuling [sclerotium of *Poria cocos* (Schw.) Wolf]
Huangqi [root of *Astragalus* spp.]
Ginger [rhizome of *Zingiber officinale* (Willd.) Rosc.]
Aconite [main root of *Aconitum carmichaeli* Debx.]
Fangfeng [root of *Ledebouriella divaricata* (Turcz.) Hiroe]
Shaoyao [root of *Paeonia lactiflora* Pall.]

All above drugs are still commonly used in traditional Chinese medicine. Some have been extensively studied by modern scientific methods, including chemical analysis and biological assays, while others have barely been examined. The most extensively studied and well known to American scientists are probably *qinghao,* licorice and *huangqi*. Although modern studies of these ancient drugs have yielded the new antimalarial qinghaosu (artemisinin) from *qinghao,* they have not been able to derive any exciting new "modern" drugs from the other two. Yet, these herbs continue to be two of the most widely consumed in China.

One of the most widely used drugs in treating rhinitis, including allergic rhinitis (e.g. hay fever), is magnolia flower bud. Its written use record dates back to the *Prescriptions* and its efficacy has been repeatedly reported in modern biomedical literature, though rarely in combinations containing less than three drugs (Ren 1985). Despite the universal occurrence of hay fever and the continued interest in treating this condition, the time-tested magnolia flower has not been exploited by Western drug developers.

Shen Nong Ben Cao Jing (Shennong Herbal)

While the *Prescriptions* is the earliest Chinese record devoted to diseases treated with drugs, the *Shennong Herbal* is the earliest record on Chinese drugs. This herbal, compiled about two thousand years ago, records 365 drugs, describing their sources, properties and uses as well as many cases of their incompatibilities. The drugs are divided according to properties into three categories: superior (120 drugs), medium (120 drugs) and inferior (125 drugs). Superior drugs are those considered at that time to be nontoxic, which could be safely taken in large amounts for extended periods; they are what we now know as tonics. Medium drugs are those that could be toxic or nontoxic, depending on usage. Inferior drugs are toxic, and are used for treating diseases and should not be used for extended periods.

Superior drugs include such well-known ones as ginseng, licorice, *gandihuang* (root of *Rehmannia glutinosa* Libosch.), *huangqi* (root of *Astragalus* spp.), *huanglian* (rhizome of *Coptis* spp.), *wuweizi* [fruit of *Schisandra chinensis* (Turcz.) Baill.], sesame seed, magnolia flower, *lingzhi* (*Ganoderma* spp.), *fuling* or poria [sclerotium of *Poria cocos* (Schw.) Wolf], Chinese date (fruit of *Ziziphus jujuba* Mill.), Job's tears [seed of *Coix lacryma-jobi* L. var. *mayuen* (Roman.) Stapf] and *duzhong* (bark of *Eucommia ulmoides* Oliv.).

Medium drugs include ginger, *mahuang* or ephedra herb (*Ephedra* spp.), *danggui* [root of *Angelica sinensis* (Oliv.) Diels], *jixuecao* or gotu kola [*Centella asiatica* (L.) Urb.], *kuandonghua* or coltsfoot flower (flower of *Tussilaqo farfara* L.), *yinyanghuo* (herb of *Epimedium* spp.), *haizao* (*Sargassum* spp.), *hehuan* (bark of *Albizzia julibrissin* Durazz.), *gaoben*, and zhuling or polyporus [sclerotium of *Polyporus umbellatus* (Pers.) Fries].

Inferior drugs include fuzi and *wutou*, which are lateral and main root respectively of aconite (*Aconitum carmichaeli* Debx.), rhubarb root (root and rhizome of *Rheum* spp.), *baitouweng* [root of *Pulsatilla chinensis* (Bge.) *Regel*], *lianqiao* or forsythia fruit [*Forsythia suspensa* (Thunb.) Vahl], *qinghao*, croton seed (fruit of *Croton tiglium* L.), *guanzhong* (rhizome of *Dryopteris crassirhizoma* Nakai and other ferns), and *langdangzi* or henbane seed (*Hyoscyamus niger* L.).

Many of the drugs in the *Shennong Herbal* are still being used today including all the ones listed above. Some of these uses have not changed after more than two thousand years and their rationale can be scientifically justified. For example, the use of *haizao* (*Sargassum* spp.) in the treatment of swelling of the neck (goiter) can be explained by its high content of iodine; the use of *guanzhong* (Dryopteris) in the treatment of intestinal worms certainly has its counterpart in the West, so does the use of *langdangzi* (henbane seed) as a muscle relaxant.

Tang Ben Cao (Tang Herbal)

The *Tang Herbal* is considered the first official Chinese pharmacopeia which was compiled in the 7th century (659 AD). It was a work compiled by a team of twenty-two high officials and court physicians under the edict of the emperor. It describes 850 drugs, including some foreign ones introduced since the era of the *Shennong Herbal*, such as benzoin, asafoetida, turmeric, black pepper and hezi (fruit of *Terminalia chebula* Retz.). Compared to the *Shennong Herbal*, the *Tang Herbal* records more drugs and in more detail; new uses and properties of old drugs are also described and the number of drugs more than doubled that in the *Shennong Herbal*.

Ben Cao Gang Mu (Herbal Systematics)

The most well-known Chinese herbal is the *Ben Cao Gang Mu* compiled by Li Shi-Zhen in the later part of the 16th century (1590 AD). This work is considered the most extensive work on materia medica ever compiled by a single author. It took Li 38 years to complete. It was based on his own medical and herbal expenence and on data from earlier herbals, such as the well-known 11th-century herbal named *Zheng Lei Ben Cao*. Li's herbal describes 1892 drugs (with 1110 drawings), including 11,096 prescriptions, for treating hundreds of illnesses, ranging from the common cold to drunkenness and food poisoning (Chen 1982). The prescriptions in this herbal have recently been categorized and published as a separate volume, making the information much easier to access (Shaanxi 1983). Now a researcher no longer needs to laboriously search the original herbal to locate a treatment for a particular condition. All one has to do is to look up the index in the new book.

When the *Ben Cao Gang Mu* was introduced overseas in the 17th century, it was promptly translated into numerous languages, including Latin, French, German, English, Russian, Japanese and Korean, indicating its usefulness and importance in the field of materia medica.

Zhong Yao Da Ci Dian (Encyclopedia of Chinese Materia Medica)

Although several well-known herbals had appeared since the *Ben Cao Gang Mu*, none can be compared to the *Encyclopedia* in scope and depth. This encyclopedia was compiled by the Jiangsu Institute of New Medicine and was published in 1977. It is the most extensive work ever, in the field of materia medica, consisting of three volumes, one of which is an appendix/index, and comprising a total of 3518 pages. It describes 5767 drugs with 4500 drawings, many in great detail. Of these, over 4800 are of plant origin, the remaining being animal and mineral drugs. In keeping with modern scientific progress, this modern work has many modern features. The information on each long-used medicinal typically contains the following:

Synonyms
Drug Source [plant family, species, and part(s) used]
Description of Plant Species [including habitat and distribution]
Cultivation Method(s)
Collection [including initial treatment]
Crude Drug Description [including production regions]
Chemical Composition
Pharmacology
Processing
Traditional Taste Properties
Traditional Channel Affiliations
Traditional Properties and Uses
Dosages and Methods of Administration Precautions
Selected Traditional Prescriptions Clinical Reports
Quotations/Comments from Traditional Herbals or Medical Treatises
Historical Identification and Sources

The modern botanical, chemical, pharmacological and clinical data included in this book are from the world literature up to and including 1972. It provides the reader with concise information on most Chinese medicinals currently used in traditional medicine. The detailed Appendix/Index allows the researcher to identify drugs of a particular pharmacologic category or drugs that treat a particular disease; it also provides chemical structures of compounds reported present or isolated from drugs described in the *Encyclopedia.*

CONTEMPORARY SOURCES OF INFORMATION ON CHINESE MEDICINALS

During a period of 2500 years, more than 2000 volumes of herbal records have been written by some 330 herbalists/physicians (Hao 1986). The works described above constitute only a few of the dozens of wellknown texts that are frequently consulted by traditional physicians, herbalists and modern researchers who read Chinese.

Books

In addition to the *Encyclopedia*, contemporary works on Chinese medicinals are abundant. They include treatises on general materia medica such as *Zhong Yao Zhi* (*Manual of Chinese Materia Medica*) and *Quan Guo Zhong Cao Yao Hui Bian* (*National Collection of Chinese Herbal Drugs*) as well as works on regional medicinals such as *Sichuan Zhong Yao Zhi* (*Manual of Chinese Drugs of Sichuan*), *Hubei Zhong Cao Yao Zhi* (*Manual of Chinese Herbal Drugs of Hubei*), *Hunan Yao Wu Zhi* (*Manual of Materia Medica of Hunan*), *Chang Bai Shan Zhi Wu Yao Zhi* (*Manual of Plant Drugs of Chang Bai Mountain*), *Fujian Yao Wu Zhi* (*Manual of Materia Medica of Fujian*), and *Chinese Medicinal Herbs of Hong Kong* (Chinese/English; 5 volumes; total 943 pp.). These are all sizable compilations covering information generally contained in the *Encyclopedia*, but with a slightly different approach and/or regional accent; some also contain medicinals not found in the *Encyclopedia*. Compared to others, the *Chinese Medicinal Herbs of Hong Kong* is the least extensive as it describes in brief only 500 herbs, each with a colored photograph.

Like books on single herbal drugs, there is an equally large number of books that are exclusively devoted to herbal formulas, some of which date back at least 2000 years. Many well-known classical formulas can now be found in the *Zhong Yi Da Ci Dian: Fang Ji Fen Ce* (*Encyclopedia of Traditional Chinese Medicine. Prescriptions*), published in 1980. This formulary incorporates and describes from traditional medical treatises and formularies 7500 selected prescriptions, including 1320 that have duplicate names but different ingredients. Information in each formula includes its classical literature source, the amounts of its component herbs, conditions for which it is used, method(s) of preparation, and method(s) of administration and dosages. The prescriptions included in this work have been selected from such well-known classics as the *Pu Ji Fang* (*Prescriptions for Healing the Masses*, published in the 14th century with 61,739 formulas) and the *Tai Ping Sheng Hui Fang* (published in 992 AD with 16,834 formulas). Examples of well-known classical formulas that are still widely used today include the *Yu Ping Feng San* Oade Screen Powder) and *Yin Qiao San* (Honeysuckle Forsythia Powder) for the prevention and treatment of the common cold and other illness; and the *Da Huang Mu Dan Tang* (Rhubarb Peony Decoction) for treating conditions known as *changyong* ("intestinal carbuncle") which includes acute appendicitis. For more recent formulas, one can consult the *Zhong Yao Zhi ji Hui Bian* (*Collection of Chinese Herbal Preparations*) and *Qian lia Miao Fang* (*One Thousand Superb Prescriptions*). The former describes 3873 prescriptions collected from published data during the past 50 years while the latter, published in 1982, describes some 1 100 formulas collected from 600 famous traditional Chinese physicians and/or clinics throughout China.

For those who are interested in herbal veterinarian medicinals, there is the recently published *Min jean Shou Yi Ben Cao* (*Folk Veterinarian Herbal*). It describes over 600 herbs (with 461 drawings) and about 10,000 prescriptions for treating more than 1000 diseases in domesticated animals, including pigs, cattle, sheep, horses, donkeys, mules, rabbits, dogs, cats, chickens, ducks, geese, and camels, among others. Information contained in this herbal is based on traditional works on herbal veterinarian medicine compiled over the past 2000 years plus the experience of the author who is a leading authority in herbal veterinarian medicine in China.

For those with mycological interests, *Zhong Guo Yao Yong Zhen Jun* (*Chinese Medicinal Fungi*) has become a standard reference in this field since its publication in 1974. This book documents

121 fungi used in Chinese traditional medicine, including such highly priced edible fungi as the *Morchella* spp. (for indigestion, excessive phlegm and shortness of breath) to the highly toxic *Amanitopsis volvata* Sacc. (in combination with other fungi for treating backache, numbness in the limbs, and muscle tightness/spasms).

Another area of popular interest is diet therapy A very useful book on this field is the *Zhong Guo Shi Liao Xue* (*Chinese Diet Therapy*). Published in 1987, this book deals with the treatment and prevention of illnesses by using common Chinese medicinals that serve the dual functions both as food and medicine. Information in this book is derived from close to 200 books on diet therapy and related fields, which have been published over the past 2500 years. Food/medicinal plants described in this volume include lily buds (*Hemerocallis fulva* L.), mung bean, chrysanthemum flower, black sesame seed, green onion (*Allium fistulosum* L.), and many other common food/medicinal substances. This book should be useful to both the health products industry and to regulatory agencies as it might help answer some questions relating to the history of herbal foods.

Also, the currently official *Chinese Pharmacopeia* of natural drugs (1985), containing monographs on 506 single drugs and 207 formulas, can serve as a handy reference on common Chinese medicinals.

Journals

In addition to contemporary books, there are at least 100 journals that deal directly with traditional Chinese medicine and the use of Chinese herbal drugs. They include those published at the national, provincial, and city levels as well as those published by traditional medical institutions. The following is a partial list of these journals.

National:

Acta Botanica Sinica (some English abstracts)—botanical and chemical
Acta Chimica Sinica (most with English abstracts)—chemistry
Acta PhartnaceuHca Sinica (most with English abstracts)—general
Acta Phartnacologica Sinica (most with English abstracts)—general
Bulletin of Chinese Materia Medica—general
Chinese Journal of Integrated Traditional and Western Medicine (some English abstracts)—clinical & pharmacological
Chinese Medical Abstracts-Traditional Medicine—general
Chinese Pharmaceutical Bulletin—general
Chinese Traditional and Herbal Drugs—chemical & pharmacological
Journal of New Chinese Medicine—general
Journal of Traditional Chinese Medicine (English version available)—general
National Medical Journal of China (some English abstracts)—clinical & pharmacological Plants—botanical sources

Regional:

Acta Botanica Yunnanica (most with English abstracts)—botanical and chemical
Beijing Journal of Traditional Chinese Medicine—clinical
Fujian Journal of Traditional Chinese Medicine—clinical
Henan Traditional Chinese Medicine—clinical

Hubei Journal of Traditional Chinese Medicine—clinical
Jiangsu Journal of Traditional Chinese Medicine—clinical
Jiangxi Journal of Traditional Chinese Medicine and Pharmacology—clinical
Journal of Traditional Chinese Medicine and Chinese Materia Medica of Jilin—clinical
Liaoning Journal of Traditional Chinese Medicine—clinical
Shaanxi Journal of Chinese Traditional Medicine—clinical
Shandong Journal of Traditional Chinese Medicine—clinical
Shanghai Journal of Traditional Chinese Medicine—clinical
Shanxi Journal of Traditional Chinese Medicine—clinical
Sichuan Journal of Traditional Chinese Medicine—clinical
Tianjin Journal of Traditional Chinese Medicine—clinical
Yunnan Journal of Traditional Chinese Medicine—clinical
Zhejiang Journal of Traditional Chinese Medicine—clinical

Institutional:

Journal of Anhui College of Traditional Chinese Medicine—general
Journal of Beijing College of Traditional Chinese Medicine—general
Journal of Chengdu College of Traditional Chinese Medicine—general
Journal of Guiyang College of Traditional Chinese Medicine—general
Journal of Hunan College of Traditional Chinese Medicine—general
Journal of Nanjing College of Traditional Chinese Medicine—general
Journal of Shaanxi College of Traditional Chinese Medicine—general
Journal of Shandong College of Traditional Chinese Medicine—general
Journal of Shenyang College of Pharmacy—general
Journal of Yunnan College of Traditional Chinese Medicine—general
Journal of Zhoiang College of Traditional Chinese Medicine—general

Reports published in these journals are mostly on clinical use of herbs and herbal combinations, although there are a sizable number of research reports as well. The latter can be found primarily in nationally published joumals at the top of the above list.

Apart from above journals that primarily deal with natural drugs, reports on these medicinals can also be found in national, regional and institutional joumals that cover general medical and pharmaceutical topics. A partial list of such journals follows.

Chinese Journal of Cancer (some Enghsh abstracts)
Chinese Journal of Cardiology (some English abstracts)
Chinese Journal of Clinical Pharmacology Chinese Journal of Dermatology (some Enghsh abstracts)
Chinese Journal of Hematology (some English abstracts)
Chinese Journal of Internal Medicine (some English abstracts)
Chinese Journal of Microbiology and Immunology (most with English abstracts)
Chinese Journal of Oncology (most with English abstracts)
Journal of Marine Drugs (some Enghsh abstracts)
National Medical Journal of China (some English abstracts)

SCOPE OF CHINESE MATERIA MEDICA

Single Drugs

The Chinese constitute a fifth of the world's population. Due to the empirical nature of traditional Chinese medicine, most of the effective Chinese medicinals and their combinations as we now know them have been well tested in humans over a period of hundreds to thousands of years. A rough estimate based on available information indicates that there are at least 5000 single plant drugs used in China that have readily accessible documentation. The ones that have not yet been recorded in major works probably also number in the thousands.

One major feature that distinguishes Chinese medicinals from those of most other countries is the specific and often elaborate treatment given Chinese medicinals. Over a period of centuries, crude drugs have often been processed according to specific methods to yield the desired effects. Whether they are simply boiled or heated or mixed with other herbs such as licorice, ginger, or black beans, the purpose is often to reduce toxic side effects and/or accentuate the drugs' beneficial effects. Thus, for example, unprocessed aconite is rarely used internally. In order to render it less toxic and yet retain its desired cardiac effects, it is usually soaked for days and boiled for hours. Recent studies have revealed that under these processing conditions, the most toxic alkaloid, aconitine, can be destroyed or greatly reduced. The resulting processed aconite has cardiotonic activities and is used to treat cardiac failure and other heart diseases. Another processed aconite (lateral root), called fuzi, is also used in tonic preparations. Consequently, when one intends to study Chinese medicinals, one should bear in mind the nature of their source, because simply knowing their correct taxonomic origin is not enough. The same plant part from the same species, if obtained by different processing methods, can produce widely different pharmacological effects.

Combinations

Chinese drugs are normally used in combinations for various reasons. Two major ones are: to enhance the action of the main drug(s); and to mitigate the toxic side effects of principal component drugs. Since Chinese medicinals are normally used in combinations, the number of herbal prescriptions used by the Chinese people are countless. An educated guess is that they are in the low to middle six figures, as prescriptions in the *Pu Ji Fang* (*Prescriptions for Healing the Masses*) alone number close to 62,000.

Current Evaluation and Documentation of Chinese Medicinals

Drugs of practically any pharmacological category can be found among Chinese medicinals. During the past twenty-five years, the Chinese have made much progress in bringing their traditional medicines into a modern environment. While scrutinizing traditional medicines with modern methods on the one hand, they continue to expand their traditional uses on the other. Thus, one finds a steady flow of a considerable number of research publications and at the same time huge numbers of clinical reports on use of traditional prescriptions in treating diseases ranging from the common cold to cancer. Most of the published information during the past 150 years has so far been abstracted in a series of three volumes called *Zhong Yao Yan Jiu Wen Xian Zhai Yao*

(*Research on Chinese Materia Medica: Literature Abstracts,* 1820-1961, 1962-1974, 1975-1979). Also, research and clinical data on about 250 important Chinese medicinals are summarized in the *Zhong Yao Yao Li Yu Ying Yong* (*Pharmacology and Applications of Chinese Drugs*). The most active areas of current research and practice in Chinese materia medica include medicinals used in the treatment of cancer and cardiovascular, viral and irnmunological diseases.

The following are some data on recent studies on Chinese medicinals. As the information is so extensive, the examples given in the following only represent a very small fraction of what actually is available.

Antitumor drugs. There must be thousands of herbal formulas currently used for treating cancer in China. Over 400 of these can be found in three recently published books on anticancer medicinals (Chang 1987, Yang 1981, Hu and Xuan 1982), which were compiled primarily from modern published data; they are prepared from more than 200 single drugs. The prescriptions range from ones that contain medicinals with known antitumor chemicals to those whose components have not yet been chemically and/or pharmacologically studied. Examples are many and the f ollowing are a few selected at random (Cheng and Xu 1985, Cheng et al. 1984, Guo et al. 1985, Huang 1987, Jiang 1984, Jiang and Yan 1986, Li 1982, Liu et al. 1985, Ren and Hong 1986, Wang 1987, Yu 1983):

Cephalotaxus fortunei Hook. f, *C. sinensis* (Relid. et Wils.) Li, *C. hainanensis* Li [bark, root, twigs]—hainanolide, harringtonines, etc.

Camptotheca acuminata Decne. [root, bark fruit, twigs, leaves]—camptothecine, etc.

Iphigenia indica Kunth [bulb]—colchicine

Curcuma zedoaria Rosc., *C. aromatics* Salish., *C. kwangsietisis* S. Lee et C.F. Liang [rhizome]—curdione, curcumol

Crotalaria sessiliflora L., *C. assamica* Benth. [whole plant]—monocrotaline

Sophora subprestrata Chun et T. Chen, *S. flavescens* Ait. [root/rhizomel—matrine, oxymatrine, sophocarpine, etc.

Trichosanthes kirilozvii Maxim, *T. uniflora* Hao [root]—trichosanthin

Strobilanthes cusia (*Nees*) O. Kuntze, *Isatis indigotica* Fort., *Indigofera suffruticosa* Mill., *Polygonum tinctorium* Ait., etc. [qingdailnatural indigo]—indirubin

Rabdosia rubescens (Hemsl.) Hara and other *Rabdosia* spp. [whole plant]—diterpenoids (rubescensines, oridonin etc.)

Cucumis melo L. [pedunclel—cucurbitacins B and E

Ailanthus altissima (Mill.) Swingle [root/stem bark, fruit]—lactones

Cardiovascular drugs. A considerable number of traditional drugs and prescriptions are used in conditions related to the heart and blood. They include those grouped under the categories of *huo xue hua yu* (invigorating blood circulation and dispersing stasis), blood tonics, and hemostatics. The following are a few examples of such medicinals (Chai et al. 1985, Chen 1987a, Deng and Gong 1987, Huang 1986, Jiang 1984, Li et al. 1983, Liu and Chen 1984, Ou et al. 1987, Shan

1988, Shan et al. 1986, Song et al. 1988, Wang and Ba 1985, Wang and Jing 1984, Yang 1988, Yue et al. 1985, Zhang 1985, Zhou 1984):

> *Pueraria lobata* (Willd.) Ohwi [root]—antiarrhythmia, hypotensive, hypoglycemic (e.g. puerarin.)
>
> *Ephedra* spp. [root/rhizome]—hypotensive (ephedranin A, mahuanin A & B, alkaloids)
>
> *Aconitum carmichaeli* [*fuzi,* lateral root]—cardiotonic, anti-thrombin, etc. (e.g. higenamine)
>
> *Salvia miltiorrhiza* Bunge [root]—anticoagulant, vasodidator (e.g. tanshinones, danshensu)
>
> *Ligusticum chuanxiong* Hort. [rhizome]-vasodilator, anti-thrombin, anti-atherosclerotic (e.g. tetramethylpyrazine)
>
> *Lentinus edodes* (Berk.) Sing. [fruiting body]—antiplatelet aggregation, etc. (hydro-alcoholic extract).
>
> *Panax pseudo-ginseng* Wall. var. *notoginseng* (Burk.) Hoo et Tseng [rhizomel—anti-arrhythmia (saponins)
>
> *Polygonum multiflorum* Thunb. [root tuber]—anti-atherosclerotic (alcohol extractives)
>
> *Polygonum cuspidatum* Sieb. et Zucc. [rhizome]—antiplatelet aggregation (polydatin)

Antivital drugs. Antivital drugs can be found in several categories of traditional medicinals. They include the so-called heat-dispersing drugs (antipyretics) and those for treating "exterior symptom complex" (diaphoretics). These drugs are frequently used in prescriptions along with tonics (immunomodulating drugs). The following two formulas are worth noting as they have been in use for centuries:

1. *Yu Ping Feng San* (*Jade Screen Powder*)
Huangqi (astragalus root)
Fangfeng (root of *Ledebouriella divaricata*)
Baizhu (rhizome of *Atractylodes macrocephala* Koidz.)
2. *Yin Qiao San* (*Honeysuckle Forsythia Powder*)
Honeysuckle flower (*Lonicera* spp.)
Forsythia fruit (*Forsythia suspensa*)
Mint (*Mentha haplocalyx* Brig.)
Jingjie (herb of *Schizonepeta tenuifolia* Briq.)
Dandouchi (fermented black soybean)
Niubangzi (fruit of *Arctium lappa* L.)
Jiegeng [*Platycodon grandiflorum* (Jacq.) A. DC]
Danzhuye (herb of *Lophatherum gracile* Brongn.)
Licorice root

Jade Screen Powder was first recorded in 1481 AD. It has tonic properties and is used to build up body resistance in the prevention of the common cold and influenza. Due to its antivital as well as immunomodulating activities, it has drawn much attention in the past few years. So far, studies have demonstrated it to lower the incidence of cold and influenza, prevent the recurrence of chronic bronchitis, and enhance host immunity. After treatment with this prescription, patients' IgA, IgG, and rate of T-lymphocyte transformation and E-rosette formation are all markedly increased (Geng 1986, Li 1988, Liu 1987).

Honeysuckle Forsythia Powder was first recorded in 1798 AD. Currently it is probably the most widely used cold remedy in China and in overseas Chinese communities. It is used in treating the common cold, influenza, and other febrile viral infections. Its multiple pharmacological effects have been reported, which include antipyretic, anti-inflammatory, and anti-allergic (Deng et al. 1986).

Immunomodulating drugs. There are dozens of well-known Chinese medicinals with immunomodulating activities that have been traditionally used as tonics; some are now also used in cancer to counteract the toxic side effects of chemotherapy and radiotherapy. The following are a few examples of these medicinals (Chen 1985, Chinese 1985, Deng and Liao 1984, Du et al. 1986, Geng 1986, Li et al. 1986, Lin et al. 1985, Liu and Xu 1985, Wang 1987, Zang et al. 1985).

Tremella fuciformis Berk [fruiting body]—polysaccharides
Polyporus umbellatus (Pers.) Fries [sclerotium]—polysaccharides
Poria cocos [sclerotium]—polysaccharides
Lentinus edodes (Berk.) Sing. [fruiting body]—polysaccharides

Cordyceps sinensis (Berk) Sacc. [whole fungus plus host remains]—polysaccharides
Oriental ginseng polysaccharides
Astragalus polysaccharides

Others. I cannot leave this topic without mentioning another category of traditional drugs that are of keen interest not only to the Chinese but to Americans as well. These are the anti-aging medicinals. The newly published *Kang Shuai Lao Fangji Ci Dian* (*Encyclopedia of Anti-Aging Formulas*) records 1018 formulas, mostly selected from classic formularies, with only a few from modern sources. Over the past few years, I have seen a steady increase in reports on anti-aging research in the Chinese literature. Using modern criteria relating to aging such as immune functions, free radical formation, superoxide dismutase activity, monoamine oxidase activity, and blood lipid levels, many traditional tonics have been shown to have anti-aging effects. They include ginseng, Siberian ginseng [root/rhizome of *Acanthopanax senticosus* (Rupr. et Maxim.) Harms], *Schisandra chinensis* fruit, *lingzhi* (fruiting body of *Ganodertna* spp.), *fuzi* (processed lateral root of *Aconitum carmichaeli*), *Epimedium* herb, *heshouwu* (root of *Polygonum multiflorum*), *danggui* (root of *Angelica sinensis*), *baizhu* (rhizome of *Atractylodes macrocephala*), and *luobuma* (leaf of *Apocynum venetum* L.), among others (Jiangsu 1988, Li et al. 1986).

EXAMPLES OF COMMON CHINESE MEDICINALS

Mahuang

The most well-known Chinese medicinal that has been frequently quoted as a classic example of an herbal drug yielding a modern medicine (ephedrine) is *mahuang* (*Ephedra* spp.). It is the dried stems of one of three *Ephedra* species (*E. sinica* Stapf; *E. equisetina* Bunge; *E. intermedia* Schrenk et C.A. Mey) found in China, primarily in northem regions. It has been used in China as a diaphoretic, anti-asthmatic, and diuretic for at least 2000 years, with written records dating back to at least the *Shennong Herbal* (100 BC-200 AD.). Prescriptions based on *mahuang* for treating asthmatic conditions are countless, some of which date back to ancient formularies, such as the 3rd-century medical classic, the *Shang Han Lun* (*Theory on Febrile Diseases*). Other less known uses of *mahuang* include the treatment of influenza and rheumatism. In contrast to the diaphoretic properties of *mahuang* (stem), the root and rhizome of *Ephedra* species, known as *mahuanggen,* has antiperspirant properties. It is used to treat night sweat and spontaneous perspiration as well as excessive perspiration. For the latter, it is often used topically in the form of a powder for dusting or decoction for washing affected areas. Furthermore, recent studies have shown it to contain hypotensive flavonoids and alkaloids. The completely different medicinal properties of aboveground and underground parts of *Ephedra* species serve as another example to highlight the importance of specificity when evaluating and reporting on plant drugs.

Sour Date Kernel

One of the most commonly used sedative/hypnotic in Chinese prescriptions for treating insomnia and neurasthenia is *suanzaoren* (sour date kernel). It is the dried ripe kernels of *Ziziphus jujube* Mill. var. *spinosa* (Bunge) Hu ex H.F. Chow (syn. *Ziziphus spinosa* Hu). Although first recorded 3000 years ago, this medicinal has only recently been evaluated by modern scientific methods and found to indeed possess sedative and hypnotic effects in various experimental animals (Hong and Cao 1987). Spinosin, a flavonoid glycoside, is only partially responsible for these effects (Li and Zhang 1983, Yuan et al. 1987, Zeng et al. 1987). Other active components in this drug still await further investigations.

Sour date kernel is also traditionally known to "calm the heart." Recent studies have demonstrated it to have anti-arrhythmic and other cardiovascular activifies (Xu et al. 1987).

Qian Ceng Ta

Qian ceng ta is the whole plant of *Huperzia serrata* (Thunb.) Trev [syn. *Lycopodium serratum* Thunb.]. Although not as common as the previous two, it is traditionally used as a detoxicant to reduce swelling, break up blood stasis, and to stop bleeding. During its clinical use, patients were observed to exhibit cholinergic-type reactions in varying degrees. Subsequently, two new alkaloids, huperzine A and huperzine B, were isolated from it and shown to have strong and reversible anticholinesterase activity. The action of huperzine A against acetylcholinesterase was found to be three times stronger than that of physostigmine and thirty times that of galanthamine, with lower toxic side effects. Favorable results from a series of studies conducted in rats and mice plus a preliminary study on human subjects over the past two years indicate that these new alkaloids show promise in the treatment of Alzheimer's disease and related disorders (Liu et al. 1986, Wang et al. 1986, Wang et al. 1988, Tang et al. 1986, Xu and Tang 1987, Zhu and Tang

1987, Yan et al. 1987, Lu et al. 1988).

Detoxicants

"Detoxicant" is a rather vague term that can mean several things in traditional Chinese medicine. A detoxicant can be used to treat "toxic conditions" such as external sores and ulcers or internal conditions characterized by fevers or inflammations, results of viral or bacterial infections. Well-known Chinese medicinals used for such conditions include honeysuckle flower, *qingdai* (natural indigo), houttuynia herb [*Houttuynia cordata* Thunb.], forsythia fruit [*Forsythia suspensa,* and andrographis herb [*Andrographis paniculata* (Burm. f) Nees.]. Most of these have been extensively studied chemically and pharmacologically Modern drugs such as indirubin for leukemia and andrographolides for various bacterial infections have been the results of these studies.

Another type of detoxicants that so far have not been examined by modern technics include ginger, mung bean, soybean, and licorice that are routinely used in traditional Chinese medicine for treating drug or food poisoning as well as toxic side effects of cancer chemotherapy and heavy metal poisoning. There is no lack of clinical reports on these uses in the Chinese literature. However, reports on relevant chemical and pharmacological studies on these medicinals are lacking.

CONCLUSION

The Chinese people have been using their medicinals for several thousand years. Over this long period, they have accumulated a sizable pharmacopeia based on actual human trials, and have faithfully recorded their experience and knowledge of these medicines for posterity. Thus, compared to those of other countries, Chinese medicinals are unsurpassed in number, sophistication, and documentation.

Considering the billions of Chinese who have lived and died since ancient times, it is highly probable that for every disease known to mankind, there exists in the Chinese formularies and herbals an effective remedy to treat it. The disease may not bear the modern name familiar to us, but if one knows how and where to search one will most likely find the diseased condition and the drug or prescription for treating it. In fact the treasure house of Chinese medicinals can offer modern science sucha fertile field in which to look for leads to new drugs that we simply can no longer afford to ignore it. The data are there. But it will take industrial and/or government executives with foresight to initiate the efforts to make effective use of this information. Considering the poor results of conventional screening programs, obtaining new drug leads among Chinese medicinals may well be the most cost effective strategy and should be the concern of every executive who is interested in inexpensive and effective ways of developing new drug leads.

Since most Chinese medicinals have withstood centuries of safe use, new active principles isolated from them are viewed favorably by the Chinese who rarely hesitate to experiment with them directly on humans. They also continue to experiment with new herbal prescriptions and document them as they have for thousands of years, making the field of Chinese medicinals virtually a continuous massive clinical trial of which Western pharmaceutical and medical researchers should take advantage. With the huge sums of federal money now being spent in AIDS and cancer research, a minute fraction of it spent in tapping this Chinese resource would be most cost effective in obtaining leads to new drugs in these areas.

Lastly, many Chinese medicinals are derived from rather common plant sources. Some of these plants, such as *Pueraria lobata*, *Lonicera* spp., *Ailanthus altissima*, and *Polygonum cuspidatum*, have already been naturalized in America. They could be tumed into cash crops with minimal research should a medicinal market be developed.

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New Opportunities in the Cucurbitaceae*

Timothy J. Ng

The Cucurbitaceae consists of nearly 100 genera and over 750 species (Yamaguchi 1983). Although most have Old World origins (Whitaker and Davis 1962), many species originated in the New World and at least seven genera have origins in both hemispheres (Esquinas-Alcazar and Gulick 1983). There is tremendous genetic diversity within the family, and the range of adaptation for cucurbit species includes tropical and subtropical regions, arid deserts, and temperate locations. A few species are adaptable to production at elevations as high as 2000 m.

The genetic diversity in cucurbits extends to both vegetative and reproductive characteristics. There is considerable range in the monoploid (*x*) chromosome number (Jeffrey 1990), including 7 (*Cucumis sativus*), 11 (*Citrullus* spp., *Momordica* spp., *Lagenaria* spp., *Sechium* spp., and *Trichosanthes* spp.), 12 (*Benincasa hispida*, *Coccinia cordifolia*, *Cucumis* spp. other than *C. sativus*, and *Praecitrullus fistulosus*), 13 (*Luffa* spp.), and 20 (*Cucurbita* spp.).

Archaeological evidence has indicated that cucurbits were present in ancient and prehistoric cultures. *Lagenaria* was associated with man as early as 12,000 BC in Peru (Esquinas-Alcazar and Gulick 1983). Archaeological expeditions in the Oaxaca region of Mexico have reported Cucurbita pepo to be associated with man as early as 8500 BC and cultivated by 4050 BC (Esquinas-Alcazar and Gulick 1983). Written Chinese records describing the use of cultivated cucurbits have been found from as early as 685 BC (Herklots 1972). American Indians cultivated squash in pre-Columbian times (Whitaker and Davis 1962), and chayote was a common vegetable among the Aztecs prior to the Spanish conquest (Herklots 1972). Depending upon the species, virtually all parts of the plant can be used for food, including leaves, shoots, roots, flowers, seeds, and immature and mature fruits. Starch can be extracted from roots, and the seeds are a rich source of oils and proteins (Jacks et al. 1972). In addition, some cucurbits have been used for ornamental purposes (e.g., gourds), for utensils (e.g., bowls, ladles, sponges, boxes, birdhouses, musical instruments), and for fuel and pharmacological uses in certain areas of the world.

NEW OPPORTUNITIES WITH COMMONLY GROWN CUCURBITS

Cucurbit crops commonly grown in the United States include cucumber (*Cucumis sativus*), melon (*Cucumis melo*), watermelon (*Citrullus lanatus*), and squash and pumpkin (*Cucurbita* spp.). Due to intensive breeding efforts, particularly with cucumber and melon, numerous new cultivars have been developed, some of them quite different from the traditional forms for these crops.

Cucumbers have been traditionally grown for either pickling or slicing purposes. Newer forms which are increasing in importance include hothouse cucumbers, which are elongated, seedless, and "burpless" (putatively reducing eructation). Nerson et al. (1990) reported on the development of melofon, a genotype of *Cucumis melo* which is suitable for pickle production.

Until recently, melon production has been limited in most parts of the United States to the reticulated (netted), orange-fleshed muskmelon. However, the smooth-skinned, green-fleshed honeydews have increased in popularity over the past decade, and varied displays of casaba and canary (smooth-skinned with yellow or mottled rinds, white-fleshed), Persian (lightly-netted, pink-fleshed), and crenshaw (smooth-skinned, pale orange-fleshed) melons are becoming an increasingly common sight in major markets. The genetic diversity within the species for fruit characteristics has resulted in recent cultivar developments such as orange-fleshed honeydews and green-fleshed netted melons. Additionally, producers are showing interest in forms cultivated in other countries, including the smooth-skinned, delicately-fleshed "Charentais" types in Europe and the dark green smooth-skinned "hami gua" melons of Asia.

Watermelon types have traditionally been red-fleshed and seeded. There is genetic variation for flesh color in the species, however, and colors can range from white or yellow to orange, depending upon the genetic constitution. Yellow-fleshed cultivars are now available, and there may be a market for white-fleshed cultivars if quality could be assured, since consumers tend to associate white flesh with immaturity. A relatively recent development in watermelon breeding has been the use of ploidy manipulations to produce seedless triploid genotypes (Kihara 1951). A number of seedless cultivars have been developed, but they tend to be more susceptible to physiological problems such as poor seed germination and hollow heart. In northwest China, edible seed watermelons are an important crop (Zhang and Jiang 1990); these melons are small in size (2.5 to 3.5 kg) with low soluble solids content, but have a high ratio of seed to flesh in the fruits. The seeds are roasted before eating.

Squash, derived from Algonquin Indian "askoot asquash" which means "eaten green," is a generic term to describe cultivars of four *Cucurbita* species: *C. argyrosperma* (= *C. mixta*), *C. maxima*, *C.*

moschata, and *C. pepo*. These species are New World in origin, with all but *C. maxima* originating in central to southern Mexico (*C. maxima* originated in South America and was the only species not cultivated in the United States until post-Columbian times). Traditional forms of the *Cucurbita* spp. include summer squash, winter squash, pumpkins, and gourds. Production has recently increased with specialty forms such as spaghetti squash (*C. pepo*), whose internal flesh texture resembles strands of spaghetti following cooking. Another specialty crop is calabaza (*C. moschata*), a hard-shelled squash with bright orange, fine-grained flesh and excellent nutritive properties (Wessel-Beaver and Varela 1991). There has also been recent interest in edible pumpkin seed, particularly in genotypes with the hull-less trait (Loy 1990).

Although the new forms of these commonly grown cucurbits represent an increase of diversity within each commodity, they will probably not expand the market substantially (with the exception of niche markets) since consumers will probably elect to purchase them in place of the more traditional forms. Where the true opportunity for increased diversity and market growth exists is with cucurbit crops which are grown on an international scale, but are cultivated to only a limited extent in the United States.

CUCURBITS OF POTENTIAL ECONOMIC IMPORTANCE

Although by no means exhaustive, Table 1 lists cucurbit species which are cultivated to a significant extent in other parts of the world. Loosely grouped according to Old World and New World origins, Table 1 also lists the more frequently used common names for each of these species, along with growth habit and the parts of the plant which are used on an economic basis. Many of these species are described in detail by Chakravarty (1990), Herklots (1972), Tindall (1983), Whitaker (1990), Whitaker and Davis (1962), and Yamaguchi (1983).

Old World Cucurbits

Benincasa hispida. The winter melon has been reported to have been grown as a vegetable in China since 500 AD; even today, however, it is cultivated little outside of Asia. It was one of two cucurbit species identified by the National Academy of Sciences (1975) as being an underexploited tropical crop. Exhibiting relatively rapid growth, *B. hispida* grows best in temperate climates with adequate but not excessive rainfall. In Sri Lanka, the plant produces fruit from seed in two months during the rainy season. The distribution of staminate and pistillate flowers is influenced by temperature and daylength. Plants may be grown recumbent or trellised.

The mature fruit is the primary harvested plant part, although seeds are sometimes extracted, fried and eaten like pumpkin seeds. The fruit is covered by a white, chalky wax which deters microorganisms and helps impart an extraordinary longevity to the melon. Winter melon fruits can be stored for as long as a year without refrigeration. Fruits may weight up to 35 kg and consist of more than 96% water. They are usually sold whole in domestic markets, but are commonly displayed and sold by the slice in Asian markets. Somewhat bland in flavor when eaten fresh, the flesh is often used to make soup stock. Canned winter melon soup and dehydrated winter melon slices represent two of the processed products made from this species.

Citrullus colocynthis. A relative of watermelon, egusi is native to tropical Africa and highly drought tolerant. Productivity is enhanced during dry, sunny periods and reduced during periods of excessive rainfall and high humidity. It is suitable for production in "marginal growing areas." The fruits are extremely bitter, but the seeds are can be removed and roasted as an edible commodity (Soliman et al. 1985). The seeds are rich in oils, which can be extracted for cooking purposes, and the seeds can also be ground into a powder and used as a soup thickener or flavoring agent (Badifu and Ogunsua 1991).

Coccinia cordifolia. Ivy gourd is a semi-perennial which grows best under conditions of adequate rainfall and high humidity. One of the few dioecious cucurbits, with a hetermorphic (XY) chromosome pair determining sex, it produces best when a 1:10 ratio of male to females is used. Plants are commonly trellised. The leaves, shoots, and immature fruits are cooked and eaten; mature fruits are sometimes preserved.

Cucumis anguria. The West Indian gherkin grows and is used in a similar fashion as the cucumber. It was introduced into the United States in the early 1800s, but remains cultivated to only a limited extent. Oval in shape with a round cross-section, it has a highly warted skin, long spines and a large cavity with many seeds.

Lagenaria siceraria. The origin of the bottle gourd is acknowledged to be Africa, although archaeological evidence has placed it in Peru around 12000 BC, in Thailand about 8000 BC, and in Zambia around 2000 BC (Esquinas-Alcazar and Gulick 1983). It has traveled widely, perhaps because the hard, dry skin of the mature fruits is impervious to water; they are capable of floating on salt water for the better part of a year without any loss in seed viability (Herklots 1972; Tindall 1983). Tolerant to a wide range of rainfall, it may be grown either on the ground or trellised.

Young fruits are used as a cooked vegetable similar to zucchini. The flesh is white, firm, and has an excellent texture and a mild taste. Young shoots and leaves can be cooked, and seeds can be used in soups. Flesh of immature fruits can also be used in making icing for cakes, and the hard skin is sometimes sliced into thin, dry strips for cooking.

Some forms of *L. siceraria* are grown for non-food uses. Mature fruits, whose inside may be poisonous, contain an extremely hard and waterproof rind when dried. They can be used as multi-purpose containers (bowls, boxes, water jugs, cups, planters), utensils (ladles, pipes), musical instruments (e.g., sitars), floats for fishnets and rafts, or for ornamental purposes such as masks or native artifacts. Designs lightly scratched into the skin of developing fruit will develop into scars that remain intact in the mature fruits.

Luffa acutangula. The angled loofah is commonly grown in hot, humid tropical areas in Asia. Plants are generally grown on a trellis. Immature fruits, which are dark green with tender ridges, are used in soups and curries or as a cooked vegetable. They generally grow up to 0.6 m in length, and the flesh is spongy although the skin is coarse. The mature fruits are bitter and inedible, but the fibrous skeleton can be used as a sponge. However, the reticulated inner tissue is not as easily separated from the outer skin and inner flesh as *L. aegyptiaca* (= *L. cylindrica*).

Luffa aegyptiaca. Along with *Lagenaria siceraria*, *L. aegyptiaca* probably has the most diverse uses of any of the cultivated cucurbits. Immature fruits of the non-bitter genotypes are eaten fresh, cooked, or in soups, although they are inferior to immature *L. acutangula* fruits. The mature fruits are the source of the spongy reticulated material known as the domestic loofah. These loofahs are used for sponges and filters, and for stuffing pillows, saddles, and slippers. They can also be used for insulation and are attractive sources for packing materials because of their biodegradability. There is an increasing interest in domestic production (Davis 1991) since the United States is the major market and imports millions of loofahs from Asia each year.

Normally, mature fruits are left on vine to dry and the dry, thin outer skin is removed. The fruit is then soaked in running water for several days, after which the softer tissue is removed. After further soaking, then drying, the seeds are shaken out and the loofah is bleached either chemically or by the sun prior to marketing.

Momordica charantia. The bitter melon is adapted to a wide variation of climates, although production is best in hot, humid areas such as tropical Asia. The bitter immature fruits are usually soaked to remove some of the bitterness, then boiled or fried. Volatile components released during cooking enhance the flavor (Binder et al. 1989). Bitter melons can also be pickled or used in curries. Relative to other cucurbits, the fruit is highly nutritious due to the iron and ascorbic acid content. Plants are usually trellised, and fruits are protected from flies by tying a paper cylinder around the stalk. Some forms have bright red seeds due to a high lycopene content; Yen and Hwang (1985) have proposed using this pigment as an artificial food colorant.

Praecitrullus fistulosus. Primarily grown in India, the round melon was long considered to be *Citrullus lanatus* but was recently given its own taxonomic category due in part to its difference in monoploid chromosome number (Sujatha and Seshadri 1989). Growth conditions and requirements are similar to those of watermelon, but the entire immature fruit is used as a cooked vegetable. The seeds can also be removed and eaten.

Telfairia occidentalis. A dioecious perennial grown at elevations up to 2,000 m in West Africa, the fluted gourd is drought tolerant and is usually trellised. Shoots from the female plants can be cooked and eaten (Lucas 1988). The fruits are large (up to 13 kg) and inedible, but the seeds contain up to 30% protein and can be boiled and eaten, or ground into powder for soup. Seeds can also be fermented for several days and eaten as a slurry (Badifu and Ogunsua 1991).

Telfairia pedata. The oyster nut is a perennial grown in Central and East Africa. It is drought tolerant, can grow at elevations up to 2,000 m, requires 18 months to flowering, and is usually trellised. It produces very large, long, flat seeds which taste similar to almonds when roasted.

Trichosanthes cucumerina. The snake melon is an annual which requires high levels of soil moisture and trellising. A long growing season is necessary, and the flowers open late in the afternoon. Immature fruits are usually harvested when they are 0.3 to 0.4 m long; mature fruits can grow up to 1.5 m in length. Some of the fruits remain straight, while others may curl to resemble a snake. Immature fruits are boiled and eaten, while mature fruits are used in soups.

New World Cucurbits

Cucurbita ficifolia. The fig-leaved gourd grows in temperate highlands at elevations up to 2,000 m. One of the earliest cultivated plants in America, archaeological evidence indicates it was cultivated in Peru around 3000 BC (Herklots 1972). The immature fruits can be prepared and eaten similar to summer squash. Mature fruits can be preserved, and the black seeds are edible. In Latin

America, the flesh is impregnated with sugar to make a candy or it can be fermented to make beer (Whitaker 1990).

Cucurbita foetidissima. Identified as an underexploited tropical crop by the National Academy of Sciences (1975), the buffalo gourd has multiple food and non-food uses (Bemis et al. 1975; Gathman and Bemis 1990). It is a perennial and is found growing wild in marginal lands in the southwestern United States. Some plants have been reported to be over 40 years old. It has a very large, fleshy storage root which can grow to depths up to 5 m and weigh as much as 30 kg after two growing seasons. Roots of older plants can weigh over 100 kg. Buffalo gourd primarily reproduces by asexual reproduction, but also produces small yellow, hard shelled fruits which are considered inedible.

American Indians have used the ripe fruit as a soap substitute and as ceremonial rattles. The seeds, which contain an abundant quantity of polyunsaturated fats and protein, are edible. The large storage roots contain large amounts of starch (up to 56% of the dry weight), and can also be used as fuel. Air-dried roots burn with the heat equivalent of wood and are being tested in Afghanistan as an alternative fuel to decrease deforestation (Winrock International 1991).

Cyclanthera pedata. Korila is relatively cold tolerant and adapted to elevations up to 2,000 m, but is also easy to cultivate in the tropics and subtropics. It is currently cultivated in the Carribean and in Central and South America. The foliage is glabrous and odoriferous. Fruits are pale green, flattened, and mostly hollow. The seed cavity is spongy, and the seeds are attached to a single placenta. Seeds are usually removed and the fruits are eaten raw or cooked. They are often used stuffed with meat, fish or cheese, then baked and eaten similar to stuffed peppers. The shoots are also edible.

Sechium edule. Chayote was a common vegetable among the Aztecs prior to Spanish conquest of Mexico. It is still one of the most widely cultivated of the cucurbits in Costa Rica. It requires high levels of soil moisture and can grow at elevations up to 1,500 m. Unlike most cucurbits, it has a daylength requirement of 12 to 12.5 h for flowering. The plants grow best on hillsides and are usually trellised. Parthenocarpic fruit set can be induced by gibberellin.

Unlike other cucurbits, the fruit contain only a single, large seed. The immature fruits can be eaten raw in salads and provide a good source of vitamin C (Herklots 1972). They can also be boiled, fried, steamed, or stuffed and baked. Young leaves and tendrils are also eaten, and seeds can be sauteed in butter as a delicacy. The large storage roots represent a rich source of starch (Chakravarty 1990).

POTENTIAL BIOCHEMICAL AND MEDICINAL USES

Cucurbits are a well-recognized source of secondary metabolites. The cucurbitacins, tetracyclic triterpenoids which impart a bitter flavor to many cucurbits, have been well-studied as attractants of beetles such as *Diabrotica* (Whitaker and Davis 1962). Alkaloids have been reported in *Momordica*, and saponins have been found in *Cucurbita, Citrullus, Lagenaria,* and *Momordica* (Schultes 1990).

As biochemical isolation techniques become more sophisticated and refined, new compounds of interest are being isolated. For instance, Mukherjee et al. (1986) isolated amarinin from *Luffa amara*; amarinin inhibits plant cell growth in culture, and its action cannot be overcome with gibberellin.

Perhaps of greatest current interest are the compounds of potential medicinal interest present within cucurbits. Table 2 lists reported pharmacological properties of many cultivated cucurbits; similar properties have been ascribed to other cucurbit species not currently under cultivation (Schultes 1990). Putative properties include purgative actions and treatment for physical ailments, diseases, and infectious organisms. "Infusions" (minced tissue suitable for steeping) of selected cucurbits are sold in some markets and reported to be able to alleviate or cure certain human ailments.

Recently, abortifacient proteins with ribosome-inhibiting properties have been isolated from several cucurbit species (Ng et al. 1991). Some of these species have been used to induce second trimester abortions in China since the 1920s. The abortifacient proteins include momorcharin (from *Momordica charantia*), luffaculin (from *Luffa operculata*), trichosanthin (from *Trichosanthes kirilowii*), and beta-trichosanthin (from *Trichosanthes cucumeroides*). Trichosanthin is of particular interest because its ribosome-inhibiting properties have been shown to be effective in inhibiting the replication of human immunodeficiency virus (HIV) in infected lymphocyte and phagocyte cells, indicating potential as a therapeutic agent for AIDS (McGrath et al. 1989). These proteins vary in their level of action and effectiveness, and further germplasm evaluation of cultivated and wild species may identify related compounds with greater efficacy for ribosome inactivation.

GERMPLASM RESOURCES

Few of these Old World and New World species have been subjected to major, intensive breeding efforts. However, extensive germplasm collections are maintained by the USDA Plant Germplasm System at the Plant Introduction Station in Iowa (Clark et al. 1991) and by the Vavilov Institute in Leningrad, USSR (Robinson 1989). Another major germplasm repository is maintained by the Peoples' Republic of China (Robinson 1989), and smaller gene banks are located in Mexico, India, Spain, Nigeria, Costa Rica, and the Philippines (Esquinas-Alcazar and Gulick 1983). These germplasm collections represent a valuable resource for breeding adapted cultivars of these exotic cucurbits for domestic production.

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Table 1. Old World and New World cucurbit species with potential for cultivation in the United States[z].

Species	Origin	Common names	Primary plant parts used	Other plant parts used	Growth habit
Old World					

Benincasa hispida (Thunb.) Cogn.	SE Asia & Indonesia	Winter melon, ash pumpkin, wax gourd, white gourd, dong gua, tallow gourd	Mature fruits	Young leaves, flower buds, seeds, immature fruits	Annual
Citrullus colocynthis (L.) Schrad.	Tropical Africa	Egusi	Seeds	Annual	
Coccinia cordifolia Cogn.	Trop. Asia & Africa	Ivy gourd, scarlet-fruited gourd	Leaves, shoots, immature fruits (preserved)	Mature fruits	Semi-perennial
Cucumis anguria L.	Tropical Africa	West Indian gherkin, bur gherkin, maroon cucumber	Immature fruits		Annual
Lagenaria siceraria (Mol.) Standl.	Tropical Africa	Bottle gourd, calabash gourd, white-flowered gourd, trumpet gourd, Zucca melon	Young fruits, mature fruits[y]	Young shoots, young leaves, seeds	Annual
Luffa acutangula (L.) Roxb.	India	Angled loofah, towel gourd, dish-cloth gourd, ridged gourd, silk gourd, long okra, ribbed loofah, ribbed gourd	Immature fruits, leaves		Annual
Luffa aegyptiaca Muell.	India	Smooth loofah, dish-cloth gourd, vegetable sponge, sponge gourd, rag gourd, hechima	Immature fruits, mature fruits[y]		Annual
Momordica charantia L.	Tropical Africa	Bitter melon, balsam pear, carilla fruit, carilla gourd, bitter gourd, alligator pear	Immature fruits young shoots	Young leaves,	Annual
Praecitrullus fistulosus (Stocks) Pang.	Tropical Africa	Round melon, squash melon	Mature fruit	Seeds	Annual
Telfairia occidentalis Hook. f.	Tropical Africa	Fluted gourd, fluted pumpkin	Female shoots, seeds		Perennial

Telfairia pedata (Sims) Hook.	Tropical Africa	Oyster nut, fluted pumpkin, Zanzibar oil vine	Seeds		Perennial
Trichosanthes cucumerina L.	India	Snake gourd, club gourd mature fruits	Immature fruits, young shoots	Young leaves,	Annual
New World					
Cucurbita ficifolia Bouche	Central Mexico	Fig-leaved gourd, Malabar gourd	Mature fruits, seeds	Immature fruits	Annual
Cucurbita foetidissima HBK	Mexico & Southern US	Buffalo gourd, mock orange, stinking wild gourd, chilicote	Mature fruits[y]	Roots[y], seeds	Perennial
Cyclanthera pedata Schrad.	South America	Korila, wild cucumber, caihua, achoccha	Immature fruits	Shoots	Annual
Sechium edule (Jacq.) Sw.	So. Mexico & Central America	Chayote, choyote, cho-cho,christophine, choke, choko, sou-sou, chaka plant, chayotl vegetable pear, mirliton	Immature fruits, tubers, seeds	Young leaves, young tendrils	Perennial

[z]Modified from Chakravarty 1990; Herklots 1972; Tindall 1983; Whitaker 1990; Whitaker and Davis 1962; and Yamaguchi 1983.

[y]Non-food uses such as soaps, fuels, sponges, utensils, containers, musical instruments.

Table 2. Putative medicinal and pharmacological properties of cultivated cucurbits[z].

		Therapeutic medications			
Species	Purgative	Physical ailments	Diseases	Infectious organisms	Other purported uses
Benincasa hispida	Diuretic, laxative	Dermatological, fever	Epilepsy, gonorrhea	Intestinal worms	Aphrodisiac
Citrulus colocynthis		Paralysis, muscle spasms			
Citrullus lanatus	Diuretic	Liver	Malaria		
Cucumis anguria		Stomach, edema, hemorrhoids		Ringworm	Freckle removal
Cucumis melo	Emetic			Intestinal worms	
Cucurbita maxima				Intestinal worms	

Cucurbita moschata & *Cucurbita pepo*	Diuretic	Ulcers, fever, jaundice	Measles, smallpox	Intestinal worms	
Lagenaria siceraria	Laxative	Kidney, flatulence, dermatological	Intestinal worms		
Luffa acutangula	Emetic	Stomach, fever		Intestinal worms	
Luffa cylindrica	Emetic, laxative	Asthma, sinusitis		Intestinal worms	Abortifacient
Momordica charantia	Laxative, emetic, emmenogogue	Colic, arthritis, hypertension, colds & fever, kidney & liver	Eczema, herpes, influenza, diabetes	Intestinal worms	Aphrodisiac
Sechium edule	Diuretic	Bladder, intestinal, hypertension, arteriosclerosis, dermatological			

[z]Modified from Chakravarty 1990; Herklots 1972; Morton 1971; Nagao et al. 1991; Ng et al. 1991; Schultes 1990.

Last update April 28, 1997 aw

Dactylis glomerata L.

Poaceae

Orchardgrass, Cocksfootgrass

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Sea grape

Seaside grape, Uva de playa

Polygonaceae *Coccoloba uvifera* L.

Source: Magness et al. 1971

The sea grape is native to sandy shores of the American tropics. The plant is a small tree, sometimes reaching to 30 feet with stiff near-round leaves up to 8 inches across. Fruits are globose to pyroform, about 0.75 inch diameter and borne in clusters. The skin is pubescent, enclosing an edible pulp and single seed. The pulp is eaten directly and makes an excellent jelly. Ripening is mainly in midsummer. The sea grape appears not to be grown commercially, but some fruit from native plants is harvested.

Last update June 28, 1996 bha

Solanum sessiliflorum Dunal.

Solanaceae

Cocona, Topiro

We have information from several sources:

Cocona—Julia Morton, Fruits of Warm Climates

The Naranjilla, the Cocona and Their Hybrid—Charles B. Heiser

"New" Solanums—Charles Heiser and Gregory Anderson

Cocos nucifera L.

Arecaceae

Coconut, Coco, Cokernut, Narel

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Coconut
Coconut oil

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links

Coconut—FAO/IPGRI Technical Guidelines for the Safe Movement of Coconut Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Xanthosoma spp.

Xanthosoma sagittifolium (L.) Schott

Araceae

Cocoyam, Abalong, Arvi, Barbados edoe, Chinese eddoe, Curcas, Dagmay, Dalo, Dasheen, Eddo, Eddoe, *Keladi*, Koko, Kolkas, Malangay, Malangu, Taioba, Tannia, Taro, *Taro de Chine, Ya, Ya bene*, Yautia, *Yu-tao*

We have information from several sources: Evaluation of Macabo Cocoyam Germplasm in Cameroon—O.U. Onokpise, J.G. Wutoh, X. Ndzana, J.T. Tambong, M.M. Meboka, A.E. Sama, A. Aguegia, S. Nzietchueng, J.G. Wilson, and M. Burns

Tropical Root and Tuber Crops—Stephen K. O'Hair

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Coffea arabica L.

Rubiaceae

Arabica coffee, Arabian coffee, Abyssinian coffee, Brazilian coffee, Colombian coffee, Expresso, Hawaiian Kona, Jamaican Blue Mountain, Java, Joe, *Kaffe, Kahve, Kahwa*, Mocha, *Robusta, Supremo* coffee, Turkish coffee

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We have information from several sources:

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links:

Coffee—Descriptors for Coffee (*Coffea* spp. and *Psilanthus* spp.)—Link to the publication on the International Plant Genetic Resources Institute web site

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Coffee

Cafe

Rubiaceae: *Coffea arabica* L.

***C. liberica* Bull ex Hiern**

Source: Magness et al. 1971

These two species constitute most of the coffee of commerce. The plants are woody, tropical, evergreen shrubs up to 15 feet in height. The leaves are elliptical, glossy, up to 6 inches long and 1/3 as wide. The fruit is a fleshy berry, in which 2 seeds are imbedded. Blossoming and fruit setting occur mainly 2 to 3 times per year. About 6 to 7 months are required to ripen the fruit, so fruits at various stages of maturity are on the plants at the same time. Ripe berries are picked at about 2-week intervals. The pulp is removed by machines. Seeds are dried in the sun or in dehydrators and roasted before being marketed. U.S. production was given as 5,000 tons, 1959 census (Hawaii only). Imports total about 1,450,000 tons annually.

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Coix lacryma-jobi L.

Poaceae
Job's-tears, Adlay, Millet

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Weed to some, necklace to others, staff-of-life to others, job's tear is a very useful and productive grass increasingly viewed as a potential energy source. Before Zea became popular in South Asia, Coix was rather widely cultivated as a cereal in India. Still taken as a minor cereal, it is pounded, threshed and winnowed, as a cereal or breadstuff. The pounded flour is sometimes mixed with water like barley for barley water. The pounded kernel is also made into a sweet dish by frying and coating with sugar. It is also husked and eaten out of hand like a peanut. Beers and wines are made from the fermented grain. Chinese use the grain, like barley, in soups and broths.

Folk Medicine

According to Hartwell (1967-1971), the fruits are used in folk remedies for abdominal tumors, esophageal, gastrointestinal, and lung cancers, various tumors, as well as excrescences, warts, and whitlows. This folk reputation is all the more interesting when reading that coixenolide has antitumor activity (List and Horhammer, 1969-1979). Job's tear is also a folk remedy for abscess, anodyne, anthrax, appendicitis, arthritis, beriberi, bronchitis, catarrh, diabetes, dysentery, dysuria, edema, fever, gotter, halitosis, headache, hydrothorax, metroxenia, phthisis, pleurisy, pneumonia, puerperium, rheumatism, small-pox, splenitis, strangury, tenesmus, and worms (Duke and Wain, 1981). Walker (1971) cites other medicinal uses.

Chemistry

Per 100 g, the seed is reported to contain 380 calories, 11.2 g H_2O, 15.4 g protein, 6.2 g fat, 65.3 g total carbohydrate, 0.8 g fiber, 1.9 g ash, 25 mg Ca, 435 mg P, 5.0 mg Fe, 0 ug beta-carotene equivalent, 0.28 mg thiamine, 0.19 mg riboflavin, 4.3 mg niacin, and 0 mg ascorbic acid. According to Hager's Handbook (List and Horhammer, 1969-1979), there is 50-60% starch 18.7% protein (with glutamic-acid, leucine, tyrosine, arginine, histidine, and lysine) and 5-10% fatty oil with glycerides of myristic- and palmitic-acids.

Description

Annual (in the temperate zone) but perennial where frost is absent or mild, freely branching upright or ascending herb 1-2 m tall, the cordate clasping leaf blades 20-50 cm long, 1-5 cm broad. Spikelets terminal, and in the upper axils, unisexual, staminate spikelets two-flowered, in twos or threes on the continuous rachis; pistillate spikelets three together, one fertile, and two sterile; glumes of the fertile spikelet several-nerved, all enclosed finally in a bony beadlike involucre, the grain, white to bluish white, or black, globular orvoid, 6-12 mm long.

Germplasm

Reported from the Indochina-Indonesia Center of Diversity, Job's Tears or cvs thereof is reported to tolerate laterite, low pH, photoperiodic latitude, poor soil, slope, virus, and waterlogging. ($2n$ = 10, 20) (Duke, 1978)

Distribution

Native perhaps to southeast Asia, but now rather pantropical as cultigen and weed. Listed as a serious weed in Polynesia, a principle weed in Italy and Korea, a common weed in Hawaii, Iran, Japan, Micronesia, and Puerto Rico, also in Australia, Borneo, Burma, Cambodia, China, Congo, Colombia, Costa Rica, Dominican Republic, Fiji, Ghana, Guatemala, Honduras, Hong Kong, India, Iraq, Melanesia, Nepal, Pakistan, Peru, Philippines, Rhodesia, Senegal, South Africa, Sudan, Thailand, United States, and Venezuela (Holm et al, 1979).

Ecology

Ranging from Cool Temperate Moist to Wet through Tropical Very Dry to Wet Forest Life Zones, Job's Tears is reported to tolerate annual precipitation of 6.1 to 42.9 dm (mean of 31 cases = 17.9) annual temperature of 9.6 to 27.8°C (mean of 31 cases = 21.5) and pH of 4.5 to 8.4 (mean of 23 cases = 6.2). (Duke, 1978, 1979)

Cultivation

Propagation by seeds, sown during monsoon (in India) at rate of 6-10 kg/ha. Seed dibbled 2.5 cm deep, at spacing of 60 x 60 cm. One intercultivation, before the plants tiller, and shade on ground may be necessary. Sufficient rains in early stage of growth and a dry period when grain is setting are necessary for good yields. Plants respond well to liberal applications of organic manure.

Harvesting

Crop harvested in 4-5 months after sowing. Plants are cut off at base and grain separated by threshing. Seeds are dried in sun prior to milling. Adlay flour milled and used with wheat flour for baking purposes.

Yields and Economics

Yields vary as to strains cultivated in different countries: yield of unhusked grains in Philippine Islands is about 3.5 T/ha; in Sri Lanka, 2.1 T/ha. In some areas 40-75 bu/acre is considered good under average conditions. Loss in hulling is about 30-40% in Philippine Islands and 70% in Sri Lanka. Adlay is extensively cultivated in Philippine Islands, Indochina, Thailand, Burma, and Sri Lanka, and is used as an auxiliary food crop, especially as a substitute for rice. It does not enter international trade, although it is used locally in large quantities.

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges around 5 MT/ha, but few data are available. Duke's field observations in Panama suggest that in Tropical Fresh Water Swamp situations, standing biomass visually suggests closer to 10 20 MT/ha. In Mali, it provides only 45-53 MT fresh fodder/ha. If perennial in the tropics, there is the good possibility that 2 MT grain and 10 MT biomass could be harvested renewably, with proper soil management.

Biotic Factors

Following fungi attack adlay: *Cladosporium herbarum, Curvularia coicis, Diplodia coicis, Epicoccum hyalopes, Fusarium equiseti, F. graminearum, F. moniliforme, F. semitectum, Helminthosporium coicis, Ophiobolus graffianus, Phyllachora coicis, Phyllosticta coixicola, Ph. coix-lacrimae, Puccinia operta, Nigrospora sphaerica, Trilletia okudaire, T. taiana, Uredo operta, Ustilago coicis, U. lachrymae-jobi.* Leaf-gall virus and the nematode *Meloidogyne incognita acrita* also attack this plant. Most losses are due to rats and parrots.

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- Duke, J.A. 1981b. The gene revolution. Paper 1. p. 89-150. In: Office of Technology Assessment, Background papers for innovative biological technologies for lesser developed countries. USGPO. Washington.
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- Walker, G. 1971. Job's tears. Lasca Leaves 21(1):14-18.

Complete list of references for Duke, Handbook of Energy Crops

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Cola

Kola

Sterculiaceae *Cola acuntinata* (Beauv.) Schott & Endl.

***C. nitida* (Vent.) Schott & Endl.**

Source: Magness et al. 1971

The cola seeds of commerce are from medium size spreading trees, up to 40 feet, native to tropical Africa, but now cultivated in the West Indies and other tropical countries. The seeds or nuts are borne in leathery or woody oblong capsules, about 6 inches long. Seeds are near globose, about an inch in diameter. They, or preparations from them, are widely used in tropical countries as a stimulant and appetizer. Preparations from the seeds are widely used for flavoring the cola drinks, very popular in the U.S. and other countries.

Last update February 18, 1999 by ch

Colocasia esculenta (L.) Schott

Araceae

Taro, callaloo, cocoyam, dasheen, eddo, eddoe, eddy root, Egyptian taro, elephant's-ear, poi, swamp taro, tara, tarro, tarrow, true taro

We have information from several sources:

Tropical Root and Tuber Crops—Stephen K. O'Hair

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Taro
Dasheen

Outside Links:

Taro—Descriptors for Taro (*Colocasia esculenta*)—Link to the publication on the International Plant Genetic Resources Institute web site

Edible Aroid—FAO/IBPGR Technical Guidelines for the Safe Movement of Edible Aroid Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Coltsfoot

Tussilago farfara L.

Figure 41.—Coltsfoot (*Tussilago farfara*)

Other common names.—Coughwort, assfoot, horsefoot, foalfoot, bull's-foot, horsehoof, colt-herb, clayweed, cleats, dove-dock, dummyweed, ginger, gingerroot, hoofs, sowfoot, British tobacco, gowan.

Habitat and range.—Coltsfoot is found along brooks and in wet places and moist clayey soil along roadsides from eastern Quebec to Pennsylvania, Ohio, and Minnesota.

Description.—The white woolly, scaly flowering stalks of this plant with their yellow blossoms appear in the spring before the leaves. There are several stalks, from 3 to 18 inches in height, arising directly from the rootstock and each one bearing at the top a single yellow flower head having in the center numerous tubular disk flowers which are surrounded by ray flowers. The flowers open only in sunny weather. The ripe seed head looks somewhat like that of a dandelion. Some time after the flowers appear the leaves are produced on long erect stalks directly from the rootstock. They are from 3 to 7 inches wide and in shape resemble a horse's hoof. The lower surface is white with densely matted woolly hairs.

Part used.—The leaves and roots, the former collected when they are nearly full size.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Symphytum spp.

Boraginaceae

Comfrey, Knit-bones

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Handbook of Energy Crops—James A. Duke. 1983. unpublished

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Comfrey: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Kaua-kaini (*Commelina benghalensis* Linn.)

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Scientific Name: *Commelina benghalensis* Linn.
Family: Commelinaceae
English Name: Day Flower, Dew Flower.
Hindi Name: Kanchara, Kaua-kaini, Kanuraka.

General Description: It grows as common weed in crop fields particularly in rice fields in India. It is popularly used as folk medicine.

Botanical differences among the major *Commelina* species.

Characters	*C. benghalensis*	*C. albescens*	*C. diffusa*	*C. forskalae*	*C. paludosa*	*C. erecta*
Plant	A large, straggling annual, rooting at basal nodes and covered on all parts with a colourless pubescens	A perennial diffuse or suberect herb from a woody, knotted rhizomotous stock	A variable, straggling annual with glabrous, arching internodes, rooting at lower nodes	A much branched, diffuse annual, rooting at lower nodes	A. scadent, perennial herb	A perennial much branched, decumbent or ascending herb

Stem	branches many, some of them growing under ground and bearing reduced leaves and spathes with apetalous closed flowers and capsules	Annual, much branched, clothed below with many, white, membranous sheaths with or without whittering leaves		Branches slender, glabrous or puberulent	Stem stout, branched from the base, rooting at basal nodes, glabrous	
Leaves	Ovate-elliptic or oblong, shortly triangular or subobtuse apex.	Linear-lanceolate, broadest a little above base, gradually tapering to an acute apex	Broadly lanceolate or ovate-lanceolate, abruptly acuminate	Narrowly oblong or scarcely elliptic, obtuse or subacute at apex	Subsessile, elliptic-lanceolate or oblong-lanceolate, some what oblique at base, glabrous	Lanceolate, entire, somewhat pubescent above, glabrous and greyish-green below, acute or acuminate
Flowers	Bluish-violet, cyme branches 1 or 2, one often suppressed, when 2, inner bearing one male flower, outer bearing 2-3 perfect flowers	Pale blue	Deep cobalt-blue		White, in simple or branched cymes.	
Fruit	Capsule broadly ovoid-oblong	Capsule 5mm long	Capsule elongate, 7 mm long	Capsule sub-cubic, buff coloured.		Capsules oblong
Seeds	Ovoid	Obliquely ovoid	Ovoid elongate			Black with membranous margin. One in each cell

Useful Parts: Whole herb.

Traditional Medicinal Uses: According to Ayurveda, it is bitter and useful in treatment of leprosy, and nervous system related disorders.

Internet Resources
Traditional Medicinal Knowledge about Common herbs used for hair care in Chhattisgarh, India.

http://botanical.com/site/column_poudhia/17_hair_care.html
Traditional knowledge about medicinal rice soils in Chhattisgarh (India).
http://botanical.com/site/column_poudhia/13_rice_soils.html

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Bhandari, M.M. (1990). Flora of the Indian Desert. Pbl. MPS Repros, Jopdhpur, India. : 320-323.
Caius, J.F. (1986). Medicinal and poisonous plants of India. Pbl. Scientific Publishers, Jodhpur, India. : 126-127.

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Sweetfern

Comptonia peregrina (L.) Coulter.

Synonyms.—*Comptonia asplenifolia* Gaertn.; *Myrica asplenifolia* L.

Figure 104.—Sweetfern (*Comptonia peregrina*)

Other common names.—Ferngale, fern bush, meadow fern, shrubby fern, Canada sweetgale, spleenwort bush, sweet bush, sweet ferry.

Habitat and range.—Sweetfern is usually found on hillsides, in dry soil, from Canada to North Carolina and west to Indiana and Saskatchewan.

Description.—Sweetfern is a shrub from 1 to 3 feet high with slender, erect, or spreading branches and reddish-brown bark. The thin, narrow leaves are from 3 to 6 inches long, from one-fourth to one-half an inch wide, deeply divided into many lobes and in general resembling the leaves of a fern. Both male and female flowers are produced. The former are borne in cylindrical catkins in clusters at the ends of the branches and the latter in egg-shaped catkins. The whole plant has a spicy, aromatic odor, which is more pronounced when the leaves are bruised.

Part used.—The entire plant, especially the leaves and tops.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Poison Hemlock

Conium maculatum L.


Figure 85.—Poison hemlock (*Conium maculatum*)

Other common names.—Spotted parsley, spotted cowbane, poison parsley, St.-Bennet's-herb, bad-man's-oatmeal, wode-whistle, cashes, bunk, heck-how, poison root, spotted hemlock, spotted conium, poison snakeweed, beaver poison.

Habitat and range.—This poisonous weed is occasional in waste places and along roadsides, principally in the Eastern States.

Description.—Poison hemlock is a very dangerous weed, the close resemblance of the leaves to those of parsley often causing it to be mistaken for the latter with fatal results, all parts of the plant being extremely poisonous. It has a smooth, hollow, purple-spotted stem about 2 to 6 feet in height with muchbranched, and large, parsleylike leaves. In June or July it produces showy, flat-topped clusters of small white flowers. The fruit, which ripens in August and September, is grayish green and about an eighth of an inch m length The entire plant has a disagreeable, mouselike odor which is especially noticeable when the plant is bruised.

Part used.—The fruit, collected when fully developed but still green, carefully dried and stored in tight containers to protect it from air and light. It is of no value after it has been kept more than two years. The leaves are also used to some extent.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

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Eucalyptus microtheca F. Muell.

Myrtaceae
Flooded box, Coolibah

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

This tall tree, featured in the song, "Waltzing Matilda", produces one of the hardest and strongest timbers in the world. The wood is, however, difficult to work because of the interlocking grain. Unsuitable for construction, it makes durable poles and fence posts. Little (1983) suggests that the wood is suitable for bearings, bushings, bolts, shafts, frames, and wheel parts for heavy vehicles. The tree is esteemed for erosion control, shade and soil conservation in hot arid climates. Aborigines obtained water from the superficial roots, by cutting forearm-sized root segments, then holding them vertically, after debarking. Sometimes they blew into the distal portion to enhance the flow. Aborigines use the branch and leaf as a fish poison (Watt and Breyer-Brandwijk, 1962).

Folk Medicine

Reported to be antiseptic and disinfectant, the inner bark is a folk remedy poulticed onto snakebite.

Chemistry

Leaves contain 0.49% essential oil with cineol, phallandrene, and pinene. The bark contains ca 6% tannin (Watt and Breyer Brandwijk, 1962).

Description

Evergreen tree 6–20 m high, usually crooked or irregular, 30–100 cm in diameter. Bark gray or brackish, thick, fibrous, rough, not shedding. Leaves alternate, narrowly lanceolate, 6–20 cm long, 1–3 cm wide, acuminate apically, basally acute, not entire, glabrous, slightly thick, leathery, dull green, slightly paler underneath. Panicles mostly near ends of twigs, short, branched with slightly angled slender stalks ending in umbels of 3–7 short stalked fragrant flowers. Flowers very small, the bud 4–6 mm long. Stamens many, spreading, white, short, 3–4 mm long, anthers rounded with small round gland. Pistil with inferior 3–4-celled ovary and stout style. Capsules short-stalked, hemiglobose or turbinate, very small, 3–4.5 mm long and wide. Seeds many, tiny, 2 mm long, blackish (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, coolibah, or cvs thereof, is reported to tolerate alkalinity, clay, drought, fungus, heat, heavy soil, high pH, insect, savanna, waterlogging, and wind (NAS, 1980a; Little, 1983). Trees will not tolerate fires, especially when young.

Distribution

Widely distributed in Australia (except Victoria and Tasmania) in open woodlands, floodplains, seasonally flooded areas, and the edges of swamps, coolibah has been successfully introduced to Egypt, Iran, Iraq, Nigeria, Pakistan, Sudan, and Tanzania.

Ecology

Estimated to range from Tropical Thorn to Tropical Very Dry (Little also suggests Tropical Moist) through Warm Temperate Thorn to Dry Forest Life Zones, coolibah is estimated to tolerate annual precipitation of 2 to 12 dm, annual temperature of 17 to 25°C, and pH of 6.0 to 8.2. Mean maximum temperatures in the hottest months are 35–38°C; mean minimum in the coolest, ca 5°C. It can withstand a few light frosts. In its native range it grows between 80–700 m elev. on clays or silty clay loams, often alkaline.

Cultivation

Easily propagated by seeds, seedlings are outplanted at ca 6 mos. when they are ca 4 dm tall. Seeds must be exposed to light during germination. Trees must be carefully weeded until they are well established.

Harvesting

The tree coppices well. In the Gezira, the seedling crop is harvested in 8 years, then harvested on a 6-year coppice rotation.

Yields and Economics

The tree may grow 3 m a year (in height). Wood yield of 5 to m^3/ha/yr are reported (Webb et al., 1980).

Energy

Making an excellent firewood, coolibah is cultivated as such in the Sudan, for example. It makes a fairly good charcoal with a relatively high ash content (2–6%).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, January 6, 1998 by aw

Copaifera langsdorfii Desf.

Caesalpiniaceae
Diesel tree

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

That the oleoresin called copaiba could be obtained by incising the trunk was first reported in England in 1625, in a work published by Purchas, "...a single tree is said to yield about 40 litres." (Grieve, 1931, reprinted 1974). Quoting nobel-laureate Calvin, Maugh says (1979), "Natives ... drill a 5 centimeter hole into the 1-meter thick trunk and put a bung into it. Every 6 months or so, they remove the bung and collect 15 to 20 liters of the hydrocarbon. Since there are few Rabbit diesels in the jungle, the natives use the hydrocarbon as an emollient and for other nonenergy-related purposes. But tests have shown, he says, that the liquid can be placed directly in the fuel tank of a diesel-powered car." (Maugh, 1976). The copal is used in lacquers, massage preparations, medicines, and paints. Wood and resin can be used for fuel. The wood is used in carpentry (Burkart, 1943).

Folk Medicine

According to Hartwell (1967-1971), balsam of one species is used in folk remedies as a fomentation, for tumors of the prostate gland. Grieve (1931) describes the balsam as stimulant, diuretic, carminative, laxative; in large doses purgative, causing nausea, vomiting, strangury, bloody urine, and fever. A good remedy for chronic catarrh and bronchitis, as it assists expectoration and is antiseptic; given with advantage in leucorrhoea, chronic cystitis, diarrhea, and hemorrhoids. It is chiefly used in gonorrhea (though not advocated for chronic cases), often combined with cubebs and sandal. It has also been recommended externally for chilblains. Both the volatile oil and resin are greatly altered when expelled in the urine, and when precipitated by nitric acid might be mistaken for albumen; it is considered a valuable hydragogue diuretic in obstinate dropsy. It creates an irritant action the whole mucous membrane, imparts a peculiar odor to the urine and breath, causes an eruption resembling measles attended with irritation and tingling; it is the resin, not the oleoresin, that is used as diuretic. Duke and Wain (1981) note that this species is a folk remedy for dermatosis, eczema, and gonorrhea. In Panama, Yaviza negros mix cabismo resin with honey and give it to the newborne, to impart knowledge and ward off hexes. The gum is also used for treating venereal diseases, for massage, and for hair oil (Duke, 1972, under "cabismo").

Chemistry

In what could as well apply to other species, Hager's Handbuch lists delta-elemene, copaene, alpha- and beta-cubebene, cyperene, alpha-bergamoten, beta- and gamma-elemene, beta-farnesene, alloaromadendrene, alpha- and beta-humulene, beta-bisabolene, alpha- and beta-selinene, delta- and gamma-cadinene, ar-curcumene, calamenene. From the wood, Langenheim (1981) reports the following diterpenoids: polyalthic acid; (-)-jkaur-16-en-19-oic acid, (-) 16 betakauren- 19-oic acid and eperu-8(20)-en-15,18-dioic acid. In 1980, Calvin published the chromatogram of products obtained from Copaiba oil.

Langenheim (1981) compares the sesquiterpenes of *Hymenaea*, shall we call it the "kerosene tree," and *Copaifera*, Calvin's "diesel tree."

Sesquiterpene Hydrocarbons	*Hymenaea*	*Copaifera*
Allo-arodendrene	--	wood
alpha-Bergamotene	--	wood
beta-Bisabolene	wood	wood
delta-Cadinene	leaf-pod-stem cortex	wood, leaf
gamma-Cadinene	leaf-stem cortex	leaf
Calamenene	--	wood
Calarene	pod	--
Caryophyllene	leaf, pod-stem cortex	wood, leaf
alpha-Copaene	leaf-stem cortex	wood, leaf

beta-Copaene	leaf-stem cortex	wood*, leaf*
alpha-Cubebene	leaf-stem cortex	wood, leaf*
beta-Cubebene	--	wood
Curcumene	--	wood
Cyclosativene	pod	--
Cyperene	leaf	wood, leaf
beta, delta, and gamma-Elemene	--	wood
beta-Farnesene	--	wood
alpha-Himachalene	pod	--
beta-Humulene	leaf-stem cortex	leaf*
alpha-Muurolene	pod	--
beta-Muurolene	--	wood
gamma-Muurolene	leaf-stem cortex	wood, leaf*
alpha-Selinene	leaf-stem cortex	wood, leaf*
beta-Selinene	leaf-stem cortex	wood, leaf*
Selina-4(14), 7(1l)-diene	pod	--
Selina-4(14), 7-diene	pod	--

*probably present Langenheim (1981)

Description

Evergreen tree to 35 m tall, to 1 m in diameter, otherwise rather resembling *Copaifera officinalis*, which see. In Argentina (Territorio de Misiones) it is 6-12 m tall, with paripinnate glabrous, subcoriaceous leaves 5-10 cm long; leaflets 2-4 pairs, opposite or semialternate petiolulate, elliptic ovoid, 2-6 cm long, 1.2-2.5 cm broad with finely pinnate reticulate nervation, glandular-punctate. Flowers in terminal racemes to compound panicles with numerous, subsessile whitish flowers. Sepals 4 lanceolate, concave, firm, glabrous outside, pubescent inside. Petals absent. Stamens free, (8-)10, the anthers elliptic, versatile. Ovary hirsute; briefly stipitate; fruit ovoid, compressed, ca 2 x 3 cm, coriaceous, with one large seed partially covered with a thick aril (Burkart, 1943). There is some question about the distinctness of the species. This species, called "Copaiba" in Brazil, is called "Cabismo" in Venezuela, a name applied in Darien Panama to what was identified by Duke (1972) as *Copaifera officinalis*, but has since been relegated to another species. Duke describes "cabismo" as one of the finest timbers in Darien. Calvin (1980) mentions another similar species, *Copaifera multijuga*.

Germplasm

Reported from the Middle and/or South America Center of Diversity, the diesel tree, or cvs thereof, is reported to tolerate some waterlogging. Seedlings germinate well in dense shade. In his lecture at Beltsville, Calvin states that he has obtained somatic fusion of *Copaifera* and *Euphorbia*. Perhaps he has changed his mind since then. ($2n = 2$)

Distribution

Because of the taxonomic obscurity of the species, I cite only northern and Amazonian South America.

Ecology

Probably ranging from Subtropical Dry to Wet through Tropical Dry to Wet Forest Life Zones, this copaiba probably tolerates annual precipitation of 10 to 40 dm, annual temperature of 20 to 27°C (with no frost), and pH of 4.5 to 7.5. Early USDA publications suggest that most copaiba comes from regions with annual precipitation of 3500 mm or more and annual temperature ca 27°C.

Harvesting

A cross section of the trunk shows that the hydrocarbons collect in thin capillaries that may extend the full 30-meter height of the tree. A holedrilled into the tree probably collects hydrocarbons from capillaries ruptured by the drilling, Calvin speculates, so that it may be possible to increase the yield by drilling additional holes. An acre of 100 mature trees might thus be able to produce 25 barrels of fuel per year. Unfortunately, in the United States the tree would probably grow only in Southern Florida. The Brazilian government has already established experimental plantations. Calvin concedes that copaifera will probably never represent a significant source of diesel fuel for the U.S. It is of interest chiefly as an example of the great diversity of materials produced by plants (Maugh, 1979). Old USDA information summaries give a slightly different harvesting story. "The wood of the tree is honeycombed with a network of connected cavities in which the oleoresin forms. To tap the tree, a drainage reservoir is hollowed out near its base by cutting inward and downward into the center of the trunk. The cavities containing the oleoresin gradually drain into these hollowed-out wells. This process is repeated several times during the season. When first obtained, copaiba is thin and clear but on aging becomes thicker and acquires a yellowish tinge."

Yields and Economics

USDA once reported per tree yields as high as 53 liters (14 gallons). A tree yields 53 liters of "diesel" and diesel sells for $1.00 per liter, it would pay the natives to gather the material. Apparently this is not happening to any great extent. Back in 1938, the U.S. imported from Brazil nearly 100 tons worth only ca $30,000 then, 106 tons worth ca $34,000 in 1939, and 102 tons worth ca $36,000 in 1940.

Energy

Although not specifically recommended as a firewood, the balsamiferouswood, with density of 700-900 kg/m^3, should burn readily, perhaps even when green. Calvin (1980) reports yields of 40 liters of hydrocarbon per tree per year, which can be "used directly by a diesel-powered car." Calvin sent a sample to Mobil Corporation to obtain a cracking pattern. "It produces the same kind of mixture in general as the oil from the *E. lathyris* [mostly aromatics (50%), LPG (25%), and low-molecular-weight fuel gas (3 to 4%) and coke]." (Calvin, 1980). In his seminar at Beltsville, Calvin (1982) seems to favor the terpenes of *Copaifera* to those of *Euphorbia* and hopes, by somatic hybridization to develop a *Euphorbia*, suitable for our climates, which will produce the sesquiterpenes. Apparently N-fixation has not been reported for this species.

Biotic Factors

No data available.

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[Complete list of references for Duke, Handbook of Energy Crops]

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last update July 8, 1996

Goldthread

Coptis trifolia (L.) Salisb.

Other common names.—Coptis, cankerroot, mouth root, yellowroot.

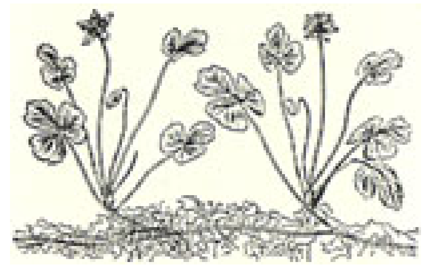

Figure 57.—Goldthread (*Coptis trifolia*)

Habitat and range.—Goldthread is found in damp, mossy woods and bogs from Canada and Alaska south to Maryland and Minnesota. It is most common in the New England States, northern New York and Michigan, and in Canada, where it frequents the dark sphagnum swamps, cold bogs, and the shade of dense forests of cedars, pines, and other evergreens.

Description.—This plant, which in its general appearance somewhat resembles the strawberry plant, is of low growth, being only 3 to 6 inches in height. Its shiny, evergreen leaves, which are divided into three parts, grow directly from the base of the plant. A single small, white, star-shaped flower, which appears from May to August, is borne at the end of each flowering stalk. The plant is appropriately named after the long, slender, creeping, much-branched and frequently matted, bright golden-yellow root.

Part used.—The root, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Erythrina berteroana Urb.

Fabaceae
Coralbean, Macrette

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Cultivated here and there as an ornamental, as a living fence post, as fuelwood species, and cork substitute (Duke, 1972). Resides living fenceposts and hedges, the trees have been grown as support in vanilla plantations. According to Little and Wadsworth, it is seldom used for anything but fuel in Puerto Rico. The wood is whitish, soft, lightweight (specific gravity 0.3) and has been used for carving toys and figurines. Cattle and rabbits graze the young shoots and leaves. In Guatemala, flower buds, young leaves, and young twigs are eaten like stringbeans though deemed potentially harmful (Little and Wadsworth, 1964). Poisonous seeds have been strung into bracelets, necklaces, and novelties. Bark yields a yellow dye. Crushed branches are used to intoxicate fish. Corollas of this and other species, placed in hollow leaf stalks, serve as a children's whistle.

Folk Medicine

Reported to be narcotic, piscicidal, poisonous, and soporific, coralbean is a folk remedy for dysmenorrhea and other female ailments (Duke and Wain, 1981). According to Morton (1981), the sedative flower decoction is used for dysentery, hemorrhages and nervousness. Guatemalans believe that tucking the flowers and leaves under ones pillow will make one sleep well. Recently we acquired large quantities for further research in the now-defunct cancer-screening program. Bayano Cuna of Panama use the plant for female ailments (Duke, 1972).

Chemistry

Per 100 g, the leaves and young buds are reported to contain 48 calories, 84.2 g H_2O, 4.4 g protein, 0.2 g fat, 10.0 g total carbohydrate, 2.4 g fiber, 1.2 g ash, 108 mg Ca, 80 mg P, 2.2 mg Fe, 220 ug beta-carotene equivalent, 0.19 mg thiamine, 0.19 mg riboflavin, 1.2 mg niacin, and 37 mg ascorbic acid. (Duke and Atchley, 1984). On a zero-moisture basis, leaves contain 304 calories, 27.8 g protein, 1.3 g fat, 63.3 g total carbohydrate, 15.2 g fiber, 7.6 g ash, 684 mg Ca, 216 mg P, 9.7 mg Fe, 12,433 ug beta-carotene equivalent, 1.3 mg thiamine, 0.92 mg riboflavin, 25.43 mg niacin, and 16 mg ascorbic acid (Duke, 1981b). Seeds contain erysodine, erysoline, erysopine, erysothiopine, erysothiovine, erysovine, alpha- and beta-erythroidine (also in the wood), and hypaphorine. Hypaphorine, the betaine of tryptophane is a curare-like convulsive poison. Chawla et al., (1982) report one new alkaloid in the seed extract, 8-oxo-alpha-erythroidine, and 8-oxo-beta-erythroidine in the leaf extract.

Description

Armed tree to 10 m tall, the leaves alternate, trifoliate, 10-35 cm long, the leaflets ovate or deltoid, 5-12.5 cm long, 4-12.5 cm wide, entire shortly acute or acuminate at the apex. Flowers pinkish to red, appearing with the leaves, in terminal racemes, each flower ca 5-10 cm long, embracing 10 stamens, the anthers protruding. Ovary stalked, pubescent. Pod dark brown, curved, moniliform, 10-30 cm long, 1-1.5 cm broad, the beak 2-4 cm long, the several seeds oblongoid, bright orange red, with a conspicuous black hilum (Morton, 1981; Little and Wadsworth, 1964).

Germplasm

Reported from the Central American (and possibly West Indian) Center of Diversity. ($2n = 42$)

Distribution

According to Krukoff (1970) *E. berteroana* is by far the most common species in Central America. It is the common lowland species ascending to nearly 1500 m in drier regions, like the Oriente of Guatemala. Morton (1981) extends the range to 2000 m and to Colombia, noting that it is wild or naturalized in Cuba and Hispaniola, cultivated and naturalized in Panama.

Ecology

Estimated to range from Tropical Dry to Wet through Subtropical Dry to Wet Forest Life Zones, this coralbean is estimated to tolerate annual precipitation of 10 to 40 dm, annual temperature of 20 to 28°C, and pH of 6 to 8.

Cultivation

According to Martin and Ruberte (1975), this is one of the easiest species of *Erythrina* to grow. Like most *Erythrinas*, this probably roots readily from large fence-post sized cuttings. Seeds germinate rather rapidly.

Harvesting

For those risking them as vegetables, the young buds and leaves are probably at their tenderest when leafing out, often in tandem with the commencement of the rainy season.

Yields and Economics

No data available.

Energy

With no hard data available to me, I have no reason to suspect that this species would be any less productive than *E. poeppigiana*, which probably returns ca 25 MT/ha/yr in monoculture, 10 MT/ha in intercropping.scenarios. Nitrogen fixing nodules are reported in Hawaii (Allen and Allen, 1981).

Biotic Factors

No data available.

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Complete list of references for Duke, Handbook of Energy Crops

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last update July 9, 1996

Corchorus olitorius L.

Tiliaceae

Nalta jute, Tussa jute

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Nerd, A., J.A. Aronson, and Y. Mizrahi. 1990. Introduction and domestication of rare and wild fruit and nut trees for desert areas. p. 355-363. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Introduction and Domestication of Rare and Wild Fruit and Nut Trees for Desert Areas*

Avinoam Nerd, James A. Aronson, and Yosef Mizrahi

INTRODUCTION

The range of crops that can be grown commercially in hot desert regions is very limited. This is specially true for orchard crops. The purpose of our research program is to develop new crops for hot desert area's through introduction and domestication. Our approach is based on perennial plants from two sources: wild plant species from arid and semiarid areas, yielding nutritious fruits or nuts eaten by the local people (Wehymeyer 1966, Felger and Moser 1976, Biesele et al. 1979, Felger 1980, Fox and Norwood-Young 1982, Taylor 1986); and rare fruits that can be obtained in local markets or from growers of rare fruits. Israel's Negev desert, with its broad spectrum of climatic conditions and types of soil and water, is an appropriate site for such a project. We have set out to exploit the Negev's variation to test the suitability of a number of plant candidates for introduction and domestication in desert areas. This is our first report on the project, and summarizes four years of work starting from 1984. We will describe our activities in general and give some details regarding six of our plant candidates.

METHODOLOGY

Suitable plant candidates, i.e., wild or semi-domesticated perennials yielding tasty, nutritious fruits or nuts as well as fruit trees not commonly cultivated in developed countries, were selected on the basis of information collected from rare fruit growers and investigators. The common and botanical names and families of the plant candidates are listed in Table 1. With the exception of *Opuntia ficus-indica* and *Ziziphus mauritiana*, which were introduced as cuttings and grafted plants, respectively, all the plant material was obtained from seeds collected in the wild or obtained from growers of rare fruits.

Seeds were germinated and plants established under quarantine conditions, then transferred to a nursery. Introduction orchards were established throughout the Negev desert (Fig. 1). Each of the introduction orchards has distinct climate and water quality characteristics (Table 2, 3, 4). To eliminate the effect of random local conditions each species was planted in three separate blocks at each site. Five to ten plants were used for each species per block.

All orchards are equipped with drip irrigation systems. Each tree is supplied with a 2-liter/hour dripper. When the canopy has developed either the dripper is replaced with one of larger capacity or additional drippers are added. Fertilization with NPK is given via the irrigation system. Sequestrene 134 is applied to correct iron deficiency symptoms. All irrigation and fertilization regimes were adapted from the recommendations of the Extension Service for mango trees grown in the Negev area (Frenkel and Zohar 1987). The following operations relevant for plant establishment are being carried out at all locations: growth measurements; phenological observations; climate, soil, water, and mineral analyses.

At the next stage, fruit and nut yields and quality will be determined, followed by clonal propagation of the selected clones and rootstocks.

This research was partially supported by the following agencies: US-AID CDR; GIARA-Germany-Israel Agriculture Research Agreement; PEF-Israel Endowment Fund; New-jersey Freedom From Hunger Campaign (Headed by Mr. Brach); and the Israeli Ministry of Agriculture.

PROMISING SPECIES

Cordeauxia edulis

Yehib is an evergreen shrub native to and zones on the borders of Somalia and Ethiopia. The plant produces pods usually containing a single seed weighing 2-3 g and rich in starch and sugars. The seed is tasty and is used by nomads as a staple food. It is also sold in local markets. The yehib has been described as a drought tolerant plant and is an endangered species (Miege and Miege 1979, National Research Council 1979).

Seeds germinated well, and seedlings grew under quarantine conditions and then in the nursery. Upon transfer to the various locations growth was inhibited, followed in many cases by death. With the exception of a few survivors at Qetura, the yehib plants did not become established in most of the orchards. Growth of the survivors occurred from May until October but was very slow both in the nursery and in the orchard (Fig. 2 and 3). Yellowing of leaves was common in many plants, generally followed by death. The survivors also showed some yellowing of leaves; this phenomenon was particularly marked in mid-summer, when temperatures can reach up to 48°C, but it was also observed in winter.

Ricinodendron rautanenii

Mongongo is a large, dioecious, deciduous tree which grows in the wild on sandy soils between latitudes 15 and 21° S in southern Africa. The fruit of the tree has a thin edible flesh and a pleasant-tasting kernel contained in a hard-walled stone. The kernel weighing about 1.2 g is rich in fats (~40%) and proteins (~38%) and plays a central role in the diet of the Kung San food gathering and hunting people of the Kalahari desert (Biesele et al. 1979, Fox and Norwood-Young 1982). The mongongo fruits abscise green when mature, and start ripening (skin color change to brown, flesh softening and taste development) a few days later.

Seeds germinated after treatment with (2-chloroethyl) phosphonic acid (ethephon) (Keegan and Van Staden 1981). Seedlings were transplanted successfully in all orchards. At Neot Hakikar after a brief growth spurt in June the plants turned yellow, showed the typical leaf bum symptoms of NaCl damage, and subsequently died. At Qetura the main growth period occurred during the spring; in mid-summer growth slowed down. At the Besor location winter dormancy broke very late (in June), and growth continued until November (Fig. 4, 5). This location is much cooler than Qetura (Table 2). In all locations some of the trees showed signs of leaf yellowing, which was diagnosed as iron deficiency and corrected by applications of iron. The healthiest looking trees are those growing at the Besor plot (Fig. 5).

Sclerocarya birrea subsp. *caffra*

Marula is a large, dioecious, deciduous tree which grows wild in northern South Africa and parts of eastern Botswana. The flesh of its fruit is very juicy and aromatic and is eaten fresh or processed, yielding quality jams, juices and alcoholic beverages. Inside the stone is a very small tasty nut. The fruit serves as an important source of vitamin C for the rural people (Shone 1979, Taylor 1986). When mature, the green fruit abscise followed by a skin color change to yellow, flesh softening and aroma development. These changes occur 7-10 days after abscission. Recently Prof. Holtzhausen (pers. commun.) of the University of Pretoria selected improved clones producing large fruits up to 100 g in weight and with a variety of skin colors.

Seeds germinated after the operculum had been opened (Teichman et al. 1985). All plants were transferred successfully to the orchards. Breaking of winter dormancy occurred at Qetura first, then at Besor and Neot Hakikar. The slowest growth rate was recorded at Neot Hakikar. While growth was steady at Besor, at Qetura, rapid growth occurred from June to August followed by slower growth in September and October (Fig. 6, 7). Neot Hakikar is characterized by high salinity due mainly to NaCl, and many plant species failed to survive there. Marula did not show any signs of salinity leaf burns. At Qetura three-year-old male and female trees started to flower and fruit developed.

Stenocereus gummosus

Pitahaya agria, a columnar cactus which grows wild in the Sonora and Baja California deserts of Mexico, produces variously colored edible fruits resembling those of prickly pear. In many cases the thorns of the fruits abscise upon ripening. The seeds are small and can be eaten without difficulty, unlike those of the prickly pear (Felger and Moser 1976).

The seeds germinated rapidly; however, first development was very slow, and it took two years for seedlings to reach a size suitable for transplanting (a height of ca. 10-15 cm). The slowest growth rate was at Neot Hakikar. Cessation of growth occurred only during the mid-winter months (December, January, and February). At Qetura three-year-old plants reached a total shoot length of 160 cm (Fig. 8, 9).

Casimiroa edulis

White sapota is a medium-sized evergreen tree from central America which can be found in backyard gardens. Growers of rare fruits in California and Florida have selected a number of high-yielding cultivars with improved fruits. The fruits are medium to large with a thin green-yellow skin and cream-white sweet flesh (Batten, 1984). Our seeds were obtained from the collection of Mr. and Mrs. Chambers of Fallbrook, California and from trees growing in Israel.

The seeds germinated easily and seedlings transplanted well at all locations. At Neot Hakikar the plants turned yellow with severe symptoms of NaCl leaf burn; they survived for a while and then died. Fig. 10 shows plant growth at Besor and Qetura. At Qetura growth started in March/April and slowed down in the hottest months, namely July and August. At this time the leaves showed some symptoms of yellowing and tip burns, which vanished in the autumn. Despite these difficulties, development at Qetura is satisfactory (Fig. 11). At Besor the fastest growth occurred in May-August, and damage to leaves was not observed.

Ziziphus mauritiana

Ber is a medium-sized evergreen thorny tree believed to be of African origin. Ber is grown commercially on a wide scale in the hotter areas of India, and is reported to be salt- and drought-tolerant (Alexander 1984). The fruits can reach the size of a plum and when ripe develop a thin, yellow-brown skin enclosing a tasty, white, sweet flesh.

Many cultivars are known in India of which two, 'Gola' and 'Seb', were introduced by us to Israel. They were grafted onto *Z. spina-cristi* (native to our region) and onto *Z. abysscinica*. Development at the various sites on each of the two rootstocks is successful; a one-year-old plant at Qetura is shown in Fig. 12.

PROBLEMS

The first problem one faces when seeds are collected from the wild is that they often fail to germinate or that the germination rate is low. In the wild it is sufficient for some seeds to germinate every few years to ensure a steady population. Indeed, one of the mechanisms by which a population maintains itself under drought conditions is by staggering germination over a long period of time (Koller 1972). This is the case for the mongongo and marula which we collected from Botswana. Some work has already been done by various authors for both species. Mongongo can germinate efficiently if the exocarp is removed and the seed treated with either ethylene or ethephon (Keegan and Van Staden 1981). Marula can be forced to germinate by opening the operculum found in the very hard and thick exocarp (Teichman et al. 1985). Using these techniques we obtained over 80% germination for mongongo and 100% for marula. All other species germinated without special difficulty. The next stage after establishment in the nursery is planting the seedlings at the various locations. Among the species studied, yehib showed a very high mortality rate. While the reason has not yet been established, we speculate that damage to the very long roots in the shallow nursery containers may have been partially responsible. We found that growth rate of the roots was 15 times faster that of the shoots. It appears that Besor is too cold for yehib, since during two consecutive years it died in the spring after a spell of low temperatures. In any case, this shrub grows very slowly. Despite these difficulties, several yehib plants at Qetura are now three years old and are continuing to grow. Vegetative propagation will be considered in the future. In addition, as soon as seeds become available from these plants we will try to sow seeds directly in the field in order to avoid damage to the root system.

There is no way of predicting the success of the various species at each locations. Both marula and mongongo were introduced from Botswana (a semiarid zone), yet there are considerable differences in performance between the two species. Mongongo failed at Neot Hakikar, probably due to NaCl salinity. Marula is growing well in all locations despite some inhibition of growth at Neot Hakikar. In the latter orchard only a few species have survived and are still growing. These include ber (which was introduced from India) and various cacti including pitahaya agria but excluding *Hylocereus* species, which suffered both from the extreme light and from the extreme salinity. Ciruelo is also growing very well at this location. The sulfate salinity at Qetura is less harmful to the new plant introductions than the NaCl salinity characteristic of Neot Hakikar. Mango *and pummelo* on a proper rootstock (13-1 and sour orange, respectively) are grown commercially at Qetura, but are unable to survive at Neot Hakikar. White sapota grows well at Besor. It seems to tolerate cold weather but not very high temperatures. Given special care and proper selection of rootstocks and cultivars, the plant might also be grown at Qetura. To draw definite conclusions about the performance of a species at a particular location it is obligatory to test in situ. Aside from simple survival, successful economic performance, which depends on yields and product quality, requires evaluation.

Selection of rootstocks and scion cultivars will have to be performed for promising species in the future. Correspondingly, proper vegetative techniques will have to be developed for each of the plant species that grows successfully. These rare and wild fruit trees deserve much more attention from the scientific community than they have so far received.

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Table 1. List of candidate species.

Botanical name	Common name	Family
Fruits		
Casimiroa edulis	White sapota	Rutaceae
Crytocarpa edulis	Ciruelo	Anacardiaceae
Diospyros digyna	Black sapota	Ebenaceae
Dovyalis caffra	Kei apple	Flacourtiaceae
Hylocereus undatus	Pitaya	Cactaceae
Inga vera	Ice cream bean	Mimosaceae
Manilkara zapota	Sapodilla	Sapotaceae
Mimusops angel	Angel	Sapotaceae
Opuntia ficus-indica	Prickly pear	Cactaceae
Pachycereus pringlei	Cardon	Cactaceae
Santalum acuminatum	Quandong	Santalaceae
Sclerocarya birrea subsp. *caffra*	Morula (Marula)	Anacardiaceae
Stenocereus gummosus	Pitahaya agria	Cactaceae
Stenocereus thurberi	Pitahaya dulce	Cactaceae
Strychnos cocculoides	Monkey orange	Loganiaceae
Vangueria infausta	Mmilo	Rubiaceae
Ziziphus mauritiana	Ber (Indian jujube)	Rha.mnaceae

Nuts		
Bombax glabra	Malabar	Bombacaceae
Cordeauxia edulis	Yehib	Caesalpiniaceae
Ricinodendron rautanenii	Mongongo (Manketti)	Euphorbiaceae

Table 2. Climatic data for the four introduction sites.

Parameter	Qetura	Neot Hakikar	Besor	Ramat Negev
Mean daily temperature (°C)				
Hottest month (August)	30-32	32-34	26-28	26-28
Coldest month (January)	14-16	14-16	12-14	8-10
Annual number of days with temperature of:				
35°C or more	125-150	126-150	0-10	11-25
10°C or less	1-25	1-25	76-100	126-150
Average pan evaporation rate (mm/day)				
Hottest month	15	14	8	10
Coldest month	4	5	3	3
Annual rainfall (mm)	<40	<40	200	90

Table 3. Water quality at the four introduction sites.

				Ramat-Negev[z]	
Parameter	Qetura	Neot Hakikar	Besor	Fresh water	Brackish water
EC (dS/m)	3.2+/-0.6[y]	3.7+/-0.2	0.9	0.9	6.1+/-0.1
pH	7.7+/-0.3	7.6+/-0.2	7.4+/-0.1	7.5+/-0.1	7.2+/-0.3
ion content (mg/1)					
Na+	259+/-90	300+/-10	95+/-7	95+/-7	1080+/-5
Ca++	262+/-9	208+/-11	51+/-1	45+/-2	227+/-9
Mg++	103+/-13	133+/-3	29+/-4	29+/-4	83+/-7
Cl-	588+/-52	885+/-22	290+/-25	240	1800+/-5
SO4- -	823+/-228	360+/-43	49+/-2	47+/-2	490+/-5

[z]At this location we are in the process of establishing plants for comparison of fresh and saline water irrigation

[y]Values in the table are means +/-SD of samples taken throughout the last year.

Table 4. Soil properties at the four introduction sites.

Parameter[z]	Qetura	Neot Hakikar	Besor	Ramat Negev

Texture	sandy loam	sandy loam	sandy loam	loam
Conductivity (dS/m at 25°C)	0.63-3.39	1.34-6.13	0.6-2.1	0.7-2.3
pH	7.4-7.7	7.3-7.7	7.7-8.3	7.9-8.5
Total $CaCO_3$ (%)	6-10	14-32	2-12	8-27

[z]Soil was analyzed to depth of 120 cm.

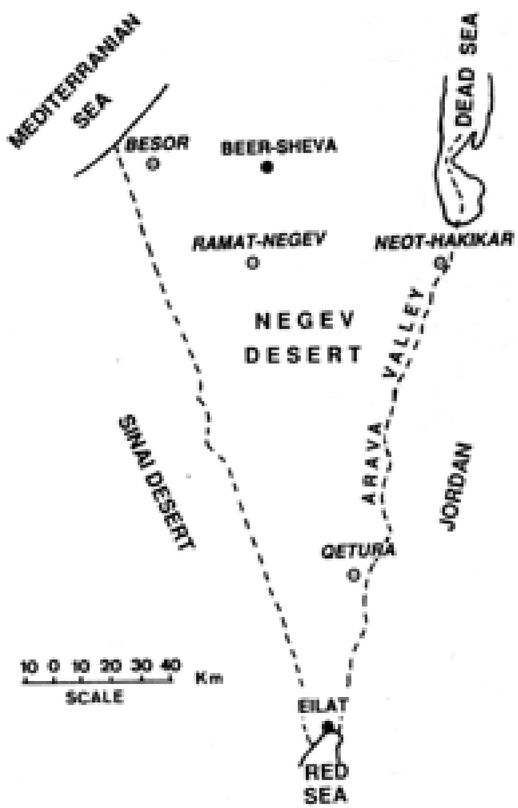

Fig. 1. Site of experimental orchards established in the Negev desert.

Fig. 2. Surviving yehib plant at Qetura (3 years old) (October 1988).

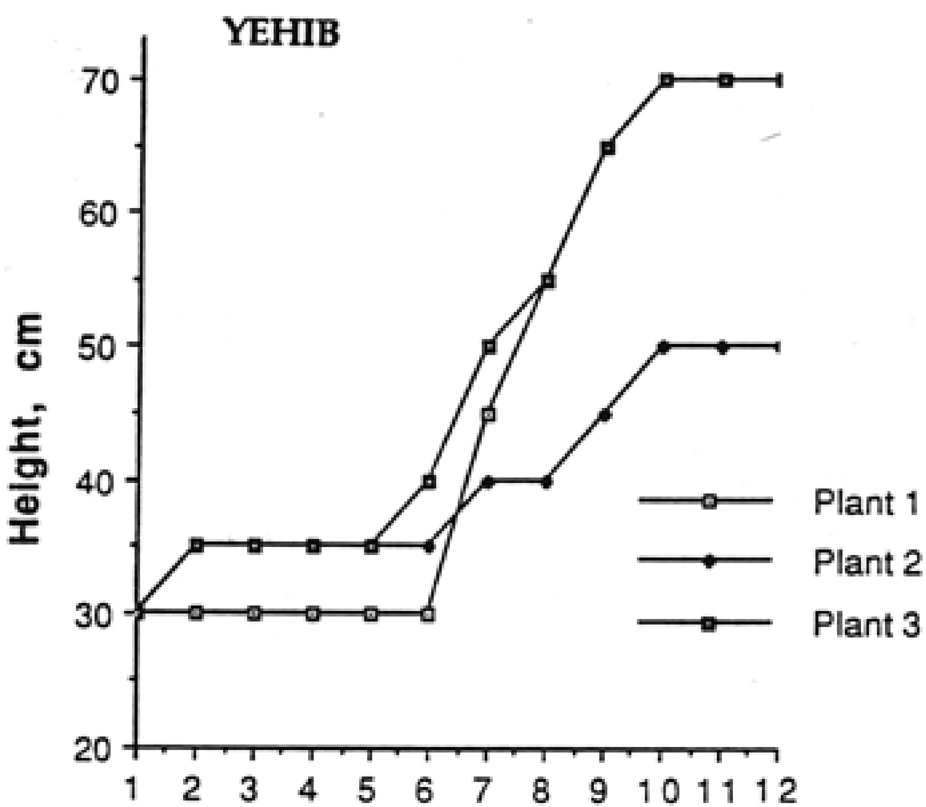

Fig. 3. Growth of individual yehib plants at Qetura during 1987. Seedlings were planted in 1985. Plants died at all other locations.

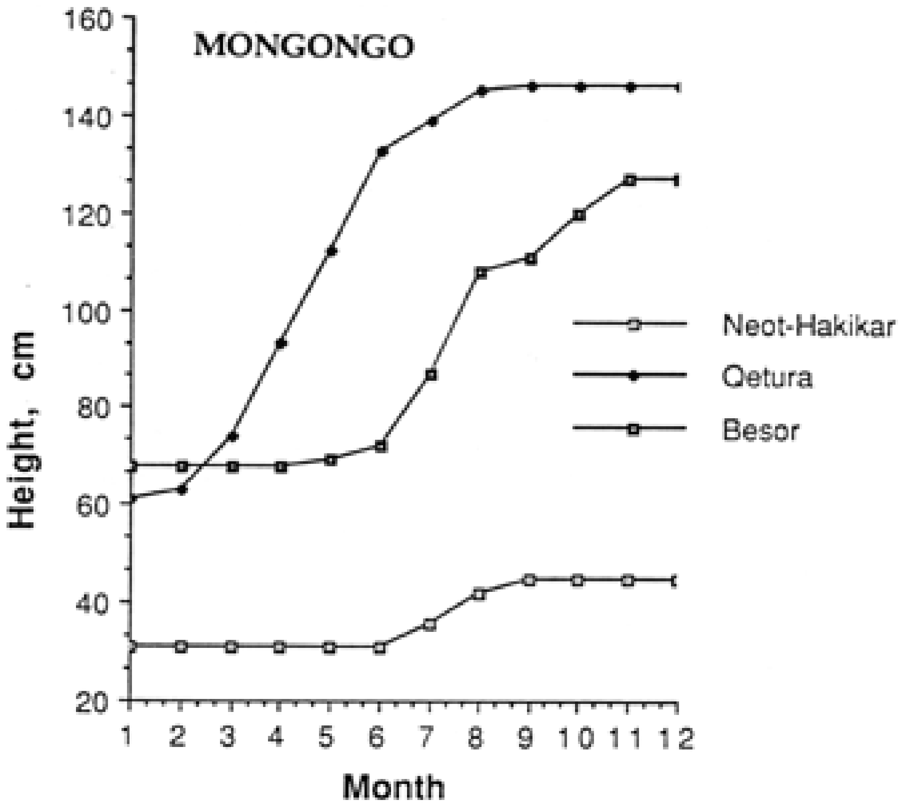

Fig. 4. Growth of mongongo plants at three locations during 1987. Seedlings were planted in 1986. After initial growth at Neot Hakikar, all plants showed leaf yellowing followed by leaf burns from NaCl salinity and died. No. of plants: 29 (Qetura), 13 (Neot-Hakikar), 27 (Besor).

Fig. 5. Well-developed 3-year-old mongongo tree at Besor (October 1988).

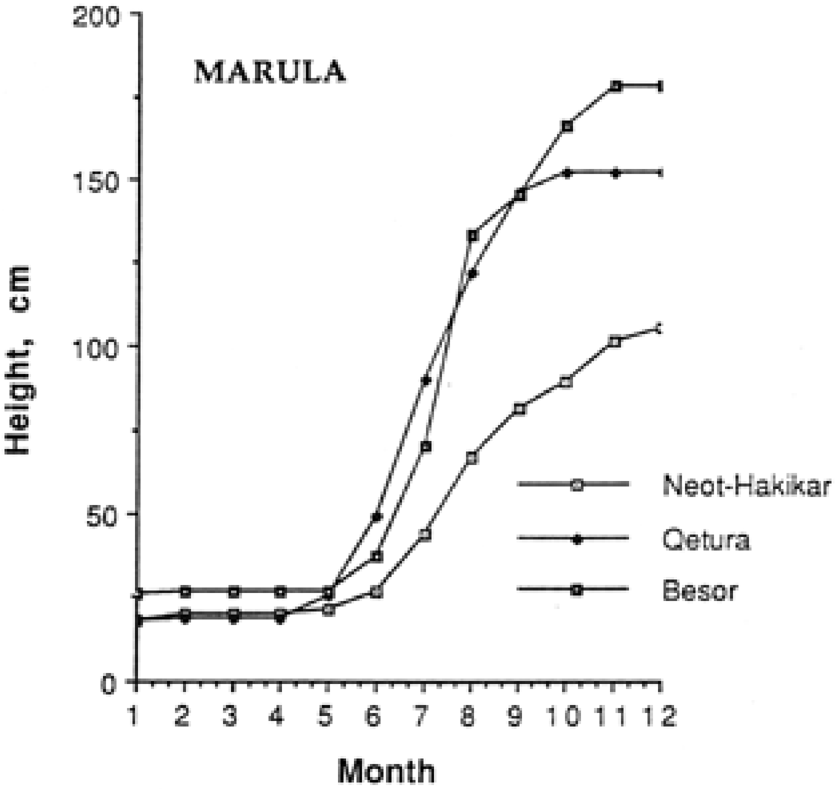

Fig. 6. Growth of marula plants at three locations during 1987. Seedlings were planted in 1986. No. of plants: 30 (Qetura), 29 (Neot Hakikar) and 30 (Besor).

Fig. 7. Fast-development 3-year-old marula tree at Qetura (October 1988).

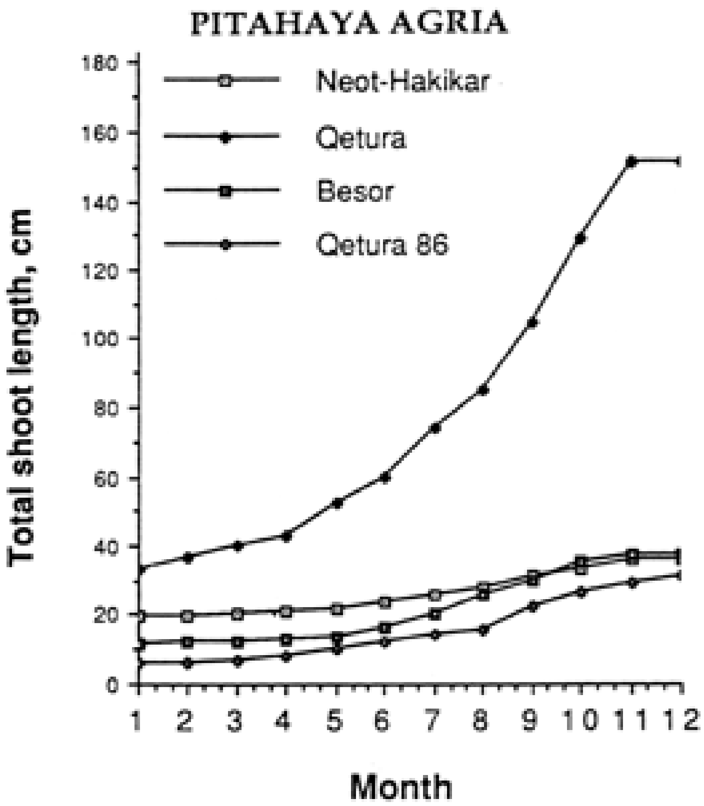

Fig. 8. Growth of pitahaya agria plants at three locations during 1987. Seedlings at Neot-Hakikar and Besor were planted in 1986. Since seedlings at Qetura were planted one year earlier, growth in 1986 is included. No. of plants: 30 (Qetura), 20 (Neot-Hakikar), 30 (Besor).

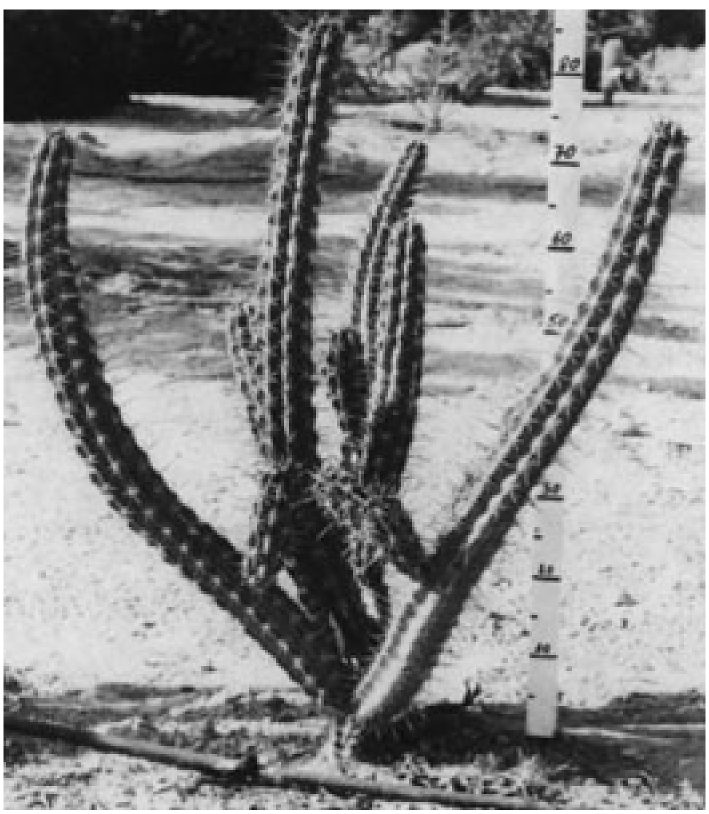

Fig. 9. Pitahaya agria cactus (3 years old) at Qetura (October 1988).

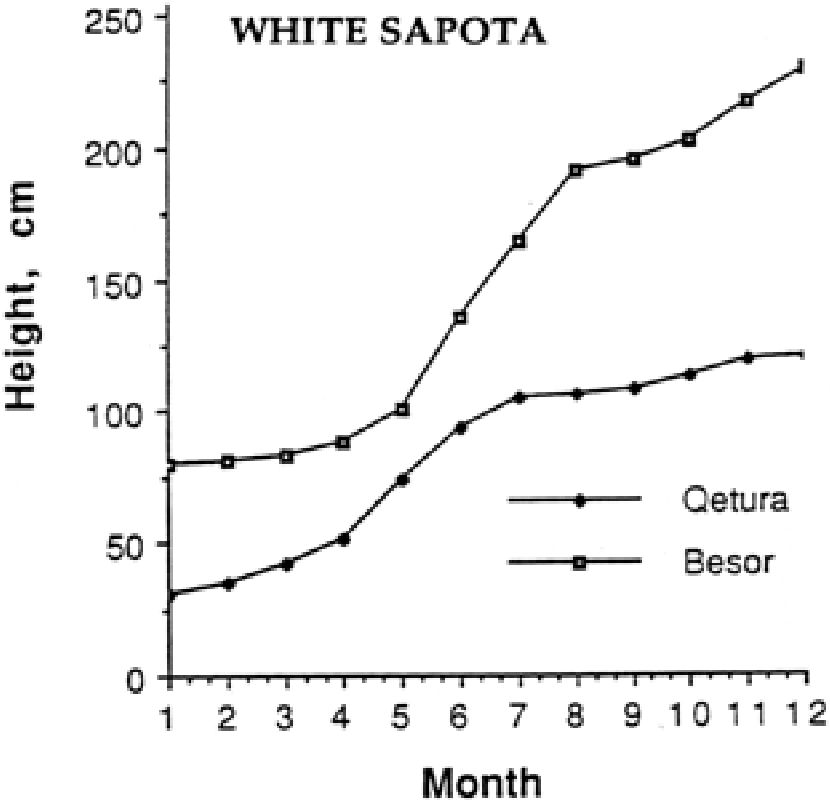

Fig. 10. Growth of white sapota plants at two locations during 1987. Seedlings were planted in 1986. No. of plants: 14 (Qetura), 30 (Besor). All the white sapota plants died at Neot Hakikar after showing symptoms of severe leaf bum from NaCl salinity. At Qetura some plants showed leaf yellowing, especially during midsummer months.

Fig. 11. White sapota (3 years old) at Qetura (October 1988).

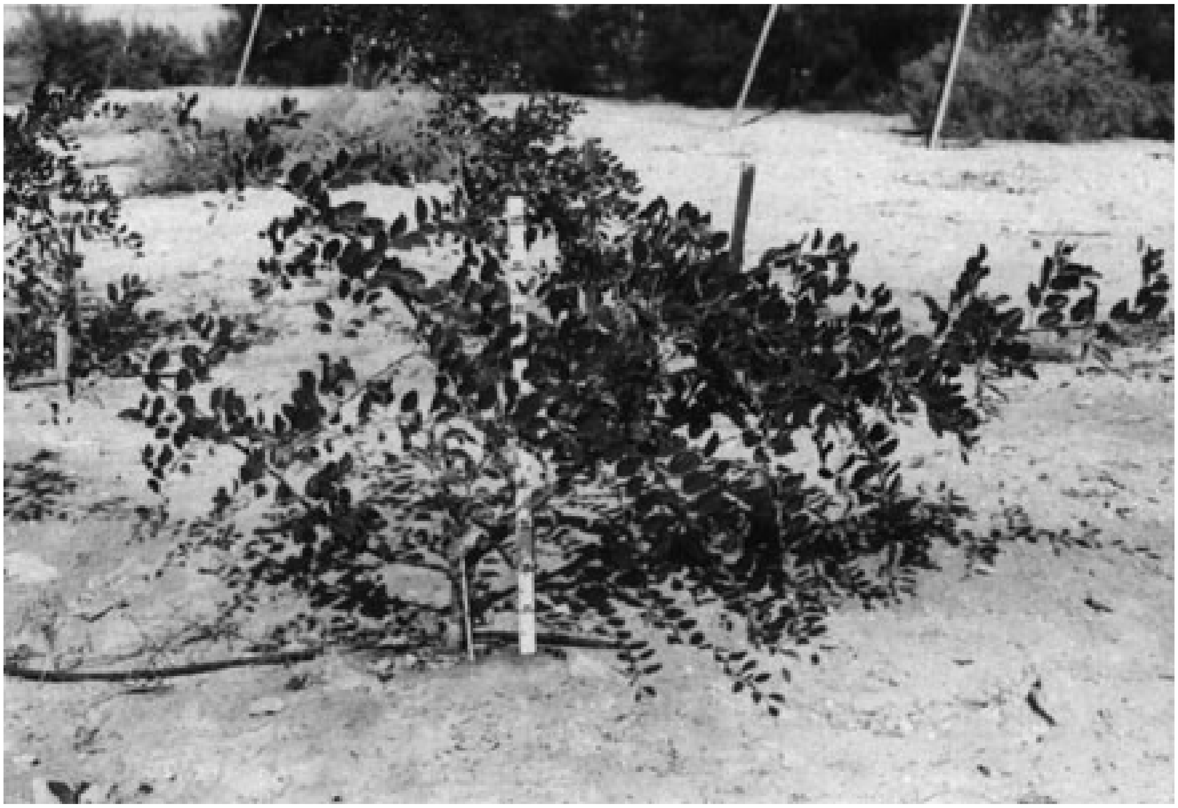

Fig. 12. One-year-old ber tree, 'Gola' cultivar, grafted on *Ziziphus spina-cristi* at Qetura (October 1988).

Last update August 28, 1997 by aw

Ti Palm

Liliaceae *Cordyline terminalis* (L.) Kunth

Source: Magness et al. 1971

The plant is low, slender and palm-like, to 6 feet, with leaves up to 30 inches long and 5 inches wide, native in the East Indies. There it is cultivated for the large, tuberous roots, up to 14 pounds, which contain much sugar. Roots are usually baked or roasted. Baked, macerated roots are also fermented in water and an intoxicating liquor is obtained by distillation. So far as known, Ti Palm is not grown in the U.S. outside of Hawaii.

Last update June 27, 1996 bha

New Crops News, Spring 1994, vol. 4 no. 1

Productive Shelterbelts

Decorative branches from woody perennial shrubs are becoming extremely popular for use by the florist industry in floral arrangements. Trends in floral design have increased the demand for branches from a number of shrubs with decorative flowers and fruits, as well as branch form and color. A study is underway under the leadership of Bruno Moser, head of Purdue's Department of Horticulture, to develop a sustainable system to produce economic shoots of a number of plant species including the *Salix caprea* (pussy willow) and *S. matsujdana tortuosa* (corkscrew willow).

Pussy willow is a large (8-12' high), multistemmed perennial woody shrub with attractive flowers in early spring. It has been used in landscapes for years, and its branches are often found in floral arrangements during the months of March through May as a signal of the spring season. Popularity of the pussy willow has outstripped supply, and the availability of high quality branches is limited.

Large scale growing of this new crop has been shown to be feasible on marginal wet areas. The crop becomes an economically viable filter strip between agronomic crops and waterways and streams running through farmland. Plants are grown 6' apart in rows with rows 10' apart to facilitate access by equipment. The filter strip approach utilizes three rows of plants occupying a 50-60' wide strip of land parallel to watercourses. The result is an environmentally sound planting on marginal land which absorbs runoff from adjacent agricultural fields and limits contamination of surface watercourses from soil and agricultural chemicals.

Branches are harvested in February when most farmers would have time to devote to this new crop. Shrubs are pruned to within 18" of the ground. The harvested branches are trimmed, graded into appropriate lengths, and tied in bundles of 50 each. Markets are primarily wholesale florists, but limited sales can be made directly to individual retail florists in a grower's area. Results indicate that each plant will produce between 60 to 80 branches per plant each year (about 50,000 shoots per acre). Research efforts are now being directed towards forcing systems for branches and other postharvest techniques to broaden the market window and provide added value in the form of longer shelf life. Decorative branches for the florist trade offer new entrepreneurial opportunities for those with marketing skills who are looking for a niche crop in which most of the work is done during the winter and early spring.

Zea mays L.

Poaceae

Bactrian typha, Barbary corn, *ble de Turquie*, Corn, Cornmeal, *Cucurutz*, Dent maize, Egyptian corn, Flint maize, Floury maize, Guinea corn, Indian corn, Indian meal, *Kana*, Maize, Mealies, *Milbo*, Popcorn, Roman corn, *Sara chulpi*, Sicilian corn, Spanish corn, Sweet corn, Syrian dourra, Turkie corne, Turkish wheat, Virginia wheat, Waxy maize, Welsch corn, Yellow maize

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We have information from several sources: Blue Corn—Duane L. Johnson and Mitra N. Jha

New Grains and Pseudograins—Duane L. Johnson

New Crops or New Uses for Old Crops: Where Should the Emphasis Be?—Shelby F. Thames and Thomas P. Schuman

International Repercussions of New Crops—Lowell S. Hardin

New Crops: Solutions for Global Problems—Noel Vietmeyer

Blue Corn and Quinoa: New Grain for the Southwest New Crops News

New Opportunities for SH-2 Sweet Corn New Crops News

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Corn Stover Potential: Recasting the Corn Sweetener Industry—David Glassner, James Hettenhaus, and Tom Schechinger

New Crops for Canadian Agriculture—Ernest Small

Midwest Vegetable Production Guide for Commercial Growers 2000

Specialty-Corn Types

Popcorn: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

- Field corn
- Sweet corn
- Corn oil

Outside links: Sweet Corn production links

Kingcorn the Corn Growers' Guidebook

Purdue (Indiana) Extension Publications

Popcorn Production and Marketing

Baby Corn production from Washington State University

Baby Corna Pacific Northwest Extension Publication

Maize—Descriptors for Maize—Link to the publication on the International Plant Genetic Resources Institute web site

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Corn Salad

Lambs lettuce, Fetticus

Valerianaceae *Valerianella olitoria* (L.) Pohl

Italian Corn Salad

***V. eriocarpa* Desv.**

Source: Magness et al. 1971

Corn salad is extensively grown in Europe as a salad vegetable, but little grown in the U.S. The plant is a biennial, forming a rosette of leaves the first year, and a seed stalk the second. Leaves are spoon shaped to round, up to 6 inches long. Exposure of leaves is comparable to that of spinach. Leaves are used both as raw salad and as pot herbs.

Italian corn salad is similar in growth and use. Leaves are slightly smaller, somewhat pubescent and toothed near the base. The plant is more southern in adaptation than corn salad.

Season, seeding to usable leaves: 2 to 3 months.

Production in U.S.: No data. Very limited.

Use: Salad, pot herb.

Part of plant consumed: Leaves.

Last update February 18, 1999 by ch

Flowering Dogwood

Cornus florida L.

Other common names.—Cornus, American dogwood, Virginia dogwood, Florida dogwood, American cornelian tree, flowering corner, Florida cornel, white cornel, Indian arrowwood, nature's-mistake.

Figure 50.—Flowering dogwood (*Cornus florida*)

Habitat and range.—Dogwood occurs in woods from southern Maine and southern Ontario to Florida, Texas, and Missouri, but grows most abundantly in the Middle Atlantic States.

Description. The dogwood sometimes grows to a height of 40 feet, but more frequently is a shrub. In the early spring the naked, leafless branches support numerous large, showy white flowers, so-called. The four showy parts of these "flowers" are petallike bracts which surround the true flowers, which are small, greenish-yellow, and inconspicuous. The leaves, which develop after the flowers have disappeared, turn a bright red in autumn, and this with the scarlet fruit makes the tree very attractive at that time of the year.

Part used.—The bark of the root, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Coronilla varia L.

Leguminosae

Crown vetch

We have information from several sources:

New Crops for Canadian Agriculture—Ernest Small

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Corylus avellana L.

Betulaceae

Filbert, Hazelnut, American hazelnut, Beaded hazel, Chinese filbert, Chinese hazel, Chinese hazelnut, Cob, Cobnut, Curri, European filbert, European hazel, Giant filbert, *Haselnuss*, Himalayan hazel, Lambert's filbert, *Noisette*, Siberian hazel, Tibetan filbert, Tibetan hazelnut, Turkish filbert, Turkish hazel

We have information from several sources:

Nuts with Commercial Potential for America's Heartland—Joseph Lukasiewicz

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Articles & Books About Hazelnuts

Corylus accessions and genetic resources at the National Germplasm Repository, Corvallis Oregon.

Hazelnut or Filbert, Corylus avellana

Beaked Hazelnut, Corylus cornuta

Keukand (*Costus speciosus* Koen ex. Retz.) Sm.

Contributor: Pankaj Oudhia

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Common (Indian) Name
Hindi: Keukand, Keu, Kust
Gujrati: Pakarmula
Canarese: Changalkashta, Chikke,Karikattu,
Marathi: Penva, Pinga, Pushkarmula
Sanskrit: Kustha, Kashmira, Kemuka, Shura, Pushkarmula
Malyalam: Narum canna, Cannakkuvva, Cannukkilannu
Tamil: Kostam
Telugu: Cengalva Kostu

Family: Zingiberaceae

Botany: An erect plant, up to 2.7 meters high; root stock tuberous; stem sub-woody at the base; Leaves 15–30 × 5.7–7.5 cm sub sessile, oblong, spirally arranged, silky-pubescent beneath; sheaths coriaceous; flowers in very dense spikes, many; bracts ovate, mucronate, bright red; corrolla tube short, lobes ovate-oblong subequal; lip white with yellow center, crisped, concave; disk with a tuft of hair at the base. Fruits capsule, globosely trigonus, red; seeds black with white aril. Flowering time in Indian condition is August to October.

Useful parts: Roots

Medicinal Properties: According to Ayurveda the rhizomes are bitter, astringent, acrid, cooling, aphrodisiac, purgative, anthelmintic, depurative, febrifuge, expectorant and tonic and useful in burning sensation, constipation, lepsory, worm infection, skin diseases, fever, asthma, bronchitis, inflammatians and anaemia.

Chemical Constituents: Tigogenin and diosgenin from rhizomes (2.6% diosgenin) and stems have been isolated. α-amyrin stearate, β-amyrin and lupeol. Palmitates from leaves have been isolated.

Cultivation: Costus is under cultivation in isolated patches in different parts of India. It is cultivated as rainy season (Kharif) crop. About 15–20 quintal rhizomes are used for sowing per hectare. Standard cultivation practices of Costus have yet not been developed.

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Fax: 91-771-536312

Cotton seed oil

Malvaceae *Gossypium* sp.

Source: Magness et al. 1971

Cotton is grown primarily for the fibers or lint, but the oil containing seeds are highly important. World production of cotton seed oil averaged 2,673,000 tons, 1964-66. The cotton plant is a stiff growing herbaceous annual outside the tropics, with fairly large, lobed leaves. The fruits are capsules which dehisce as they ripen. Each capsule contains up to 40 or 50 obovate, rounded or angular seeds, to which are attached the fibers or lint. The lint and seeds are harvested from the dehiseed bolls, partly by hand but now largely by machine in the U.S. The longer lint is removed from the seeds mechanically at cotton gins, then baled. The seeds of most varieties are still covered with short fibers or linters after the ginning. The seeds consist about half of hull and half of kernel. The kernels contain 28 to 40 percent oil. In extracting the oil the seeds are cleaned, delinted, and pressed or put through expellers either whole or after dehulling. A ton of seeds yields around 300 pounds of oil. The meal or press cake is a valuable high-protein livestock feed and the cotton fields, after the harvest, may be used for livestock pasturage. The oil is used mainly for shortenings. Smaller quantities are used for cooking and salad oils, margarines, and soap manufacture.

Last update February 18, 1999 by ch

Hymenaea courbaril L.

Caesalpiniaceae
Coubaril, Kerosene tree, West Indian locust

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Important timber tree, used for furniture, (sometimes compared with mahogany), carpentry, general construction, wheels and cogs, dugouts, shipbuilding, crossties, posts, looms, cartwheels, etc. The wood should be attractive for cabinet work, interior trim, plywood, turnery, and veneer. Indians made canoes from the smooth, hard, thick bark by stripping in one piece the bark of a large tree, sewing the ends together, waterproofing the seams with gum or resin, and inserting wooden crosspieces. The roots and trunk yield a pale yellow or reddish resinlike gum known commercially as South American copal. The gum exudes and forms hard lumps which become buried in the soil at the base of a tree. Sometimes as much as a barrel of gum has been found around the roots of a large tree or at the site of a former tree. The gum is used mainly in varnish but also for incense and local medicines (Little and Wadsworth, 1964). The copal is also used for patent leather and in stains for tin ware (Uphof, 1968).

Folk Medicine

Reported to be anodyne, antiseptic, astringent, expectorant, laxative, pectoral, purgative, sedative, stomachic, stimulant, tonic, and vermifuge, coubaril is a folk remedy for arthritis, asthma, beriberi, blenorrhagia, bronchitis, bruises, catarrh, cystitis, diarrhea, dyspepsia, emphysema, fractures., headache, laryngitis, lungs, malaria, nephritis, rheumatism, sore, spasms, stomatitis, ulcers, and venereal disease (Duke and Wain, 1981). According to Ayensu (1981), the bark infusion is used as a depurative stomachic in exanthema; smoke from rosin used for headaches and rheumatism.

Chemistry

Per 100 g, the dry fruit pulp is reported to contain 309 calories, 14.6 g H_2O, 5.9 g protein, 2.2 g fat, 75.3 g total carbohydrate, 13.4 g fiber, 2.0 g ash, 28 mg Ca, 143 mg P, 3.2 mg Fe, trace of β-carotene equivalent, 0.23 mg thiamine, 0.14 mg riboflavin, 4.1 mg niacin, and 11 mg ascorbic acid. Langenheim (1981) compares the sesquiterpenes of *Hymenaea* the tongue-in-cheek "kerosene tree" and *Copaifera*, Calvin's "diesel tree".

Sesquiterpene hydrocarbons	*Hymenaea*	*Copaifera*
Allo-arodendrene	--	wood
α-Bergamotene	--	wood
β-Bisabolene	wood	wood
Δ-Cadinene	leaf-pod-stem cortex	wood, leaf
γ-Cadinene	leaf-stem cortex	leaf
Calamenene	--	wood
Calarene	pod	--
Caryophyllene	leaf, pod-stem cortex	wood, leaf
α-Copaene	leaf-stem cortex	wood, leaf
β-Copaene	leaf-stem cortex	wood*, leaf*
α-Cubebene	leaf-stem cortex	wood, leaf*
β-Cubebene	--	wood
Curcumene	--	wood
Cyclosativene	pod	--
Cyperene	leaf	wood, leaf
β-, Δ- and γ-Elemene	--	wood
β-Farnesene	--	wood
α-Himachalene	pod	--
β-Humulene	leaf-stem cortex	leaf*

α-Muurolene	pod	--
β-Muurolene	--	wood
γ-Muurolene	leaf-stem cortex	wood, leaf*
α-Seliene	leaf-stem cortex	wood, leaf*
β-Seliene	leaf-stem cortex	wood, leaf*
Selina-4(14), 7(1l)-diene	pod	--
Selina-4(14), 7-diene	pod	--

*probably present

Wood contains the diterpene copalic acid. The wood and copal may cause dermatitis.

Description

Tree to 20 (30) m tall and 50 (200) cm DBH; outer bark brown, closely lenticellate, bitter tasting; wood reddish-brown, hard. Leaves bifoliolate; petioles 1–2 cm long; leaflets narrowly oblong to elliptic-lanceolate, asymmetri- cal, short-acuminate, unequally rounded at base, 4–10 cm long, 2–5 cm wide, coriaceous, punctate, the midrib conspicuous below. Inflorscences terminal, sub-corymbose, to ca 8 (12) cm long, the branches puberulent, jointed and articulate;flowers white or purplish, soon falling, probably opening at night; bracts caducous; pedicels thick, ca 7 mm long; calyx tube ca 8 mm long, 4-lobed, the lobes ovate to oblong, expanding to ca 15 mm long, coriaceous, densely tomentose inside, easily caducous; petals 5, white, sometimes tinged with purple, rounded, 1.5–2 cm long, ca 9 mm wide, clawed below, the claw ca 1.5 mm long; stamens 10, alternately short and long, the long ones to 2 cm long; style attached laterally at apex of ovary, directed somewhat to one side of the flower; stigma held above the lower anthers and at some distance from the divergent longer set. Legumes oblong, flattened, to 17 cm long and 6.5 cm wide, turgid, hard, reddish-brown; seeds (2) 4–6, embedded in sticky pulp (Croat, 1978).

Germplasm

Reported from the South American (Amazonian) Center of Diversity, the courbaril, or cvs thereof, is reported to tolerate shade and slope (Duke, 1978). ($2n = 24$)

Distribution

Throughout West Indies from Cuba and Jamaica to Trinidad and Tobago. Also from central Mexico to Peru, Bolivia, Brazil, and French Guiana. Rarely planted in southern Florida (Little and Wadsworth, 1964).

Ecology

Ranging from Tropical Dry to Wet through Subtropical Dry to Wet Forest Life Zones (Duke, 1978). Coubaril is estimated to tolerate annual precipitation of 6–42 dm, annual temperature of 22 to 28°C, and pH of 5.5–7.5. Rare in the young forest. Flowers during the dry season and the early rainy season (December to May) in Panama. The fruits mature chiefly during the rainy season, especially late in the rainy season (Croat, 1978).

Cultivation

Shade is required at first if the tree is to produce a straight trunk.

Harvesting

No data available.

Yields and Economics

Trees underplanted in a forest near Rio Piedras, Puerto Rico attained heights ranging up to 6.5 m in 13 years. Plantings in the open, for shade and ornamental purposes, pruduce attractive and spreading trees more rapidly.

Energy

I presume the wood can be used as firewood (density 750–1050 kg/m^3) the pods for alcohol generation, but there is some question as to whether this is an important nitrogen-fixing tree. Isolated from nodules on a large Hawaiian specimen reacted like a typical cowpea rhizobium. Large rough-surfaced nodules were observed on 10 of 15 Philippine specimens. In Trinidad, nodulated specimens were not found (Allen and Allen, 1981). I am surprised this has not yet been labelled the "kerosene tree." According to Pereira (1929), this species, closely related to the "diesel tree" *Copaifera,* contains a medicinal oil (the resin) which burns like kerosene. I doubt that it would produce significantly more or less resin than the *Copaifera,* but would not write either of them off without an examination of the facts.

Biotic Factors

Flowers are believed to be bat pollinated. Browne (1968) lists: Isoptera. *Coptotermes curvignathus.*

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Kapikachu or Cowhage (*Mucuna pruriens*)

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Mucuna pruriens Bak., Leguminosae, is one of the popular medicinals of India. and is constituent of more than 200 indigenous drug formulations It is widespread over most of the subcontinent and is found in bushes and hedges and dry-deciduous, low forests throughout the plains of India. (Sister and Kavathekar 1990; Agharkar 1991; Singh et al. 1996). All parts of *Mucuna* posses valuable medicinal properties (Pandey 1998; Pandey 1999; Caius 1989) and there is a heavy demand of *Mucuna* in Indian drug markets. After the discovery that *Mucuna* seeds contain L-dopa, an anti-parkinson's disease drug, its demand in international market has increased many fold (Farooqi 1999) and demand has motivated Indian farmers to start commercial cultivation.

Botany

Mucuna is an annual twinning plant.. Leaves are trifoliate, gray-silky beneath; petioles are long and silky, 6.3–11.3 cm. Leaflets are membranous, terminal leaflets are smaller, lateral very unequal sided. Dark purple flowers (6 to 30) occur in drooping racemes. Fruits are curved, 4–6 seeded. The longitudinally ribbed pod, is densely covered with persistent pale-brown or grey trichomes that cause irritating blisters. Seeds are black ovoid and 12 mm long (Sastry and Kavathekar 1990; Agharkar 1991; Verma et al. 1993).

Uses

Roots, according to the *Ayurveda*, are bitter, thermogenic, anthelmintic, diuretic, emollient, stimulant, aphrodisiac, purgative, febrifuge, tonic. It is considered useful to relieve constipation, nephropathy, strangury, dysmenorrhoea, amenorrhoea, elephantiasis, dropsy, neuropathy, consumption, ulcers, helminthiasis, fever, and delirum (Lindley 1985; Ramnath 1992; Warrier

1995; Shalini 1997; Upadhyay 2000).

Leaves are popular potherbs and are used as a fodder crop. Leaves are useful in ulcers, inflammation, cephalagia and general debility.

The trichomes of pods contain mucunain and serotonin and as a result pod causes itching, blisters, and dermatitis. Pods are also used as vegetable. Pod hairs (trichomes) are used as anthelmintic. Hairs mixed with honey have been used as vermifuge. As ointment prepared with hairs act as a local stimulant and mild vesicant. (Shastry and Kavathekar 1990; Chandra 1993; Shastry 1995) Beside medicinal properties, *Mucuna* fixes nitrogen and is as a green manure and covercrop.

Seeds contain L-DoPA (4-3,4-dihydroxy phenylalanine), glutathione, lecithin, gallic acid, glycosides, nicotine, prurenine, prurenidine, dark brown viscous oil. It is a source of minerals (Rastogi and Mehrotra 1991a,b; Singh et al. 1995). According to *Ayurveda*, seeds are astringent, laxative, anthelmintic, aphrodisiac, alexipharmic and tonic.

Cultivation

Mucuna is a popular kharif crop in India. Seeds are sown at rate of 50 kg/ha between 15 June to 15th July with plant spacing of 60 × 60 cm. Delayed sowing may result in infestation of aphids (*Aphis craccivora*) (Oudhia 2001a). Although, no named cultivar of *Mucuna* is available, locally available seeds possess good viability and higher germination (Oudhia 2001b). Plant support increases yield 25% and reduces pest infestation. Normally flowering begins 45–50 days after sowing. (Oudhia and Tripathi 2001). Yields of 5000 kg/ha have been recorded from well managed irrigated crop having supports. (Singh et al. 1995; Farooqi et al. 1999)

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Crabapple

Rosaceae *Pyrus* sp.

Source: Magness et al. 1971

The term crabapple is applied to native species of apple like fruits, as well as to hybrids of these with the larger fruited apples. Bailey lists 27 species of apple type fruits, 10 of which are native in some part of the U.S. Some American and Asiatic species are beautiful ornamentals, and fruit from these or native trees may be used in homes for jellies. The crabapples of commerce are probably all hybrids of native species with apples. These are fruits 1 to 2 inches in diameter, which in culture and general exposure are in all respects similar to apples, which see. In general, the trees are hardier than most apple varieties.

Season, bloom to harvest: About 4 months.

Production in the U.S.: No separate data; 1000-2000 tons.

Use: Mainly jelly or pickling.

Part consumed: Whole fruit; for jelly, whole fruit cooked - with core tissue and peel sieved out.

Last update Tuesday, January 13, 1998 by aw

Sonneratia caseolaris (L.) Engl.

Sonneratiaceae

Crabapple Mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The heavy wood (800 kg/m^3) is used for boatbuilding, construction, piles, and posts. Sour young fruits, used in or for vinegar, are widely used in Oriental chutnies and curries. Ripe fruits, said to taste like cheese, are eaten raw or cooked. A clear jelly can be prepared from the pectinaceous fruits. Pneumatophores cut up and used as corks or floats for fishing nets. The pulp is suitable for kraft paper production. Flowers, in anthesis, contain abundant honey (Backer and van Steenis, 1951).

Folk Medicine

Reported to be hemostat, crabapple mangrove is a folk remedy for sprains, swellings, and worms (Duke and Wain, 1981). Burmese use the fruits for poultices, Indochinese poultice crushed leaves with salt onto cuts and bruises. Malayans use old fruit walls for worms, half-ripe fruits for coughs, and pounded leaves for hematuria and smallpox (Perry, 1980).

Chemistry

Fruits yield 11% pectin (ZMB). Wood yields 52.7% brown pulp (8.5% lignin, 17.6% pentosan). Emodin and chrysophanic acid may be the coloring matter in the crude drug (Perry, 1980). Bark from Africa assayed at 17.1% tannin, of the pyrogallol class. Indian stem bark assayed 9–17%, twig bark 11-12%. Wood yields two coloring principles, archin ($C_{15}H_{10}O_5$) and archinin ($C_{15}H_{14}O_{12}$) (C.S.I.R., 1948–1976).

Description

Evergreen tree 5–15(–20) m high without buttresses or stilt roots, with rather open spreading crown, glabrous throughout. Pneumatophores 50–90 cm high, to 7 cm in diameter. Bark gray, coarsely flaky. Leaves opposite, without stipules, nearly sessile, elliptical, oblong or ovate, 5–13 cm long, 2–5 cm wide, with broad or tapering base and blunt or rounded tip, entire, with 8–12 widely spreading fine side veins on each side, leathery. Flowers 1–3 at end of drooping twigs malodorous, nocturnal. Hypanthium with 6–8 calyx lobes; petals 6–8, 2–3.5 cm long, 1.5–3.5 mm wide, dark or blood-red, stamens numerous, with threadlike filaments 2.5–3.5 cm long, pistil with 16–21-celled ovary with many ovules; style long, stout (Little, 1983).

Germplasm

Reported from the Australia, Indonesia-Indochina, and Hindustani Centers of Diversity, crabapple mangrove, or cvs thereof, is reported to tolerate coral, disease, insects pests, salt, and waterlogging (NAS, 1980; Little, 1983). ($2n$ = 24 in other *Sonneratia*).

Distribution

Sri Lanka to Malay Peninsula and northern Australia. Also Sumatra, Java, Borneo, Celebes, Philippines, Moluccas, Timor, New Guinea, Solomon Islands, New Hebrides. Not widely introduced (Little, 1983).

Ecology

Estimated to range from Tropical Moist to Rain through Subtropical Moist to Rain Forest Life Zones, crabapple mangrove is estimated to tolerate annual precipitation of 10 to 80 dm, annual temperature of 20 to 27°C, and pH of 6.0 to 6.5. Usually on the less salty parts of mangrove forests on a deep muddy soil, never on coral banks, often along tidal creeks with slow moving water, ascending these as far as the flood mounts (Backer and van Steenis, 1951).

Cultivation

According to the NAS (1980), planting is usually not needed because natural regeneration is so successful. In *Avicennia* and *Rhizophora*, direct seeding results in ca 90% survival.

Harvesting

Harvested as needed from wild stand. Trees recover rapidly after branches are lopped off for fuel. Since this mangrove can regrow rapidly from buds beneath the bark along the trunk and branches, it is said to suffer little from removal of much of the branchwood (NAS, 1980).

Yields and Economics

Cannell (1982) cites data on a mangrove forest dominated by *Rhizophora*, *Ceriops*, and *Sonneratia*, averaging 11 m tall, with an LAI (leaf area Index) of 3.7–4.2.The stemwood and bark on a DM basis weighed 74.4 MT/ha, the prop roots 61.2 MT/ha, the branches 15.8, the foliage 7.4, the fruits 0.3, for a total standing aerial biomass of 157 MT/ha. The CAI (current annual increment) of stem wood, bark, and branches was 20 MT/ha/yr, foliage 6.7, fruits 0.3. These data, taken from a mangrove on Phuket Island, Thailand, regenerated following clear felling, suggest annual productivity may attain 20 MT/ha/yr in Asian mangroves.

Energy

Although the calorific value of the wood is above average, it is inferior to true mangrove, and has a high ash and salt content.

Biotic Factors

Heartwood is said to be very resistant to teredos.

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Crambe abyssinica Hochst. ex R.E. Fries

Brassicaceae

Crambe

We have information from several sources:

Crambe: A New Industrial Crop in Limbo—Koert J. Lessman

Crambe: New Crop Success—Kenneth D. Carlson, John C. Gardner, Vernon L. Anderson, and James J. Hanzel

Crambe: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Isolation and Functional Properties of Proteins from *Crambe abyssinica* Oil Seeds—E. Massoura, J.M. Vereijken, P. Kolster, and J.T.P. Derksen

Climatic Evaluation for Crambe (Abstract)—Yunus Gul and S.E. Taylor

New Crops Research and Development: A Federal Perspective—L.H. Princen

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

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Crambe maritima L.

Cruciferae, Brassicaceae

Seakale

We have information from several sources:

Seakale: A New Vegetable Produced as Etiolated Sprouts—Jean-Yves Péron

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update October 13, 1997 by aw

Cranberry

Ericaceae *Vaccinium macrocarpon* Ait.

Source: Magness et al. 1971

This native American fruit grows on a prostrate evergreen "vine" though not a climber. The stems are actually rather tender to cold, but stand winter covering with water well. Thus in commercial culture where most are grown (Mass., Wisc., NJ) they are planted on peat bogs prepared so they can be covered with water in winter. The berries are borne on short uprights 6 to 8 inches in length, rising from the dense mass of stems prostrate on the soil surface. Fruit has a smooth skin, is generally round, eliptical, or bell shaped and about 0.33 inch in diameter and 0.5 to 1 inch long. Inconspicuous seeds are attached at the center of the fruit and surrounded by the tart pulp. Plantings persist for many years if properly managed. Weed control is a major problem.

Season, bloom to harvest: 100 to 130 days.

Production in U.S.: About 70,000 tons.

Use: Fresh, canned, frozen, juice, jellied.

Part of fruit consumed: Whole fruit or interior pulp and juice. Skins and seeds are screened out in juice and jelled products, after heating.

Last update February 18, 1999 by ch

Viburnum opulus L.

syn. *Viburnum trilobum* Marsh.

Caprifoliaceae

Cranberry bush

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Temperate Berry Crops—Chad Finn

Payne, J.A. and G.W. Krewer. 1990. Mayhaw: A new fruit crop for the south. p. 317-321. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Mayhaw: A New Fruit Crop for the South*

Jerry A. Payne and Gerard W. Krewer

INTRODUCTION

The mayhaw, an edible early ripening hawthorn, is a relatively unexplored and underutilized indigenous fruit tree of the lower southern states. Mayhaws (*Crataegus aestivalis* [Walter] Torrey & Gray *C. opaca* Hook. & Arn., *C. rufula* Sarg.) are members of the Rosaceae, subfamily Maloideae, tribe Crataegeae. This arborescent shrub or round-topped small tree (8-10 m) has outstanding ornamental characteristics (attractive foliage, showy blossoms, clusters of brilliantly colored fruits) and is often armed with thorns. Mayhaws are locally abundant in low, wet areas in the alluvial acid soils of rivers, streams and swamps from North Carolina to Florida and west to Arkansas and Texas, (Fig. 1) (Clewell 1985, Coker and Totten 1945, Correll and Correll 1975, Correll and Johnston 1970, Godfrey and Wooten 1981, Kurz and Godfrey 1962, Mohr 1969, Phipps 1988, Radford et al. 1974, Sargent 1965, Small 1913, West and Arnold 1952). Hawthorns are easily recognized as a group, but species are extremely difficult to distinguish due to polyploidy and apomixis (Cronquist 1981, Phipps 1983). Over 800 species have been described from North America (Bailey 1960, Render 1960) but only those early ripening edible southern U.S. *Crataegus*, series *Aestivales*, are considered mayhaws.

Mayhaw trees flower profusely and early (late February to mid-March in southern Georgia, Zone 9A) and the fruit ripens mostly in early May, hence the name mayhaw. Some clones (selections) ripen through June. The fruit is a small pome (8-19 mm diameter), yellow to bright red, fragrant, acid and juicy, resembling cranberries in appearance and crabapples in taste (Fig. 2). Until recently the fruit has only been used locally in marmalades, butters, preserves, jellies, condiments, syrups, wines, desserts and as food for wildlife (Elliot 1971, Gibbons 1974, Halls 1977, Hedrick 1919, Morton 1963, Reynolds and Ybarra 1984, Wood 1864). However, during the last 5-10 years mayhaws have begun to receive attention as a possible source of income for cottage industries. Fruit sells for $2.75-$4.40/kg ($5-$8/gallon) and jelly for $18-00/liter ($8.50/pint). Because demand exceeds supply, many farmers and entrepreneurs are showing interest in the culture and utilization of this crop.

HORTICULTURE

Propagation

Under natural conditions seed do not germinate until overwintered (Hartmann and Kester 1983). *Crataegus* species have embryo dormancy and require treatment in a moist medium at low temperature before germination will occur (Schopmeyer 1974). Seeds may be an easy way to propagate clones since nucellar seedlings, which produce fruit like the mother tree, are common in mayhaws (Wayne Sherman pers. commun.).

Mayhaw softwood stem cuttings can also be rooted under intermittent mist or in a humidity chamber during the summer. Dipping the cuttings in a root promoting hormone (8000 ppm K-IBA + 2000 ppm K-NAA) has promoted rooting success of 36.4% for 'Super Spur': and 34.4% for 'T.O. Super Berry' (G.W. Krewer, and J. Gibson, unpubl.). Propagation from hardwood and root cuttings have also been reported by nurserymen, however, no details were revealed.

Mayhaws are easily grafted during dormancy (late winter). A whip and tongue or simple whip graft can be used. Cleft grafting can be used on larger trees.

Rootstocks

Mayhaw appears to be initially compatible with any hawthorn species. In Mississippi the parsley haw (*C. marshallii* Eggl.) is considered an excellent rootstock for *C. opaca*. Good results have been reported using cockspur (*C. crusgalli* L.) and Washington hawthorn (*C. phaenopyrum* [L.f.] Med.) rootstock in Texas for *C. opaca*. Trials in Louisiana, however, have produced variable results with Washington hawthorn. In Georgia, the hoghaw (*C. flava* Aiton) which grows on our sand ridges can be used but due to its slow growth rate the mayhaw scions may overgrow the hoghaw rootstock. *C. aestivalis* can also be grafted onto commercially available Washington hawthorn seedlings, but it is not known how they will perform at maturity Mayhaw seedlings are probably the best choice as a rootstock in damp soils.

Cultivars

About a dozen mayhaw selections have been collected from the wilds (river bottoms, lime sinks, swamps, sloughs) of Georgia, Mississippi, Louisiana and Texas with attention given to size of fruit, harvest or ripening period and yield (Table 1), but information from field trials is very limited. Most ripen over a 30-day harvest period, but 'Lori' may have 80% of the fruit ripe at one time. Little comparative cultivar information is available at this time, 'Super Spur' appears to be the best from a yield and tree form standpoint. Yields of 30 kg/tree have been reported for 30-40 year old wild mayhaws in Georgia and 60 kg for a 15-year-old 'Super Spur' in Louisiana. Preliminary reports indicate that selected mayhaw clones are adaptable to USDA zones 8 and 9. Although some cultivars have a low chilling requirement and bloom early, other cultivars should be adapted to the piedmont of the southeast. *C. aestivalis* cultivars may bloom a few days later than *C. opaca* cultivars and may be better choices further north. Bloom occurs over an extended period of time and the fruit are reported to be fairly frost hardy once past the bloom period. Winter hardiness may be good. There are reports of mayhaws fruiting after -25°C (-13°F) (1981) and two year old trees survived -32°C (-25°F) (1985) without damage (Akin 1985).

Orchards

Although tolerant of wet, very acid soils, better growth has been observed when mayhaws are planted on well drained, slightly acid soils. Mayhaw trees are long-lived and may have a 9m canopy diameter after 20 years. Therefore current suggested tree spacing for a permanent orchard is 4.6-6.1 m (15-20 ft) in the row and 5.5-6.1 m (18-20 ft) between rows giving (270-400 trees/ha or 109-161 trees/A). Row spacing must be adjusted to fit the equipment if mechanical harvesting of mayhaw is desired. Mayhaws should be trained to a single trunk at the base with the first branches at 45 cm or higher so orchard equipment can be operated under the tree. Yearly pruning to open up the tree canopy for greater light penetration may be necessary with most cultivars. Central leader and modified central leader training systems like those used on apples are suggested.

Pest Problems

There is limited information on the pest management of mayhaws; however, it is known that they are susceptible to many of the insects and diseases that attack other pome fruits (Crops Res. Div. 1960, Forest Service 1985). Several insects including plum curculio, hawthorn lace bug, flower thrips, roundheaded appletree borer, whitefringed beetle, leafminers, scales and mealybugs feed on the foliage, flower, fruit and wood of mayhaw. The plum curculio in particular has caused extensive damage to fruit in some locations and will probably need to be controlled in future commercial orchards.

There are numerous diseases known to occur on various hawthorn species but little information is available on diseases of mayhaws. Quince rust, (*Gymnosporangium clavipes* Cke. & Pk.), has been quite severe on some southern Georgia native mayhaws and several *C. aestivalis and C. opaca* cultivars since 1983. Presently no rust control recommendations are available except the planting of rust-free selections. At this time only two natural pesticides, insecticidal soap and rotenone/pyrethrin, can be utilized for pest control on mayhaws destined for food use.

PROSPECTS

Although mayhaw appears to be initially compatible on most *Crataegus* rootstocks, our knowledge of mayhaw rootstocks is rudimentary at best. There is little published information available on the productivity and long term compatibility since mayhaw orchard plantings have existed for less than 5 years. Existing information on methods of propagation is also very limited. Cultivar evaluations have not been conducted in replicated orchard plantings and low-chilling requirements of many cultivars may limit their commercial adaptability to zone 9A or 9B.

While only the jelly manufacturing has been investigated by university or industry personnel, there are many other products made from mayhaws such as juices, jellies, preserves, candies, pastries and wine that could have commercial potential. Thus, the opportunity exists for a greatly expanded market based upon a consistent supply of fruit. If the industry is to seriously develop, cultivars adapted to mechanical harvesting will be needed. Unless problems associated with production are solved, supplies will be too short to allow for alternate product development.

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We gratefully acknowledge the following for input in native mayhaw distribution: Alabama—John D. Freeman; Arkansas—Edwin B. Smith; Florida—Loran C. Anderson, Robert K. Godfrey, Georgia—Nancy Coile, Laurie Consaul; Louisiana—F. Dale Thomas, Lowell E. Urbatsch; Mississippi—Sidney McDaniel; North Carolina—J.R. Massey; South Carolina—Cynthia Aulbach-Smith, Victoria Hollowell; Texas—Herbert Durand, Elray Nixon. We are especially indebted to J.B. Phipps, Ontario, Canada for sharing his unpublished distribution of mayhaw.

Table 1. Major mayhaw selections with information on fruit appearance, size and peak harvest

based on southern Georgia conditions.

	Fruit			
Cultivar	Appearance	Size (mm)	Peak harvest (May)	Comments
'Lori'[z] *Crataegus aestivalis*	Skin red; elongated; white flesh	13	1	80% ripe at one time
'Lindsey'[z] *C. aestivalis*	Skin red; elongated; white flesh	13	6	Concentrated ripening
'Big Red' ('#1 Big')[y] *C. opaca*	Skin red; round; red flesh	16-19	1	Large fruit, late blooming
'Red & Yellow'[y] *C. opaca*	Skin red & yellow; oblong or sub-globose; yellow flesh	13-16	1	Heavy bearer, precocious
'Heavy'[y] *C. opaca*	Skin red; round; white flesh	13	1	Twiggy growth habit, Heavy bearer; rust susceptible
'Mason's Super Berry' ('Texas Super Berry')[x] *C. opaca*	Skin red; round; reddish flesh	16-19	1	Attractive fruit, early blooming; fruit hangs well on tree
'T.O. Super Berry'[x] *C.opaca*	Skin red; round; reddish flesh	16-19	1	Attractive fruit
'Highway Super Berry'[x] *C. opaca*	Skin red; round; reddish flesh	16-19		Thorny tree
'Super Spur'[w] *C. opaca*	Skin red & yellow, round; yellow flesh	16-19	1	Excellent production; spur-type tree; rust susceptible; fruit drops when ripe

[z]Selections from the wild by Thomas Crocker & Tom Stone, Thomas County, GA.
[y]Selections from the wild by T.O. Warren, Hattiesburg MS.
[x]Selections from the wild by Durand, Mason, Warren, and Akin, Buna, TX.
[w]Selections from the wild by J.S. Akin, Sibley, LA.

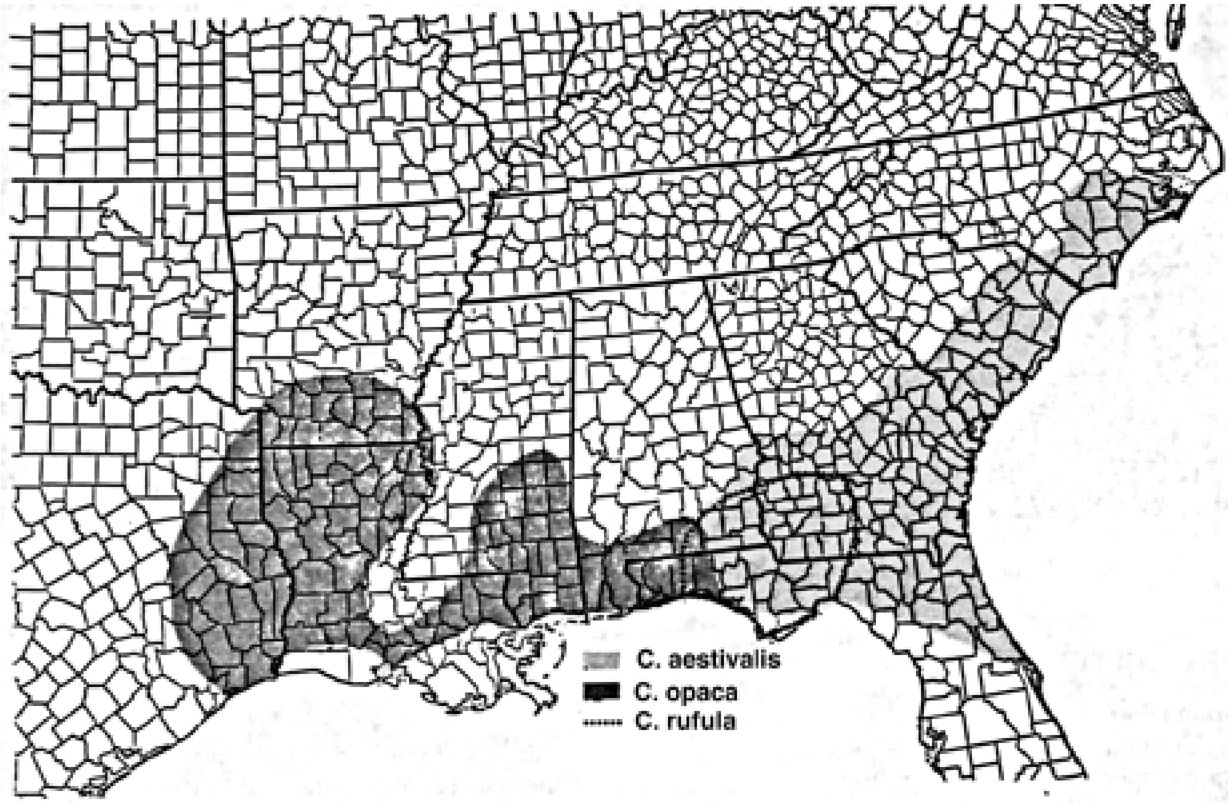

Fig. 1. Native range of mayhaw, *Crataegus aestivalis, C. opaca, C. rufula*, in North America.

Fig. 2. Fruit clusters of mayhaw, (a) 'Heavy'

(b) 'Mason's Super Berry'

(c) 'Big Red'

(d) 'Red and Yellow'.

Last update August 28, 1997 by aw

Orconectes virilis

Crayfish

We have information from several sources:

Soft-shell Crayfish: A New Crop for the Midwest—Paul B. Brown

Articles in New Crops News, the Newsletter of the New Crops Center

Soft-Shell Crayfish: A New Crop for Indiana—Paul B. Brown

Soft-Shell Crayfish Production in Indiana—Paul B. Brown

Crayfish: New Aquatic Crop for the Midwest—Paul B. Brown

Aquaculture Network Information Center (AquaNIC) AquaNIC is a gateway to the world's electronic resources for aquaculture. AquaNIC is maintained at Purdue University in the Department of Animal Sciences.

last update Tuesday, May 05, 1998 by aw

Lepidium sativum L.

Brassicaceae = Cruciferae

Garden Cress, Pepper-grass

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Nasturtium officinale L.

Brassicaceae (Cruciferae)

Watercress

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, January 6, 1998 by aw

SAFFRON

Family: Iridaceae, *Crocus sativus* L.

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Saffron, *Crocus sativus* L. is a perennial herb known ,only in cultivation. The plant has been prized since antiquity for the yellow-colored dyestuff that comes from the flower stigmas. Also known as saffron crocus, the species is principally grown in Spain, but is also cultivated in Greece, Turkey, India, France, Italy, and the People's Republic of China. The low-growing, cormous plant, whose linear upright leaves reach heights of 0.15 to 0.3 meters, has fragrant flowers.

The reported life zone of saffron is 6 to 19 degrees centigrade with an annual precipitation of 0.1 to 1.1 meter and a soil pH of 5.8 to 7.8 (4.1-31). The crop grows best in well-drained soils of medium fertility (14.1-31). Planted from early spring to autumn from corms, the plants can remain undisturbed for three to five years before they need to be divided. Blossoming lasts only a few weeks, and flowers must be collected daily as they open in order to remove the stigmas. Approximately 210,000 dried stigmas from 70,000 flowers make one pound of true saffron (11.1-128).

Saffron contains a volatile oil, picrococin, crocin, a fixed oil, and wax (1.1-275, 14.1-35). The volatile oil consists of safranal, oxysafranal, pinene, 1,8-cineole isophorone, napthalene and other compounds (1.1-275). Extracted saffron is a red-orange color, and has an aromatic odor and a bitter taste. Principal coloring pigments of saffron include crocin, crocetin, carotene, lycopene, zeaxanthin, and picrocrocin (11.1-126).

Saffron, available commercially as individual stigmas, ground, or crushed, is used in cookery as a spice, in flavoring aperitif beverages, and to color such foods as butter, cheese, rice, sauces, and soups (11.1-75). The high cost of saffron production encourages the use of turmeric and the synthetic colorant tartrazine as alternatives to saffron (11.1-75).

As a medicinal plant, saffron has traditionally been considered an anodyne, antispasmodic, aphrodisiac, diaphoretic, emmenagogue, expectorant, and sedative (11.1-101). The plant has been used as a folk remedy against scarlet fever, smallpox, colds, insomnia, asthma, tumors, and cancer (14.1-16). Saffron is reported to contain a poison of the central nervous system and kidneys that can prove fatal (11.1-136, 11.1-101).

Autumn or meadow crocus, *Colchicum autumnale* L., is a poisonous plant not related to saffron. Fake or American saffron actually refers to safflower, *Carthamus tinctorius* L., whose flower heads yield a dye used as an adulterant to true saffron.

Saffron is generally recognized as safe as a natural seasoning or flavoring and plant extract (21 CFR sections 182.10, 182.20 [1982]).

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Crotalaria

Leguminosae *Crotalaria* sp.

Striped crotalaria *C. mucronata* Desv.

Showy crotalaria *C. spectabilis* Roth

Slenderleaf crotalaria *C. intermedia* Kotschy

Lanceleaf crotalaria *C. lanceolata* E. Mey.

Source: Magness et al. 1971

All are upright growing summer annuals. Stems are coarse and well branched except in thick stands. Leaves are trifoliate, the leaflets varying in shape from linear to ovate. Crotalarias are adapted only to warm climates with a long growing season. They are resistant to the rootknot nematode and are valuable to reduce the nematode population in infested soils. They do well on soils of low fertility and are most used to turn into the soil for soil improvement. *C. spectabilis* contains an alkaloid poisonous to livestock. The other three species can be used for pasture or silage though palatability is low. According to the 1960 census, seed was harvested in 1959 from 2,657 acres in this country, and sufficient seed was produced to plant around 35,000 acres.

Last update February 18, 1999 by ch

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Crotalaria juncea L.

Fabaceae

Sunnhemp, Indian hemp, Madras hemp, Brown hemp, Sannhemp

We have information from several sources:

Crotalaria juncea: A Potential Multi-Purpose Fiber Crop—Charles G. Cook and George A. White

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

last update October 3, 1997 by aw

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Croton tiglium L.

Euphorbiaceae
Purging croton, Physic-nut, Croton-oil plant

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Studying insecticidal activity of 20 plants to adult females of *Uroleuron cathami*, Deshmukn and Borle (1975) reported the petroleum ether extracts of purging croton seeds to be most effective (0.125% as toxic as nicotine sulfate). Hager's Handbuch (List and Horhammer, 1969-1979) says it is more effective than Derris extract. Himalaya tribes use the bark in arrow poisons. Bark has been used as a tannin source. Mashiguchi et al. (1977) report on the molluscididal activity of the seed against *Oncomelania quadrasi*. It is also used to poison fish. When Croton oil was evaluated for possible effects on the P-388 lymphocytic leukemia in mice, significant inhibitory activity was noted. Fractionation of the oil led to characterization of the major component, the phorbol diester, phorbol 12-tiglate 13-decanoate which exhibits significant inhibitory activity at dosages of 60-250 ug per kg body weight against P-388. There is a paradoxical similarity in structure between the cocarcinogenic and antileukemic principles of the Euphorbiaceae and the Thymelaeaceae (Kupchan et al., 1976). Croton oil, a fixed oil expressed from seeds by methods similar to those used to obtain castor oil, is used in human and veterinary medicine as a cathartic, irritant, and rubefacient. Internally, it is a drastic, very rapid purgative or cathartic; applied externally to the skin, it is a powerful local irritant, causing pustular eruptions. When diluted, oil is used as a counter-irritant, and is usually administered with sugar and bread crumbs. In Malaysia, the oil is used more for illumination and soapmaking than for medicine. According to the Wealth of India (C.S.I.R. 1948-1976), "Croton oil appears no longer any place in medical practice." Crushed seeds and leaves, pulverized and put in sacks, are placed in ponds and rivers to stupefy fish.

Folk Medicine

According to Hartwell (1967-1971), the seed oil and bark are used in folk remedies for cancerous sores and tumors. Reported to be cathartic, diaphoretic, ecbolic, emetic, emmenagogue, purgative, rubefacient, and vesicant, purging croton is a folk remedy for apoplexy, cancer, carbuncles, colds, dysentery, fever, flux, paralysis, ranula, scabies, schistosomiasis, skin, snakebite, sore, throat, and toothache (Duke and Wain, 1981). Leaf poulticed onto snakebite in Sumatra. Seed, POISONOUS, employed as purgative in lead colic and cancer; recommended as a revulsive in colds and fever for obstinate diarrhea and dysentery, delayed menstruation, edema, ranula, apoplexy, paralysis, scabies, throat afflictions, toothache. Seed oil recently used in schistosomiasis. Bruised root applied to cancerous sores and carbuncles. Seeds contain one of the most purgative substances known; also quite vesicant; once used as emmenagogue. Homeopathically used for gastroenteritis, pustulose eczema, conjunctivitis, and mastitis. Here the reader should be warned that homeopathic practitioners use some very poisonous plants in very dilute concentrations. Like so many plants, this contains both cancer-causing and cancer correcting compounds. According to Pettit (1977), phorbol is the cocarcinogenic substance of *Croton tiglium*. For a man, about four seeds, for a horse, about 15 seeds represent a lethal dose. On the other hand, Pettit and Cragg (1978) list Phorbol 12-tiglate 13-decanoate as active at doses of 60-250 ug/kg against the PS-tumor system (Duke and Ayensu, 1984). In Malaya a single kernel is eaten as a purgative; when purging has gone far enough, coconut milk is drunk to stop it.

Chemistry

C.S.I.R. reports that the oil contains 3.4% toxic resin. Of the acids, 37.0% is oleic, 19.0% linoleic, 1.5% arachidic, 0.3% stearic, 0.9% palmitic, 7.5% myristic, 0.6% acetic, 0.8% formic, with traces of lauric, tiglic, valeric, and butyric, plus some unidentified.

Description

Small shrub or tree up to 12 m tall, evergreen; leaves alternate, membranous, ovate with broadly rounded, sometimes slightly decurrent base, acuminate, acute or blunt, very shallowly serrate, glabrous above, with few stellate hairs beneath, 7.5-17 cm long, 4-9.5 cm broad, metallic green to bronze or orange; petiole slender, about 4 cm long; stipules caducous, subulate, 1.5- 3.5 mm long; axis of inflorescence glabrous; flowers small, inconspicuous; male flowers stellately hairy with narrowly oblong petals and 15-20 stamens; female flowers apetalous; capsule scabrid with stellate hairs, triangular, 15-20 mm long, 10-15 mm broad, oblong or ellipsoid, 3-lobed; seeds 3 per fruit, oblong-ovoid, orange, about 12 mm long, smooth, about 4160/kg. Fl. summer; fr. Nov.-Dec.

Germplasm

Reported from the Hindustani Center of Diversity, purging croton or cvs thereof is reported to tolerate drought, insects, and poor soil. (Duke, 1978). In Java, two forms are distinguished: var. *tiglium*, with ovary and fruit trigonous, and petals of female flower consisting of a glabrous stalked bud, found in West Java; and var. *globosus*, with ovary subglobose, subtrigonous, with petals linear and hairy at apex, found in East Java. (2*n* = 10)

Distribution

Native to tropical Asia from India to New Guinea and Java, north into Indonesia and China. Wild throughout the Philippine Islands, where it is also cultivated to a limited extent; often becoming naturalized after cultivation. Grown in southern California and elsewhere as an ornamental and curious plant.

Ecology

Ranging from Subtropical Moist to Tropical Very Dry throught Wet Forest Life Zones, purging croton is reported to tolerate annual precipitation of 7.0 to 42.9 dm (mean of 8 cases = 20.6), annual temperature of 21.0 to 27.5°C (mean of 8 cases = 25.3), and pH of 4 5 to 7.5 (mean of 6 cases = 6.1). (Duke, 1978, 1979) A dry land plant, adaptable to most tropical climates, up to 1,500 m elevations, not particular as to soil type or texture. Often grown in mixed forests, and commonly planted in and about towns.

Cultivation

Propagated from seed, the seed sown directly in the forest, or in seedbeds and the young plants planted in desired places. It may be cultivated as a pure crop or as an intercrop with cacao or coffee, providing some shade (Reed, 1976).

Harvesting

Plants begin bearing seed in 3 years after planting, and are full-bearing in 6 years. Seeds ripen in November and December, and should be collected before capsules open.

Yields and Economics

Yields in the third year may be 200-750 kg seed/ha, but at full bearing 750-2,000 kg/ha, assuming the cwt/ha in our reference is a metric quintal rather than 100 pounds. Otherwise, the yield reported by Duke (1978) may be the high report at 900 kg seed/ha. Croton oil is produced in India and Europe, with most of the commercial supply of seed being obtained from Sri Lanka and India. Market value of seeds fluctuates considerably depending on demand. United States imports ca 1.5

MT/a oil from Germany and United Kingdom. Export of seeds from Sri Lanka in 1933 was 73,150 cwt.

Energy

If seed yields of 900 kg/ha are all that can be expected, this does not seem a promising energy species, especially if it can only be used outdoors. According to Burkill, "the fumes of burning oil indoors are intolerable."

Biotic Factors

Plants are attacked by the following fungi: *Cercospora tiglii*, *Fomes lignosus, Macrophomina phaseoli*, *Placosphaeria tiglii*, and *Polyporus hirsutus*. They are also attacked by root knot nematodes: *Meloidogyne acronea, M. arenaria thamesi, M. hapla, M. incognita acrita,* and *M. javanica.* Trees sometimes attacked by caterpillar, *Amyna punctum.*

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Complete list of references for Duke, Handbook of Energy Crops

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Yamaguchi, M. 1990. Asian vegetables. p. 387-390. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Asian Vegetables

Mas Yamaguchi

INTRODUCTION

Recent Asian immigrants have brought about dramatic changes in the kinds of vegetables consumed in the United States, especially in localities where these peoples are concentrated. Thirty-seven years ago, Porterfield (1951) described vegetables in New York City's Chinatown and 15 years ago Yamaguchi (1973) reported on the production of oriental vegetables in the United States. At present, these vegetables as well as new ones, especially those originating from Southeast Asia, are finding a home as new crops in the United States. In this paper, I will present some of the more interesting of these "new crops" and some which I think have potentials as new exotic vegetables in western culinary recipes. Nutritional values of some of the vegetables are presented in Table 1.

ASIAN VEGETABLES

Note on US import restrictions

Zizania latifolia Turcz. (*Z. aquatica* L.). [Common names: water bamboo, Manchurian wild rice; coba, kuw-sun, kwo-bai, jiao-bai (China, Taiwan); makomo dake (Japan)]. Water bamboo belongs to the Poaceae (-Gramineae), the same family as the common bamboo (*Phyllostachys* spp.) and is closely related to wild rice (*Zizania aquatica* L.) of North America. Grown since ancient times, this aquatic plant is cultivated in all parts of Asia from Manchuria in the north through eastern China to Indo-China on the south and east to Japan and Taiwan. A perennial water bamboo can be grown in stagnant ponds and in poorly drained soils. Plants grow from 1.2 to 2.4 m in height and the fully elongated leaves measure from 30 to 60 cm in length. Enlarged stems are harvested, the upper leaves cut off and only the stem with husk-like wrapper leaves sent to market. The edible portion is the succulent stem after the husks are removed.

There are three types of water bamboo in China:
Green stem-a small plant with fine leaves, early maturing.
White stem-large plant, mid to late season.
Pink or red stem-large plant, mid to late season.

Water bamboo is propagated by tillers. The most vigorous plants with short stout stems, large abundant leaves and no signs of floral initiation are selected for propagation. Tillers are planted in a nursery and allowed to grow for a year before transplanting to the field. Also, clumps of 4 to 5 tillers may be transplanted directly into the field. Tops are trimmed to about 40 cm height before planting.

Preparation of the field is sin-similar to that for paddy rice. Clay type soil, high in organic matter and pH range of 5.5 to 6.0 is preferred. Transplants are put into the mud about 6 cm deep at 30 to 40 cm spacing and in rows 90 to 100 cm apart. After planting the water is raised to a depth of 10 to 15 cm. Fifteen cm water depth is optimum, but in hot weather, the level is raised to 20 cm.

Field plantings in the sub-tropics are made in January through March and in the temperate regions, in March through April. If plantings are made late, the growing season is shortened so yields are reduced. High light intensity is desirable and mean temperatures of 25°C is optimal. At 20°C, the plant grows poorly and the harvested stems are not tender. The crop is fertilized with nitrogen four times during the season, twice with phosphorus and once early with potassium containing fertilizer.

Stem enlargement occurs after about 4 months growth. Harvest is made in about 150 days from planting with the green type and about 170 days with the white and pink types. Stem enlargement is due to the fungus, *Ustilago esculenta* P. Henn. Evidently, the fungus prevents floral initiation but allows the stem to elongate and enlarge. Harvest must be made before the fungus goes into the reproductive phase when the black smut (spores) is produced. With time there appears black longitudinal streaks in the swollen stem and eventually the entire stem turns black, very much like the corn ear smut. Because water bamboo is a perennial and asexually propagated, the fungal organism is apparently transferred from mother plant to the daughter tillers.

In Taiwan, the harvested swollen stems with leaves trimmed off are placed in large vats filled with water. This is done to keep the temperature down and keep the stalks moist in order to retard the formation of black streaks. Lack of nutrients in the plant or low water level in the field causes the fungus to go into the reproductive phase much earlier reducing quality and yield. In Beijing in Northern China, transplants are brought from the southern province near Guangzhou (Canton) every 2 or 3 years because production declines. Plants can survive the freezing temperatures of December and January in Beijing.

Water bamboo is a very popular vegetable in China. The swollen stem is sliced and eaten raw or cooked. Although water bamboo has a much softer texture than regular bamboo, the tissues remain crisp when stir-fried.

If water bamboo is brought into the United States, would the fungus which is necessary to cause the stem to swell, infect the wild rice and reduce production? Tests need to be made to determine whether infection can take place. I think that water bamboo would do well in the swampy regions of the Southern United States and in areas where paddy rice is produced.

Nelumbo nucifera Gaertn. (*Nelumbium nelumbo* Druce). [Common names: Lotus root (rhizome), East Indian lotus, Egyptian lotus; lian, lin ngau (China, Taiwan); hasu (Japan for the plant), renkon (Japan for the edible storage rhizome)]. A perennial aquatic plant of East Indian origin and belonging to the Nymphaceae, the lotus was brought to China and Egypt thousands of years ago. From China it was taken to other parts of Asia including Japan and northern Australia.

The plant, long known for its beautiful flowers, is mainly grown for the edible storage rhizomes (60 to 120 cm long and 6 to 9 cm in diameter). The storage rhizomes appear segmented because the diameter at the node is from 1/3 to 1/2 the diameter of the internode. The proximal segment (internode) is long and somewhat tapered, the diameter at the distal end being larger than the proximal end. Lengths of the segments decrease with increasing distance from the origin. The number of segments vary from 2 to 6.

Longitudinal circular passages are present in each segment. There is one central passage surrounded by 7 larger diameter and 2 medium diameter passages at about middistance from the center to the epidermis. Alternately to 7 large passages are small diameter passages near the outer perimeter of the rhizome. These passages probably function as ducts for gaseous exchange to the atmosphere.

Although seeds are very long lived, (there are reports of germination after 500 years in the soil) propagation is usually from recently harvested or stored rhizomes. Rhizomes are planted in paddies similar to that for rice. In Taiwan, rhizomes with at least 3 segments are planted 9 cm deep into the mud at an angle of about 20° to 30°C with the proximal end above water level. At planting time water level is kept at 6 cm depth. With growth the water level is gradually raised to about 30 cm and is maintained at this level. With the first two leaves that emerge, the blades float on the surface of the water. Petioles of subsequent leaves subtend above the surface and the blades unfurl in the air. The leaves are peltate and the blades are 30 to 90 cm in diameter on long slender tubular petioles.

The first growth is vegetative. The stem diameter is small and the internodes long so that the rhizomes do not appear segmented. From each vegetative node a leaf is produced, each petiole taller than the previous one. However, the last leaf that emerges before the onset of storage rhizome formation, is shorter than the previous one. The rhizomes grow in about 30 cm deep in the mud. Flower stalks emerge in July from the vegetative nodes.

The segmented storage rhizomes begin to form about the beginning of August. Large healthy leaves produce many segments; small or diseased leaves produce few segments. No leaves are produced from these. By late September the storage rhizomes are fully developed.

Storage rhizomes can be harvested after 120 days in warm climates and after 150 to 180 days or after the leaves die in cold weather in cool climates. At harvest, the water is drained and the fragile rhizomes are dug carefully. In some farms in Japan, high pressure water stream is used to wash away the mud and expose the storage rhizomes. Yields vary from 3.5 to 4.5 metric tons per ha. Higher yields can be obtained if flowers are removed.

Lotus rhizome retain their crisp texture even when cooked. Thread-like mucilaginous strands exude from cut or broken surfaces when the pieces are pulled apart. Starch obtained from the storage rhizome has properties similar to that from arrowroot. Immature leaves including the petioles are used as greens. Mature seeds and carpets are eaten, both are reported by the Chinese to have medicinal qualities.

Lotus has been grown in the Imperial Valley of California and I believe it can be successfully grown in the southeastern United States.

Note on US import restrictions

Ipomoea aquatic Forsk (*I. reptans* Poir.). [Common names: Water convulvulus, water spinach, swamp cabbage; ung tsoi, weng kai (China, Taiwan); kang kong (S.E. Asia); asagao na, yu sai (Japan)]. Water convulvulus belongs to the Convulvulaceae (morning glory family) and the same genus as the sweet potato (*Ipomoea batatas* L.) Probably of Chinese origin, cultivation dates back to at least 300 AD It is a very important green vegetable in Southeast Asia, because it is easy to grow, high yielding, and very nutritious.

The plant is herbaceous, an aquatic or semi-aquatic annual with hollow stems and ovate to elliptic shaped leaves. It has a creeping growth habit but may grow erect in water.

There are two main cultivars, the white flowered green stemmed type used in dry land (moist soil) culture and the pink colored purple centered flowers with white stems which are planted in flooded lands.

The green stem type is usually propagated by sowing seeds directly in the bed. Plants are spaced 12 cm apart and fertilized heavily with organic materials. When rainfall is not adequate, the crop is irrigated. Harvest of the entire plant can be made 50 to 60 days after planting.

Propagation is by stem cuttings for the white stem cultivar. Cuttings about 30 cm long with 7 to 8 nodes are obtained from the existing crop or from a nursery. The field is prepared as for paddy rice. Cuttings are planted 3 to 5 cm deep into the mud at about 40 cm spacing. Water is allowed to flow into the field as the crop grows, the depth is gradually increased to 15 to 20 cm. High rates of fertilizer are applied throughout growth; the water drained before application and flooded again a day afterwards. First harvest can be made a month after planting. Shoots are cut at about water level and bunched. After the first cutting, harvests can be made every 7 to 10 days. Annual yield of 90 metric tons per ha can be made from wet culture plantings.

Vigna sesquipedalis (L.) Fruw. (*V. unguiculata* (L.) Walp. sub spec. *sesquipedalis* (L) Verd.). [Common names: Yard long bean, asparagus bean; chang jiang dou, cheung kung tau (China, Taiwan); sitao (Philippines); zuyu roku sasage (Japan)]. Possibly of tropical African origin, the yard long bean (Fabaceae-Leguminosae), is a close relative of the cowpea. The crop is an annual trailing vine usually grown on poles or interplanted with corn for support of vines. Long slender immature pods which grow from 30 to 90 cm in length and about 0.9 to 1.0 cm in thickness are harvested.

There are two cultivars, a long white podded type which is harvested in the spring and the green podded type which is harvested from spring through fall in Southeast Asia. The crop is tolerant to high temperature and acid soils common in the tropics. It is intolerant to cold temperatures and under low soil moisture the pods are short and fibrous. Yard long beans can best be tried in regions where high temperatures prevent flower set of the common snap bean.

Cryptotaenia japonica Hassk. (*C. canadensis* D.C. var. *japonica* Makino). [Common names:

Mitsuba, Japanese honeworts.] Probably of Japanese origin, n-mitsuba, meaning 3 leaflets is cultivated in Japan, Korea, and China. It is a member of the carrot family (Apiaceae-Umbelliferae). Like celery but a much smaller plant, it is grown for its long slender petioles and leaflets. The petioles are 10 to 15 cm long and 2 to 4 mm in thickness. When blanched or grown under crowded conditions, the petioles elongate to 30 cm or more in length.

In Japan, mitsuba is grown all year round in plastic houses, with the main production from fall through winter. Some growers culture the crop on polyfoam blocks which are floated on nutrient solution. Mitsuba is grown commercially near Los Angeles, California, in plastic houses for the oriental people in that area.

Mitsuba has a very distinct flavor; it is eaten raw in salads or as garnish and is used as flavoring in soups or cooked as greens.

Raphanus sativas L., cultivar 'Sing li mei'. [Common name: red fleshed radish]. In 1979, while visiting an agricultural experiment station in Japan, I saw some red flesh winter radish grown from seed brought from mainland China. While in China this summer, I saw this radish again. It was developed by a breeder at the Beijing Vegetable Research Center. The cultivar is named 'Sing li mei', meaning "the heart is beautiful" in Chinese. The roots I saw were grown the previous fall and put into storage and kept until mid June. The pigment is probably an anthocyanin.

The radishes are eaten raw as a snack food; they are crisp and sweeten somewhat during storage. This radish cultivar should prove popular in the western world in adding color to salads and for vegetable hors d'oeuvres.

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Table 1. Nutritive composition per 100 g edible portion of some Asian vegetables.

Constituent	Water bamboo[z] (*Zizania latifolia*)	Water convulvulus[y] (*Ipomoea aquatica*)	Lotus rhizome[y] (*Nelumbo nucifera*)	Yardlong beans[y] (*Vigna sesqui pedalis*)	Radish[y] (*Raphanus sativus*)
Water (%)	92.6	92	75	89	94
Energy (Cal)	26	25	69	30	13
Protein (g)	1.2	2.6	2.6	2.8	0.6
Fat (g)	0.2	0.2	0.1	0.4	0.1
Carbohydrate (g)	5.5	3.4	14.7	3.8	2.7
Fiber (g)	1.0	-	-	-	-
Ash (g)	0.5	-	-	-	-
Minerals					
Ca (mg)	5	95	45	50	27
P (mg)	36	40	100	59	24
Fe (mg)	0.6	2.2	1.6	1.0	0.4
Na (mg)	-	6	40	4	30
K (mg)	-	370	730	210	190
Mg (mg)	-	49	25	51	22
Vitamins					
A (I.U.)	0	3500	0	1400	0
Bl (mg)	0.09	0.03	0.16	0.13	0.02
B2 (mg)	0.04	0.10	0.22	0.11	0.02
Niacin (mg)	0.2	0.9	0.4	1.0	0.2
C (mg)	2	55	44	32	22

[z]Leung, W.W. et al. (1952).

[y]Howard, F.D. et al. (1962).

The fungus *Ustilago esculenta*, which causes stem enlargement of Manchurian wild rice, *Zizania latifolia* is a regulated organism. Bringing infected *Z. latifolia* into the United States is a violation of the Federal Plant Pest Act regulations. The fungus poses a threat to native species of wild rice. One illegal planting of Manchurian wild rice was eradicated in California in 1991. Infected wild rice has been detected in Louisiana and authorities are developing recommendations to address the issue.

Ipomoea aquatica is a federal noxious weed. Under authority of the Federal Noxious Weed Act, the Animal and Plant Health Inspection Service prohibits the importation and interstate movement of this species, except under USDA-issued noxious weed permit. Although *I. aquatica* is prized as a vegetable, it is also an agricultural and environmental pest, reducing yields of rice and sugarcane in other parts of the world, and affecting aquatic ecosystems, irrigation systems, reservoirs, and navigation and recreation on fresh waterways.

APHIS (Animal and Plant Health Inspection Service) encourages importers to be aware of import restrictions meant to protect American agriculture and natural areas. Please refer to the APHIS web site for more information: http://www.aphis.usda.gov/ppq/permits/

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Cucumis sativus L.

Cucurbitaceae

Cucumber, American gherkin, Cassabanana, Cuke, Gherkin, Hothouse cucumber, Lemon cucumber, Mandera cucumber, Pickling cucumber, Serpent cucumber, Slicing cucumber, Snake cucumber, West Indian gherkin

We have cucumber information from several sources:

Melofon: A New Crop for Concentrated Yield of Pickles—Haim Nerson, Harry S. Paris, and Menahem Edelstein

Cucumber In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Midwest Vegetable Production Guide for Commercial Growers 2000

Cucumber production links.

Growing Cucumbers, Melons, Squash, Pumpkins, and Gourds—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Cucumber, Armenian

Japanese cucumber, Snake melon, Snake cucumber, Uri

Cucurbitaceae *Cucumis melo* L. (Flexuosus group)

Source: Magness et al. 1971

The plant on which this melon or cucumber is grown is closely related and similar to muskmelon. Fruits are very long and slender, up to 36 inches long and 3 inches in diameter. They are grown mainly as curiosities, but are used to some extent for preserves.

Season, seeding to harvest: 4 or more months.

Production in U.S.: No data. Limited.

Use: Preserves.

Part of plant consumed: Whole fruit.

Last update February 18, 1999 by ch

Cucumis anguria L.

Cucurbitaaceae

Concombre des Antilles, Jamaican cucumber, Jamaican gherkin, Oriental pickling melon, *Pepinito, Pepino*, West Indian gherkin, West Indian gourd

We have information from several sources:

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Cucurbita ficifolia Bouché

Cucurbitaceae

Fig-leaved gourd, Malabar gourd, Zambo

We have information from several sources:

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Neglected Crops : 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 47-62.

Outside links

Zambo can be found in Lost Crops of the Incas from National Academy Press

Cucurbita maxima Duchesne

Cucurbita mixta Pang.

Cucurbita moschata (Duchesne) Poir.

Cucurbita pepo L.

Cucurbitaceae

Calabaza, New England pie pumpkin, Pepitas, Pompion, Pumpion, Pumpkin, Squash, Sugar pumpkin

We have information from several sources:

Hull-less Seeded Pumpkins: A New Edible Snackseed Crop—J. Brent Loy

Production of Pumpkin for Oil—F. Bavec, L. Gril, S. Grobelnik-Mlakar, and M. Bavec

Production, Fruit Quality, and Nutritional Value of Spaghetti Squash—Audrey H. Beany, Peter J. Stoffella, Nancy Roe, and David H. Picha

Midwest Vegetable Production Guide for Commercial Growers 2000

Squash, Pumpkins and Gourds production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Pumpkin
Summer Squash
Winter Squash

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)
Cucurbita moschata
Cucurbita pepo

Growing Cucumbers, Melons, Squash, Pumpkins, and Gourds—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

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Outside links:

Pumpkin Diseases and Their Control

Zapallo (Winter squash) and Crookneck squash can be found in Lost Crops of the Incas from National Academy Press

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Ramcharan, C. 1999. Culantro: A much utilized, little understood herb. p. 506–509. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Culantro: A Much Utilized, Little Understood Herb

Christopher Ramcharan

Culantro (*Eryngium foetidum* L., Apiaceae) is a biennial herb indigenous to continental Tropical America and the West Indies. Although widely used in dishes throughout the Caribbean, Latin America, and the Far East, culantro is relatively unknown in the United States and many other parts of the world and is often mistaken and misnamed for its close relative cilantro or coriander (*Coriandrum sativum* L.). Some of its common names descriptive of the plant include: spiny or serrated coriander, *shado beni* and *bhandhania* (Trinidad and Tobago), *chadron benee* (Dominica), *coulante* (Haiti), *recao* (Puerto Rico), and fit weed (Guyana).

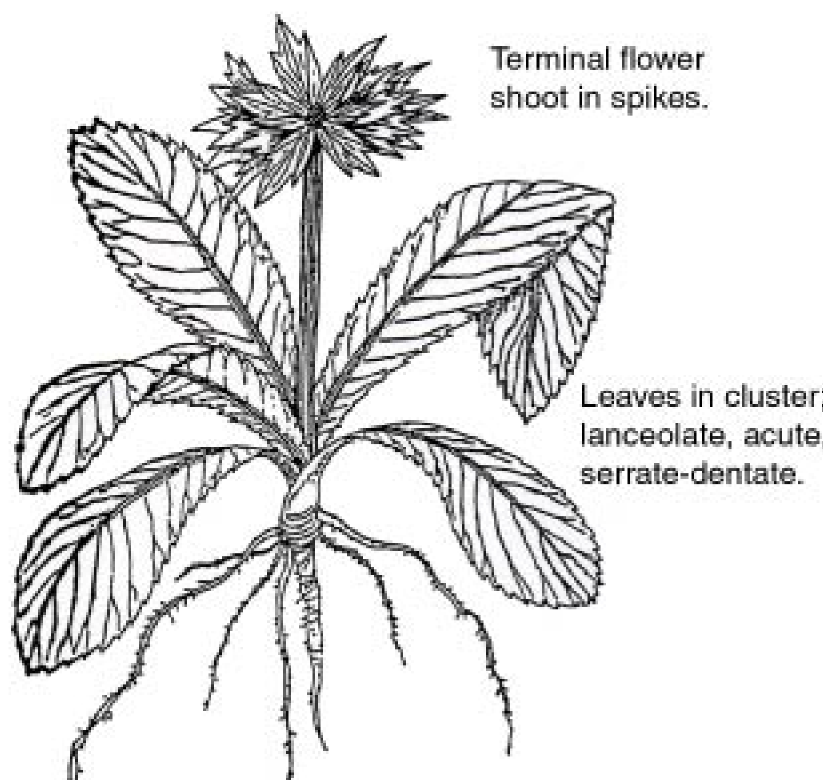
Culantro grows naturally in shaded moist heavy soils near cultivated areas. Under cultivation, the plant thrives best under well irrigated shaded conditions. Like its close relative cilantro, culantro tends to bolt and flower profusely under hot high-light long days of summer months. Recent research at UVIAES has demonstrated that it can be kept in a vegetative mode through summer when treated with GA_3 sprays.

The plant is reportedly rich in calcium, iron, carotene, and riboflavin and its harvested leaves are widely used as a food flavoring and seasoning herb for meat and many other foods. Its medicinal value include its use as a tea for flu, diabetes, constipation, and fevers. One of its most popular use is in chutneys as an appetite stimulant. The name fitweed is derived from its supposedly anti-convulsant property. The presence of increasingly large West Indian, Latin American, and Asian immigrant communities in metropolises of the US, Canada and the UK. creates a large market for culantro and large quantities are exported from Puerto Rico and Trinidad to these areas.

Culantro is increasingly becoming a crop of international trade mainly to meet the demands of ethnic populations in the developed countries of the West. Large immigrant communities in London, New York, and Toronto represents a vast potential market for the herb. One exporter from Trinidad alone packages and air freights up to 2.4 t of fresh culantro weekly to the US. In 1988, Puerto Rico reportedly produced 165,000 kg of culantro for a value of $201,000 (Dept. of Agriculture 1988). The herb is used extensively in the Caribbean and in Asia particularly in India and Korea. It is used mainly as a seasoning in the preparation of a range of foods, including vegetable and meat dishes, chutneys, preserves, sauces, and snacks. Although used in small quantities, its pungent unique aroma gives the characteristic flavor to the dishes in which it is incorporated and this is responsible for its increasing demand among ethnic populations. Culantro is also widely used in herbal medicines and reportedly beneficial in the treatment of a number of ailments (Wong 1976).

NOMENCLATURE

The derivation of culantro and recao, by which the plant is commonly known in Central America, is unknown but many of its names outside its natural habitat compare it to the common coriander or cilantro, e.g. Hindi bhandhanya, broad dhanya, or coriander, and Thai pak chi farang "foreign coriander." The botanical genus name *Eryngium* is derived from the Greek sea holly, *Eryngium vulgare*, and its specific name comes from the Latin *foetidum* meaning stink or bad odor; its smell is sometimes equated to a crushed bedbug. Some of the common names of culantro in the Caribbean area are: *shado beni* (Trinidad), *chadron benee* (Dominica), fitweed (Guyana), *coulante* or *culantro* (Haiti), *recao* (Puerto Rico) (Seaforth et al. 1983; Morean 1988; Seaforth 1988). Names in different languages include: *langer koriander* (German); *ketumbar java* (Malay); *pak chi farang* (Thai); *ngo gai* (Vietnamese); *culantro, racao, recao* (Spanish); *bhandhanya* (Hindi), and long leaf or spiny coriander (English).



Eryngium comprises over 200 tropical and temperate species (Willis 1960). Most are spiny ornamental herbs with thick roots and fleshy waxy leaves with blue flowers in cymose heads. *Eryngium foetidum* is a tap-rooted biennial herb with long, evenly branched roots (Fig. 1). The oblanceolate leaves, arranged spirally around the short thick stem, form a basal rosette and are as much as 30 cm long and 4 cm broad. The leaf margin is serrated, each tooth of the margin containing a small yellow spine. The plant produces a well-branched cluster of flower heads in spikes forming the characteristic umbel inflorescence on a long stalk arising from the center of the leaf rosette (Morton 1981; Moran 1988). The calyx is green while the corolla is creamy white in color.

Fig. 1. The culantro plant, *Eryngium foetidum*.

ECOLOGY AND CULTURE

Culantro is native to continental tropical America and the West Indies (Adams 1971). It grows naturally throughout many Caribbean islands including Trinidad and Tobago, where it is abundant in forests particularly in disturbed areas as in slash and burn sites. The herb is also commonly found along moist or shaded pathways and near cultivated areas where heavy soils predominate (Seaforth et al. 1983; Morean 1988). Although the plant grows well in full sun most commercial plantings occur in partially shaded moist locations. Shaded areas produce plants with larger and greener leaves that are more marketable because of their better appearance and higher pungent aroma. In a study on the effects of light intensity on growth and flowering of culantro, a significant delay in flowering and increased fresh weight of leaves were found in plants grown under 63% to 73% shade (Santiago–Santos and Cedeno–Maldonado 1991). Shaded plants also had fewer inflorescences with lower fresh weight. Although culantro grows in a wide variety of soils, it does best in moist well drained sandy loams high in organic matter particularly under full light. Precise fertilizer recommendations have not been made but high nitrogen fertilizers or manures promote leaf growth. Plants are usually started from seed which germinate in about 30 days, and for home or backyard gardens can be cultivated in containers or wooden boxes. For such cultivation, a slow release fertilizer such as Osmocote (14–14–14) can be incorporated in the soil mix at the rate of 1.8 kg/m^3.

Like many of its relatives, culantro tends to bolt and flower profusely under long day conditions resulting in reduced leaf growth and market value, and increasing costs for flower pruning. In a study to reduce bolting and increase leaf:flower size, ProGibb (PG) 4% a vegetative growth promoter was applied in increasing concentrations as a foliar spray to 1-month old culantro plants grown under 54% shade in a poly greenhouse (Ramcharan 1998). While leaf length increased with increasing levels of PG, leaf dry weight increased up to the 150 ppm PG level but was reduced at 200 ppm. Concomitantly, both fresh and dry weights of inflorescences were reduced by increasing levels of PG. Flowers produced in treated plants were less woody and spiny and leaf-like in appearance, making them easier for pruning. Pro Gibb 4% at 100 ppm concentration was therefore found to be optimum for maximizing leaf production and minimizing flower growth in culantro.

Culantro is relatively pest- and disease-free but the author has seen root knot nematodes on plants that have been grown for 2–3 years in box containers. A leaf spot problem which appears to be bacterial black rot (*Xanthomonas* sp.) has also been observed on such long-lived plants. Anecdotal reports mention that the flower heads are attractive to ladybugs, green lacewings, and other beneficial insects. Plants around the garden have also reportedly provided excellent defense against aphids.

While there are few reports on cultivation and fertilizer requirements for culantro, there has been considerable research on postharvest techniques for the herb. In a refrigerated storage trial, Sankat and Maharaj (1991) found that unpackaged culantro became unmarketable within 4 days of storage regardless of temperature. Storage at 10°C extended shelf life up to 2 weeks and chilling injury was observed at 3°C after 8 days in storage. In another postharvest study, the combination of polyethylene packaging, gibberellic acid (GA_3) in a 200 ppm dip treatment and reduced storage temperature (20°–22°C) extended the shelf-life of culantro up to 22 days (Mohammed and Wickham 1995). Freeze drying of harvested leaves is another alternative being considered to extend postharvest life.

CULINARY USES AND NUTRITIONAL VALUE

The appearance of culantro and cilantro are different but the leaf aromas are similar, although culantro is more pungent. Because of this aroma similarity the leaves are used interchangeably in many food preparations and is the major reason for the misnaming of one herb for the other. While relatively new to American cuisine, culantro has long been used in the Far East, Latin America, and the Caribbean. In Asia, culantro is most popular in Thailand, Malaysia, and Singapore where it is commonly used with or in lieu of cilantro and topped over soups, noodle dishes, and curries. In Latin America, culantro is mostly associated with the cooking style of Puerto Rico, where recipes common to all Latin countries are enhanced with culantro. The most popular and ubiquitous example is *salsa*, a spicy sauce prepared from tomatoes, garlic, onion, lemon juice, with liberal amounts of chiles. These constituents are fried and simmered together, mixed to a smooth paste and spiced with fresh herbs including culantro. Salsa is usually consumed with tortilla chips as an appetizer. Equally popular is *sofrito* or *recaito*, the name given to the mixture of seasonings containing culantro and widely used in rice, stews, and soups (Wilson 1991). There are reportedly as many variations of the recipe as there are cooks in Puerto Rico but basically sofrito consists of garlic, onion, green pepper, small mild peppers, and both cilantro and culantro leaves. Ingredients are blended and can then be refrigerated for months. Sofrito is itself the major ingredient in a host of other recipes including eggplant pasta sauce, cilantro garlic butter, cilantro pesto, pineapple salsa, and gazpacho with herb yogurt.

Culantro is reported to be rich in calcium, iron, carotene, and riboflavin. Fresh leaves are 86–88% moisture, 3.3% protein, 0.6% fat, 6.5% carbohydrate, 1.7% ash, 0.06% phosphorus, and 0.02% iron. Leaves are an excellent source of vitamin A (10,460 I.U./100 g), B_2 (60 mg %), B_1 (0.8 mg %), and C (150–200 mg %) (Bautista et al. 1988). On a dry weight basis, leaves consist of 0.1–0.95% volatile oil, 27.7% crude fiber, 1.23% calcium, and 25 ppm boron.

MEDICINAL USES

The plant is used in traditional medicines for fevers and chills, vomiting, diarrhea, and in Jamaica for colds and convulsions in children (Honeychurch 1980). The leaves and roots are boiled and the water drunk for pneumonia, flu, diabetes, constipation, and malaria fever. The root can be eaten raw for scorpion stings and in India the root is reportedly used to alleviate stomach pains. The leaves themselves can be eaten in the form of a chutney as an appetite stimulant (Mahabir 1991).

CONCLUSION

Although used widely throughout the Caribbean, Latin America, and the Far East, culantro is still mistaken for and erroneously called cilantro. The herb is rapidly becoming an important import item into the US mainly due to the increasing ethnic immigrant populations who utilize it in their many varied dishes from around the world. It is closely related botanically to cilantro but has a distinctly different appearance and a much more potent volatile leaf oil. Recent research to prevent bolting and early flowering will increase its leaf yields and consequently its demand. Successes in prolonging its postharvest life and storage under refrigeration will undoubtedly increase its export potential and ultimately its popularity among the commonly used culinary herbs.

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Culvers-Physic

Veronica virginica L.

Figure 45.—Culvers-physic (*Veronica virginica*)

Synonym.—*Leptandra virginica* (L.) Nutt.

Other common names.—Culvers-root, blackroot, bowmansroot, beaumont root, Brinton root, tall speedwell, tall veronica, physic-root, whorlywort.

Habitat and range.—This common native herb is found abundantly in moist rich woods, mountain valleys, meadows, and thickets from Nova Scotia to British Columbia and south to Alabama, Missouri, and Nebraska.

Description.—Culvers-physic is a tall, slender-stemmed herb from 3 to 7 feet in height. The long, narrow, pointed leaves, which are arranged around the stem at intervals, in groups of from three to nine, are 3 to 6 inches in length and 1 inch or less in width. The tube-shaped flowers, produced from June to September, are borne in several densely crowded, slender, terminal, spikelike heads from 3 to 9 inches long. The flowers are usually white, but at times are pink to bluish or purple.

Part used.—The rootstock and roots, collected in the fall of the second year.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Cuminum cyminum L.

Apiaceae (Umbelliferae)

Cumin, *Comino*, Cummin, *Jintan*

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

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Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Prosopis chilensis (Molina) Stuntz

Mimosaceae
Cupesi, White algarobo

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

White algarobo used for shade, timber, fuel, and concentrated forage or food (sweet, pulpy fruits). Pods eaten as sweets "patay" or drunk as "aloja". A staple food for cattle in arid regions. Sometimes cultivated in Argentina and Chile; promising reforestation species (Burkart, 1976). South Africans believe the ripe pod makes excellent fodder but the green pod is bitter and valueless. Reddish mesquite gum may be used as a substitute for gum arabic as an adhesive and in the manufacture of gumdrops (Watt and Breyer-Brandwijk, 1962). Wood is said to have good acoustical properties (Allen and Allen, 1981).

Folk Medicine

A ten percent infusion of the leaves shows some antibiotic activity.

Chemistry

Like *P. alba* this species contains apigenin 8-glucoside, apigenin 6-glucoside, quercitin 3-glucoside, quercitin 3-rhamnoside, quercitin 3-rutinoside, and traces of myricetin 3-rhamnoside, luteolin, kaempferol-3-OMe quercetin, and quercitin 3-OMe (Simpson, 1977). Pipecolic and 4-hydroxy pipecolic acid also occur in both, but varying concentrations of pipecolic acid and proline are interpreted as reflecting a plastic response to changing environmental conditions. The consistent patterns of flavonoid distributions in several species groups, on the other hand, apparently reflects genetic fixation independent of known environmental factors (Simpson, 1977). Patay (ground beans filtered to remove the endocarp, and made into flour for breadstuffs) contains 10–12% water, 4–6% fiber, 0.8–4.3% protein, and 55–65% carbohydrates (44% sugar, 11% starch, plus cellulose) and is relatively high in calcium. Fresh pods, but not dry pods, are said to be harmful to horses. Seeds contain small quantities of saponins. Bark and root contain tannin. Young leaves contain 1.8% alkaloids, intermediate leaves, 1.7%, and mature leaves, 0.9% (Simpson, 1977).

		As % of dry matter						
	Dm	CP	CF	Ash	EE	NFE	Ca	P
Fresh young leaves, USA		23.5	24.7	4.7	2.9	44.2	0.86	0.25
Pods, Chile	91.5	11.0	11.9	7.3	2.2	67.6	0.44	0.16
Pods, Sudan	94.4	11.5	26.9	5.4	2.2	54.0		
Dried pod meal, Hawaii	89.2	9.5	23.2	7.9	1.5	57.9		
Seeds, Hawaii		35.2	9.1	5.1	5.2	45.4		
Pod husks, Hawaii		5.6	27.3	3.8	0.2	63.1		

		Digestibility (%)				
	Animal	CP	CF	EE	NFE	ME
Pod meal	Cattle	70.0	54.0	75.0	70.0	2.30

Source: Gohl, B. 1981.

Description

Tree, becoming large in age, with short trunk, 3–10 m tall, treetop rounded; branchlets flexuous, knotty, partly spinous; spines on strong shoots, axillary, geminate, uninodal, hard, conic-subulate, up to 6 cm long. Leaves deciduous, glabrous, uni- to bi- or trijugate, elongate, but giving only slight shade, mostly fascicled; petiole (rachis when extant included) 1.5–12 cm long; pinnae 8–24.5 cm long; leaflets 10 to 29 pairs per pinna, long-linear and distant on the rachis (4–12 mm apart), glabrous throughout or with some cilias on the margins at base, 1.1–5.4 cm long x 1.1–3 mm broad, pale green, nearly enervate or only the costa prominent, but not of a different color. Racemes spiciform, densiflorous, ca 7–12 cm long; flowers greenish-white to yellowish, ca 250 per raceme; calyx 1 mm; petals 3 mm long, villous within; stamens 5–6 mm long; ovary pubescent. Legume linear, compressed, with parallel margens, strawyellow, stipitate and acuminate, nearly straight, thick; mesocarp sugary, edible; endocarp segments transverse-rectangular, broader than long, subcoriaceous, easy to open numbering 20 to 32; seeds ovoid, compressed, brown, 6–7 mm long (Burkart, 1976).

Germplasm

Reported from the South American Center of Diversity, cupesi, or cvs thereof, is reported to tolerate drought. Simpson (1977) reports self–incompatibility. ($2n$ = 28, 56).

Distribution

Extending from Peru and Bolivia to central Chile and northwestern Argentina. In southern Peru it is found at elevations of up to 2900 m (Burkart, 1976).

Ecology

Our computer entries for *Prosopis* spp. are unreliable, partly due to past taxonomic confusion. I estimate this species ranges from Tropical Thorn to Moist through Subtropical Thorn to Moist Forest Life Zones. At the Bolson de Pipanaco, elevation ca 1072 m, annual precipitation ca 3 dm, annual temperature ca 18.6°C, *Prosopis chilensis* often forms dense stands along the broad washes. Associated species are mentioned in Simpson (1977). In Argentina, the species leafs out in spring (September) with mean temperature ca 16°C staying in leaf until fall (April). Blooms in October in Andalgala for about two weeks.

Cultivation

Felker et al. (1981) reported water requirements of 535.3 cm^3 per g of dry matter making this one of the more water efficient species of *Prosopis*.

Harvesting

Commonly cut for fuel as needed.

Yields and Economics

According to Simpson (1977) a mature tree produces ca 10,000 inflorescenses per year, each with about 279 flowers, but setting only 1.65 fruits per inflorescence. Each inflorescence is estimated to produce 12.89 mg sugar or ca 13 g from all 10,000; and 26.50 mg pollen (26 g in all per tree). At Riverside, #0009 *P. chilensis* average measured (not projected from regression equations) oven dry biomass corresponded to a 41 MT/ha 3-season yield or a 13.7 MT/ha/yr. This yield was obtained with total irrigation plus rainfall of 1,390 mm or a seasonal average of 460 mm. Others showed an average annual production of 14.5 MT/ha in the Imperial Valley, but the total DM production for all 55 accessions tested averaged an annual increment of 8.2 MT/ha. Under similar conditions, Felker et al. (1981) report:

	UCR biomass tree (kg)	Imp. vall. biomass/ tree (kg)	Pods (g)	Pods/ tree(s)	Coppice (%)	Salinity	Na/hr?
P. alba (0039)	6.8	10.6	48	52	100		
P. alba (0132)	4.3	15.9			100		0.18
P. alba (0166)		29.0		34	75		
P. articulata (0016)	7.8	18.5	41	68	25	1.8	0.63
P. chilensis (0009)	9.2	18.3	0.0	0.0	75	1.2	0.71
P. glandulosa glandulosa (0028)	1.7		139				0.12
P. glandulosa torreyana (000)	4.9	8.1	134	0.7	50	1.2	0.60
P. juliflora	0.0	10.4	0.0	0.7	25		
P. kuntaii (0130)	0.4		0.0				0.23
P. laevigata (0114)	3.2		0.0				
P. nigra (0038)	4.8	2.5			75		0.60
P. pallida (0041)	0.0	5.0	0.0	0.25	0	1.8	1.05
P. pubescens (0245)		2.6		86	25		
P. ruscifolia (0131)	1.0		0.0			0.18	
P. tamarugo (0042)	1.7		0.0			0.13	
P. tamarugo (0317)		0.2			100	1.8	
P. velutina (0020)	3.0	3.7	464	35	75	0.6	
Cercidium floridium		2.4			0		0.0
Leucaena leucocephala		15.5			75		
Olneya tesota		0.3			75		0.33
Parkinsonia aculeata		13.0			100		No

Energy

Felker et al (1981) report that small plots with 1.5 x 1.5 m spacing yielded 11.7 MT/ha the first year, 16.9 MT/ha the second year.

Biotic Factors

Some specialists (*Brachyphatnus* sp. and *Noctuid* sp.) and some generalists (*Melipotis bisinuata, Oiketicus geyeri, Semiothisa* sp.) are reported to "graze" the species in Argentina. The major *Prosopis* bee visitors are *Bicolletes* sp., *Centris brethesi, Collates* spp., *Eremapis pravula, Exomalopsis* sp., *Liopoeum argentina, Megachile* spp., *Oediscelis, Svastrides zebra,* and *Xylocopa splendidula* (Simpson, 1977). Among bruchids, *Rhipibruchus picturatus, R. prosopis,* and *Scutobruchus ceratioborus* are reported. Bruchids may destroy 90% of the seed. *Phoradendron hieronymi, P. liga, P. pruinosum, Prosopanche americana, Psittacanthus cuneifolius,* and *Tapinanthus* sp., possibly even *Ximenia americana* are hemiparasitic or parasitic flowering plants on the algarrobo. The desert cavy eats leaves and pods and may strip bark from small tender branches. Many other *Prosopis* eaters are listed and discussed in Simpson (1977). Golden (p.c. 1984) lists the nematode *Rotylenchus reniformis.* Felker et al (1981) review the pest infestations of their *Prosopis* plantings with suggestions for their control.

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Complete list of references for Duke, Handbook of Energy Crops

Last update January 8, 1998 by aw

Cuphea spp.

Lythraceae

Cuphea

We have information from several sources:

Breakthroughs Towards the Domestication of *Cuphea*—Steven J. Knapp

Cuphea Growth and Development: Responses to Temperature—Russ W. Gesch, Nancy W. Barbour, Frank Forcella, and Ward B. Voorhees

Rooting Characteristics and Water Requirements of *Cuphea*—Brenton S. Sharratt and Russell W. Gesch

Chemistry of New Oilseed Industrial Crops—Robert Kleiman

New Crops from Brazil—David Arkcoll

New Crops Research and Development: A Federal Perspective—L.H. Princen

New Temperate Oilseed Crops—Steven J. Knapp

Cuphea glutinosa Selections for Flowering Ornamental Ground Cover in Southeast United States—Casimir A. Jaworski and Sharad C. Phatak

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Perspective from a Large Industrial Company—Joseph S. Boggs

Theobroma grandiforum Schumann

Sterculiaceae

Cupuaçu, Cupuassu

We have information from several sources:

Cupuassu: A New Beverage Crop for Brazil—Christiane Cabral Velho, Anna Whipkey, and Jules Janick

New Crops from Brazil—David Arkcoll

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 47-62.

Turmeric, Tumeric

Tumerico

Zingiberaceae *Curcuma longa* L.

Source: Magness et al. 1971

The plant is a large-leaved herb, closely related to ginger. It is cultivated in tropical countries for the thick, rounded, underground stems or rhizomes, which constitute the spice, turmeric. Turmeric contains an oil, which consists in part of curcumin, which on oxidation is changed into vanillin, the active principle in vanilla. The rootstocks of turmeric, both fresh and dried, are also used as flavoring in curries and other cookery.

Last update June 27, 1996 bha

Kuehny, J.S., M.J. Sarmiento, and P.C. Branch. 2002. Cultural studies in ornamental ginger. p. 477–482. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

Cultural Studies in Ornamental Ginger

Jeff S. Kuehny, Mauricio J. Sarmiento, and Patricia C. Branch

INTRODUCTION

Hedychium species (butterfly ginger) and *Alpinia zerumbet* (shell ginger) have been grown in the Southern United States since at least the turn of the century (Burch 1998). *Curcuma* and *Kaempferia* are two other genera in the Zingiberaceae family that have recently gained much notoriety. *Kaempferia* species have unique foliage and *Curcuma* species colorful, long-lasting inflorescences, both with a 90- to 100-day production cycle and few pest problems. These gingers have great potential for use as flowering pot plants, both indoors and as patio and landscape plants. They are herbaceous perennials with short fleshy rhizomes and tuberous roots, often with a dormancy period (Burch et al. 1987). Inflorescence stalks arise either from a short pseudostem or independently from buds on the rhizome. The inflorescence of *Curcuma* species are a compressed spike of colorful long lasting bracts subtending 2 to 7 true flowers (Luc-Cayo and Fereol 1997). *Kaempferia* species, however, have short lived flowers with attractive, colored/patterned leaves that vary in size and shape. Burch (1998) reported that between 150,000 to 250,000 rhizomes of ginger would be sold in 1998. Because of the new genera of ginger continuing to enter the market, the value of ornamental ginger has not been well documented. The number of rhizomes sold has probably doubled (E. Welch, pers. commun.) since 1998 and this does not account for number of plants sold from tissue culture.

There is little information on the optimum production environment, postproduction longevity, and landscape survivability of commercially available gingers. The objectives of this research were to determine the effects of light intensity, photoperiod, and plant growth regulator application on various cultures of *Curcuma* and *Kaempferia* species (Fig. 1–5).

Fig. 1. *Curcuma alismatifolia* ‘Chiang Mai Pink’.

Fig. 2. *Curcuma* spp. ‘Precious Petuma’.

Fig. 3. *Curcuma cordata*.

Fig. 4. *Curcuma petiolata*.

Fig. 5. *Kaempferia* spp. ‘Grande’.

METHODOLOGY

All plants were grown in the greenhouse using a medium consisting of 1/2 peat moss, 1/3 pine bark, and 1/6 perlite, amended with dolomite limestone (5.1 kg/m^3) and superphosphate 0–18–0 (2.7 kg/m^3). Immediately after planting containers were drenched with a tank mix of metalaxyl (Subdue 2E, Novartis, Greensboro, North Carolina) at 15.6 ml/100 L and PCNB quintozene (Terraclor 75% WP, Uniroyal Chemical, Middlebury, Connecticut). Plants were spaced on 21 × 21 cm centers and fertigated with 24N–3.5P–13.3K (Peters 24–8–16 Tropical Foliage, Scotts-Sierra, Marysville, Ohio) at 150 ppm N as needed.

Data was analyzed using PROC GLM. Comparisons between means was conducted by Tukey’s studentized range test.

Light Levels and Plant Growth Retardants

Curcuma spp. ‘Precious Petuma’, *C. parviflora* ‘White Angel’, and *C. alismatifolia* ‘Chiang Mai Pink’ rhizomes were planted one per 14 cm container on 4 April 2000. Plants were grown in a greenhouse at temperature setpoints of 27°/21°C day/night. When shoot height was 10 cm, the plants were drenched with 118 ml of paclobutrazol or uniconazole at 0, 10 or 20 mg a.i. per container and grown under a 0% (1,860 µmol/s/m^2), 30% (922 µmol/s/m^2) or 60% (352 µmol/s/m^2) shade. Average daily temperatures for the three light levels were 30°C. Days to emergence, days to bloom, number of flowers, height of the flowering stalk, and days to anthesis (postproduction longevity) were determined for all plants.

There was no significant effect of shade level on days to emergence or days from emergence to first flower for *Curcuma* spp. ‘Precious Petuma’. Flower height was 22% taller for those plants grown under both shade levels. Application of paclobutrazol and uniconazole at 20 mg a.i./pot reduced the flower height of ‘Precious Petuma’ by 27% and 54% respectively. Because flower height was acceptable (approximately 25 cm) at all shade levels, the use of a growth retardant is not recommended. Shade level had no affect on flower longevity, with an average 29 day postproduction longevity. The number of days from first flower to second flower were extended by approximately 12 days when plants were grown under 60% shade.

Days from emergence to first flower of *C. parviflora* ‘White Angel’ was significantly extended by approximately 13 days when grown under 60% shade. Flower height was 23% taller at 30% shade; however, due to the short stem of this flower, this height was still acceptable (less than 25 cm). Thus, the use of a growth retardant is unnecessary. Shade level did not affect flower longevity or days to second flower. Flower longevity was favorable at approximately 30 days and days to second flower was approximately 40 days for all treatments.

Days from planting to emergence and emergence to first flower of *C. alismatifolia* ‘Chiang Mai Pink’ were unaffected by shade level or rate of growth retardant. Days from first flower to second flower was significantly extended by both shade levels with no second flower produced at 60% shade. Thus, these plants must be grown under full sun for best quality. When grown at 30% or 60% shade, flower height was significantly taller by 9 and 13 cm respectively. The flower height of these plants, regardless of shade treatment, was not of marketable quality. The results from this study indicate that for production of a marketable flowering ‘Chiang Mai Pink’ ginger, application of uniconazole at 10 mg a.i./pot and a rate greater than 20 mg a.i./pot of paclobutrazol is recommended. Postproduction longevity of this ginger is approximately 40 days.

Gibberellic Acid

Curcuma alismatifolia 'Chiang Mai Pink', *C. gracillima* 'Violet', and *C. thorelii* one cm rhizomes were planted one per 14 cm container on 17 April 1999. Prior to planting, rhizomes were soaked for 10 min in a solution containing 2% GA_{4+7} (Provide, Abbot Labs, North Chicago, Illinois) at 0, 200, 400, or 600 mg/L, 10% Physan 20 (10% dimethyl benzyl ammonium chloride, 10% dimethyl ethyl ammonium chloride, 80% inert, Maril Products, Tustin, California) and distilled water. Rhizomes were dried and planted in a greenhouse with average minimum and maximum temperatures of 23° and 30°C night/day. Treatments were arranged in a complete randomized design.

Plants were harvested once a week when they reached a stage characterized by the opening of the last bract and one flower (marketable stage). Days to bloom, number of flowers, and height of the flowering stalk were recorded for all plants.

GA at 200, 400, and 600 ppm delayed shoot emergence of *C. alismatifolia* 'Chiang Mai Pink' (Table 1). GA at 400 ppm delayed flowering but did not increase the number of inflorescences. All plants had one inflorescence per container. Application of GA at 600 ppm reduced flower height (data not shown). GA concentrations of 600 ppm delayed shoot emergence of *C. gracillima* 'Violet' and *C. thorelii* (Table 1). Days to bloom and flower height was unaffected for either *Curcuma*, and plants developed no more than one flowering stem.

Table 1. Effect of gibberellic acid (GA) on days to emergence and days to bloom of *Curcuma alismatifolia* 'Chiang Mai Pink', *C. gracillima* 'Violet', and *C. thorelii*.

	Days to emergence			Days to bloom		
GA (ppm)	*Curcuma alismatifolia*	*Curcuma gracillima*	*Curcuma thorelii*	*Curcuma alismatifolia*	*Curcuma gracillima*	*Curcuma thorelii*
0	43.5 a[z]	40.5 a	40.2 a	113 a	108 a	113 a
200	53.1 b	44.6 ab	43.7 ab	115 ab	114 a	115 a
400	57.1 b	44.6 ab	45.0 ab	128 b	109 a	113 a
600	55.4 b	47.9 b	51.2 b	126 ab	121 a	131 a

[z]Mean separation of GA rates by HSD test, P=0.05. Means within columns with different letters are significantly different.

Photoperiod

Tissue culture plants of *Curcuma petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande' were planted one per 15 cm container in the greenhouse on 16 Aug. 1999. Tissue culture plants of *C. cordata* were planted two per 15 cm container on 9 Sept. 1999. Rhizomes of *C. alismatifolia* 'Siam Tulip White' were planted one per 12.5 cm container on 27 Aug. 1999. All ginger species were arranged in a complete randomized design under each photoperiod treatment.

Photoperiod treatments were initiated 17 d after transplanting for *C. alismatifolia C. petiolata*, *C. thorelii*, and *Kaempferia* sp. 'Grande' and 18 d after transplanting for *C. cordata*. On 2 Sept. 1999 photoperiod treatments of 8, 12, 16, and 20 hr were initiated. Plants received 8 hr of natural light from 0900 to 1700 hr. Zero, four, eight, and twelve hours of supplemental light were provided for the 8, 12, 16, and 20 hr photoperiod, respectively. Light source was 100 watt incandescent light bulbs at an irradiance of 11 $\mu mol/s/m^2$ (14 to 50 foot candles). Average minimum and maximum temperatures were 18° and 26.5°C. *Curcuma petiolata*, *C. thorelii*, 'Emperor', and *Kaempferia* sp. 'Grande' completed 21 weeks in the photoperiod treatment, *C. cordata* was 19 weeks and *C. alismatifolia* 18 weeks.

Each week, the number of newly unfolded leaves was counted as a measurement of plant growth. On 1 Dec. 1999, the height of the plants was measured from the medium surface to the tip of the longest leaf. On 1 Feb. 2000, the photoperiod treatment ended. Plants which did not go dormant during the course of the experiment were forced to dormancy by terminating irrigation. After all plants were dormant, the number of rhizomes and t-roots was counted for each treatment.

Dormancy was induced on all ginger grown under an 8 hr photoperiod. The number of weeks required for plants to go dormant under an 8 hr photoperiod was 9.0±0.17 weeks for *C. cordata*, 15±0 weeks for *C. petiolata*, 11.6±1.2 weeks for *C. thorelii*, and 12±0 weeks for *Kaempferia*.

Plant height of *C. alismatifolia* increased as length of photoperiod increased to 20 h (Table 2). *Curcuma* cordata plants grown at 20 and 16 hr were significantly taller than plants grown at 12 hr. Plants grown at 8 hr became dormant. *Curcuma* petiolata plants grown under 8 and 12 hr were significantly shorter than plants under 20 and 16 hr. *Curcuma* thorelii plants grown under 16 and 20 hr were significantly taller than plants at 12 hr. There were no significant differences in height between 12, 16, and 20 hr treatments for *Kaempferia*.

Table 2. Effect of photoperiod on plant height for *Curcuma alismatifolia* 'Chiang Mai White', *C. cordata, C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

Photoperiod (hr)	Plant height (cm)				
	Curcuma alismatifolia	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia 'Grande'*
8	20.7 a[z]	dormant[y]	35.6 a	dormant	dormant
12	30.0 b	42.7 a	41.6 a	32.0 a	31.6 a
16	38.8 c	50.2 b	65.3 b	37.3 b	46.6 a
20	35.6 bc	49.0 b	70.3 b	38.0 b	46.6 a

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.
[y]Plants were dormant prior to measurement.

The number of leaves unfolded increased during the 16 and 20 hr photoperiod for *C. alismatifolia* (Table 3). *Curcuma cordata* plants under 16 and 20 hr photoperiods produced more new leaves than 8 and 12 hr photoperiods. *Curcuma petiolata* 'Emperor' plants grown at 16 and 20 hr produced more new leaves than plants grown at 8 and 12 hr (Table 3). Photoperiod did not significantly affect the number of new leaves *C. thorelii* produced. *Kaempferia* sp. 'Grande' plants in the 16 and 20 hr photoperiod produced more new leaves than those in 8 hr.

Table 3. Effect of photoperiod on total number of new leaves unfolded *Curcuma alismatifolia* 'Chiang Mai White', *C. cordata, C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

Photoperiod (hr)	Number of leaves unfolded				
	Curcuma alismatifolia	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia 'Grande'*
8	1.6 a[z]	0.5 a	2.6 a	2.0 a	2.0 a
12	2.1 a	2.8 a	3.3 a	4.6 a	3.3 ab
16	6.8 b	10.0 b	17.3 b	4.3 a	10.0 c
20	8.6 c	9.1 b	21.0 b	5.3 a	8.6 bc

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.

Curcuma alismatifolia, *C. cordata*, and *C. petiolata* plants grown under 16 and 20 hr produced a greater number of rhizomes than those plants grown under 8 and 12 hr (Table 4). Photoperiod did not affect the number of rhizomes produced by *C. thorelii* or *Kaempferia*. *Curcuma alismatifolia* grown under a photoperiod of 16 hr or less produced approximately two t-roots per plant and approximately one t-root at 20 hr (Table 5). *Curcuma cordata, C. petiolata*, and *Kaempferia* produced approximately 5 t-roots or more when grown at a photoperiod of 12 and 8 hr, and almost no t-roots at 16 and 20 hr. *Curcuma thorelii* responded to changes in photoperiod by producing a large number of t-roots for all treatments, producing the greatest number of t-roots at 16 hr.

Table 4. Effect of photoperiod on number of rhizomes of underground organs for *Curcuma alismatifolia* 'Chaing Mia White', *C. cordata, C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

Photoperiod (hr)	Number of rhizomes				
	Curcuma alismatifolia	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia 'Grande'*
8	1.0 a[z]	1.0 a	1.0 a	1.0 a	1.0 a
12	1.0 a	1.0 a	1.0 a	1.0 a	1.0 a
16	1.9 b	1.9 b	1.6 ab	1.0 a	1.0 a
20	2.3 c	2.1 b	3.0 b	1.0 a	1.3 a

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.

Table 5. Effect of photoperiod on number of t-roots of underground organs for *Curcuma alismatifolia* 'Chaing Mia White', *C. cordata, C. petiolata* 'Emperor', *C. thorelii*, and *Kaempferia* sp. 'Grande'.

Photoperiod (hr)	Number of t-roots				
	Curcuma alismatifolia	*Curcuma cordata*	*Curcuma petiolata*	*Curcuma thorelii*	*Kaempferia 'Grande'*
8	2.1 b[z]	5.9 a	6.3 b	6.0 a	8.3 b
12	2.1 b	5.3 a	6.3 b	8.3 ab	4.6 b
16	1.9 b	0.0 b	0.3 a	11.6 b	0.0 a
20	0.6 a	0.0 b	0.6 a	10.6 ab	0.0 a

[z]Mean separation of photoperiods by HSD test, P=0.05. Means within columns with different letters are significantly different.

COLCLUSIONS

Curcuma spp. 'Precious Petuma', *C. parviflora* 'White Angel', and *C. alismatifolia* 'Chiang Mai Pink' produce marketable flowering pot plants requiring no application of shade. 'Precious Petuma' and 'White Angel' can be grown under shade levels of up to 60% without use of growth retardant and no deleterious affect on plant quality. 'Chiang Mai Pink' should be grown in full sun and an application of either 10 mg a.i./pot of uniconazole or over 20 mg a.i./pot of paclobutrazol for production of a quality flowering pot plant. These ornamental gingers have an excellent postproduction longevity of up to 40 days.

GA did not increase the number of inflorescences of *Curcuma* alismatifolia but did delay shoot emergence and flowering. GA applied (as a spray) at concentrations of 1.44 and 2.88 mm suppressed shoot emergence of field grown edible ginger (*Zingiber officinale* Roscoe) (Furutani and Nagao 1986). GA usually stimulates stem lengthening however, GA at 600 ppm significantly reduced flower height of *C. alismatifolia*. Soaking rhizomes in GA at 200, 300, 400, and 600 ppm did not inhibit shoot sprouting but delayed it. GA has been recommended for extending dormancy, thereby inhibiting sprouting in storage of yams (*Dioscorea cayenensis rotundata* Lam. and *D. alata* L.), an edible tuber (Girardin et al. 1998). Thus, GA could be used to prolong storage of ornamental ginger rhizomes prior to planting. It should not be used to promote or increase flowering.

Photoperiod affected height of all species of ginger evaluated. The plants grown under 20 or 16 hr photoperiods were taller than those grown under 12 or 8 hr photoperiods. Photoperiod affected the number of unfolded leaves of all plants except for *C. thorelii*. The 16 and 20 hr photoperiods increased number of leaves unfolded compared to 12 and 8 hr. Effect of photoperiod on number of rhizomes and number of t-roots was dependent upon the species of ginger. *Kaempferia* sp. 'Grande', *C. petiolata*, *C. cordata*, and *C. alismatifolia* 'Siam Tulip White' produced more t-roots when grown under 8 or 12 hr than 20 or 16 hr photoperiods. The exception was *C. thorelii*, where more t-roots where produced on the plants growing at 20 or 16 hr photoperiod than in 12 or 8 hr. *Siphonichilus decora* did not produce t-roots under any of the 4 photoperiods. *Curcuma petiolata*, *C. cordata*, and *C. alismatifolia* 'Siam Tulip White' produced more rhizomes under the long day photoperiods (20 and 16 hr) than under 12 or 8 hr.

Ginger shoot and rhizome growth were optimized when plants were grown under 16 or 20 hr photoperiods, whereas an 8 hr photoperiod promoted dormancy. The best production strategy for growers of gingers as flowering potted plants is to plant in the spring (April) and grow the plants throughout the summer, finishing production in the fall. If production in the winter is desired, 16 hr photoperiod must be used.

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Curly mesquite

Gramineae *Hilaria belangeri* (Steud.) Nash

Source: Magness et al. 1971

This is a warm climate grass native from Central Texas and Arizona south throughout Mexico. It is stolon forming and grows on dry soils that may range in texture from clay to gravelly. The plant grows in tufts, new tufts developing at the nodes of the stolons. Stems are slender, up to a foot tall, with short narrow leaves. It is highly drought resistant, palatable both green and when dry, thus is a valuable range grass for warm dry areas.

Last update February 18, 1999 by ch

Ribes sativum Syme, *R. rubrum* L., *R. nigrum* L.

Currant, Aka-suguri, Black currant, Common red ribes, European black currant, European red currant, Garden currant, North American red currant, Northern red currant, Red currant, White currant

and

Ribes uva-crispa L., *R. hirtellum* Michx.

Gooseberry, English gooseberry, European gooseberry, *Groseille à maquereau*, Old gooseberry, Orange gooseberry, Wolf currant

Grossulariaceae, Saxifragaceae

NewCROP has currant & gooseberry information at:

Temperate Berry Crops—Chad Finn

Currant—Magness, J.R. et al. 1971. Food and feed crops of the United States.

Gooseberry—Magness, J.R. et al. 1971. Food and feed crops of the United States.

Currants and Gooseberries—Cooperative Extension Service, Purdue University, West Lafayette, Indiana

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Outside Links:

CURRANT "FRUIT FACTS"—(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Currants and Gooseberries *Ribes nigrum, R. sativum; R.rubrum, R. grossularia, R.*

hirtellum—from the University of Georgia Horticulture Crop Site

'Jahns Prairie' Gooseberry, *Ribes oxyacanthoides*—A new release by the USDA and Agri-Food Canada. This plant is disease resistant and produces high quality, dark red, dessert gooseberries.

The Small Fruits of New York, 1925 by U. P. Hedrick.—The Small Fruits of New York was published by the New York Agricultural Experiment Station. It has become a classic reference for those working with cultivated varieties of *Rubus, Ribes and Fragaria*.

Small Fruit—FAO/IBPGR Technical Guidelines for the Safe Movement of Small Fruit Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Palaniswamy, U.R., J.D. Stuart, and C.A. Caporuscio. 2002. Effect of storage temperature on the nutritional value of curry leaf. p. 567–569. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

Effect of Storage Temperature on the Nutritional Value of Curry Leaf

Usha R. Palaniswamy, James D. Stuart, and Christian A. Caporuscio

INTRODUCTION

Curry leaf (*Murraya koenigii* Spreng., Rutaceae), is a popular leafy-spice used in Asian-Indian cuisine for its characterizing authentic flavor and distinct aroma (Fig. 1). The curry leaf is used by Asian Americans originating from South Asia almost daily in its fresh form when available and is preserved as dried or frozen for long-term storage. Interest in greater use of curry leaf has been stimulated since its high antioxidant and anticarcinogenic potential were reported (Khan et al. 1997; Khanum et al. 2000), as well as the changing demographics nationwide that have created a ready market and greater demand for this spice (Palaniswamy 2001). Curry leaf is used in very small quantities for its distinct aroma due to the presence of volatile oils and as a result most studies report on the concentrations of volatile oils and not on the nutritional value and functional properties attributed to antioxidant vitamins and plant pigments. The objective of this study was to evaluate the locally available curry leaves as a source of α-tochopherol, β-carotene, and lutein and study the effect of storage temperature on the concentrations of these vitamins and plant pigments.

Fig. 1. Curry leaf.

METHODOLOGY

Postharvest Treatments for Study

Curry leaf was purchased from local Asian grocery stores, pooled, divided into four lots, and sampled as (1) freshly bought, (2) oven-dried at 60°C for 1 day, (3) air-dried for 10 days spread on a table at 22°C, and (4) sealed in polythene bags and frozen at –15°C for 10 days. The freshly bought leaf was analyzed the same day of purchase, while the other samples were analyzed ten days after purchase when all the treatments were completed. The air-dried and the oven-dried samples were put in glass bottles when completely dried to imitate the traditional method of home storage for culinary use.

Leaf Vitamin Extraction and Sample Preparation

The vitamins were extracted form the leaf tissue as given by Sommerburg et al. (1998). Leaf tissue (1 g) was homogenized for 3 min in 20 mL sodium phosphate (10 mm) containing 0.15 N sodium chloride (pH 4.7); 2 mL of methanol containing 0.5 mg/mL butylated hydroxytoluene and 10 mL internal standard (1 mg/mL) in hexane were added, vortexed for 5 min, and centrifuged for 10 min. The upper layer was collected and stored. The remaining extract was vortexed again for 2 min and centrifuged for 5 min. The upper layer was collected and combined with the first extract. The combined extracts were passed through sodium sulfate to remove moisture. All extracts were transferred and stored in 4 mL amber vials, sealed, and refrigerated.

Chlorophyll Measurement

At the time of chemical analysis, the fresh curry leaves as well as the leaf samples that received the different postharvest and storage treatments were extracted with N, N-dimethylformamide and the chlorophyll content was determined by the method of Inskeep and Bloom (1985).

High Performance Liquid Chromatography

A Restek reversed phase Ultra C18 column (150 mm, 4.6 mm i.d., 5 mm particle size; Restek Corporation, Bellefonte, Pennsylvania) with a 20% carbon load, along with a Ultra C18 Guard column (10 mm, 4 mm i.d, 5 mm packing) and 50 mL injection loop (Rheodyne Inc, Cotati, California) were used with a HPLC (Perkin Elmer Binary LC Pump Model 250, PE Biosystems, Norwalk, Connecticut) fitted with a Perkin Elmer Diode Array Detector Model 235, set at the wavelengths of 270 nm for β-carotene and lutein, and 290 nm for α-tocopherol and α-tocopherol acetate as internal standard with an attenuation of 0.2 absorbance units. Monitoring at higher wavelengths caused detector saturation. The column was placed in a Perkin Elmer Oven Model 101 set at 35°C, and the data collected on a computer (PE Nelson Model 1022 LC computer). Two solvents were prepared for the mobile phase. A rapid 20 min gradient of 90% solvent mixture A: 85% acetonitrile, 2.5% hexane, 2.5% methylene chloride, and 10% methanol followed by 20 minutes of 100% solvent B: 50% acetonitrile, 20% hexane, 20% methylene chloride, and 10%

methanol at a flow rate of 1 mL min^{-1} was used. The column was allowed to equilibrate prior to the next injection with a 25-min gradient of 90% solvent A.

Prior to injection into the HPLC, the extract was filtered through a 4 mm, 0.2 mm nylon syringe filter (Alltech, Deerfield, Illinois). After filtering 200 mL extract was injected into the HPLC. The detector was optimized at 270 nm for β-carotene and lutein, and 290 nm for α-tocopherol. The peaks were identified with standards lutein (X6250), β-carotene (C4582), α-tocopherol (T3251), and α-tocopherol acetate (T3376) purchased from Sigma Chemical Co. (St. Louis, Missouri) and confirmed by LC/MS.

Mass Spectrometry

Mass spectra were monitored in the mass range m/z 300–700 on a Quattro II mass spectrometer equipped with an atmospheric pressure chemical ionization (APCI) interface (Micromass, Beverly, Massachusettes). The capillary temperature was set to 150°C, the APCI vaporizer temperature was set to 450°C. The corona discharge voltage was optimized at 3 kV. The same column and LC conditions used in the HPLC-UV diode array experiments were also used for the LC-MS experiments, however the flow rate was reduced to 0.3 mL min^{-1}.

RESULTS

Lutein

The fresh curry leaves had the highest concentration of lutein and the frozen leaves had the lowest concentration of lutein (Table 1). Frozen curry leaves contained 70% less lutein than fresh leaves. Curry leaves subjected to oven-drying and air-drying contained 60% less lutein compared to fresh leaves.

Table 1. Anti-oxidant vitamin contents in curry leaves and post harvest storage temperature and treatment (mean concentration per gram dry weight±SD).

Post harvest storage temperature and treatment	Lutein (µg/g)	α-tocopherol (ng/g)	β-carotene (ng/g)	Chlorophyll (mg/g)
Fresh	27±2.8	592±10.1	511±10.5	27.8±1.2
Oven-dried (60°C)	11±1.9	296±8.2	148±1.2	9.9±1.2
Air-dried (22°C)	10±2.1	515±8.5	357±1.3	18.9±1.1
Frozen (-15°C)	8±2.5	589±11.2	398±1.5	26.9±1.1

α-Tocopherol

The α-tocopherol concentrations of the fresh leaves were unaffected by freezing at –15°C (Table 1). Air-drying at 22°C resulted in a lower loss of α-tocopherol (13%) compared to oven-drying where 50% of α-tocopherol was lost.

β-Carotene

The β-carotene concentration was highest in fresh leaves and lowest in the oven-dried leaves (Table 1). The loss of β-carotene were 22% in frozen, 30% in air-dried, and 71% in oven-dried samples.

Chlorophyll

The fresh and the frozen curry leaves had similar chlorophyll concentrations (Table 1). Oven-drying resulted in a greater loss (~64%) of chlorophyll compared to air-drying (~32%).

DISCUSSION

Our results report a lower loss of β-carotene and apparently no loss of α-tocopherol and chlorophyll concentration in curry leaf frozen at –15°C compared to air-drying or oven-drying. However, the loss of lutein in the frozen samples was higher perhaps due to destruction of lutein during the freezing process. The loss of β-carotene, α-tocopherol, and chlorophyll when air-dried or oven-dried may be attributed to loss of these compounds due to oxidation. Our results identify freezing at –15°C as an acceptable practical way of storing curry leaves. Air-drying resulted in higher retention of vitamins β-carotene and α-tocopherol compared to oven-drying.

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Index | Search | Home

Cyamopsis tetragonoloba (L.) Traub

Leguminosae

Guar, Clusterbean, *Gwaar ki phalli*

We have information from several sources:

Guar: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Cydonia oblonga Mill.

Rosaceae

Coines, Coing, Cydonian apple, Elephant apple, Maja pahit, Ma-tum, Pineapple quince, Quince, Quitte, Vilvam

NewCROP has information from:

Food and feed crops of the United States—Magness J.R. et al. 1971.

Outside links:

Insect Pollination of Quince from BeeCulture

Quince from Agroforestry News

Quince University of Georgia

Quince accessions available from the National Germplasm Repository, Corvallis, Oregon.

Quince from M. Grieve's Modern Herbal.

LEMONGRASS

Family: Poaceae (Gramineae), *Cymbopogon* species

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Lemongrass, a perennial herb widely cultivated in the tropics and subtropics, designates two different species, East Indian, *Cymbopogon flexuosus* (DC.) Stapf., and West Indian, *Cymbopogon citratus* (DC. ex Nees) Stapf. East Indian lemongrass, also known as cochin or Malabar grass is native to India, while West Indian lemongrass is native to southern India and Ceylon. The lemongrasses are cultivated commercially in Guatemala, India, the People's Republic of China, Paraguay, England, Sri Lanka, and other parts of Indochina, Africa, Central America, and South America (11.1-73). The plant grows in dense clumps up to 2 meters in diameter and has leaves up to 1 meter long.

The reported life zone for lemongrass is 18 to 29 degrees centigrade with an annual precipitation of 0.7 to 4.1 meters with a soil pH of 5.0 to 5.8 (East Indian) or 4.3 to 8.4 (West Indian) (14.1-9). The plants need a warm, humid climate in full sun. They grow well in sandy soils with adequate drainage. Since the plants rarely flower or set seed, propagation is by root or plant division. The plants are harvested mechanically or by hand about four times each year with the productive populations lasting between four and eight years (14.1-9). Extensive breeding programs have developed many varieties of lemongrass.

The quality of lemongrass oil is generally determined by the content of citral, the aldehyde responsible for the lemon odor. Some other constituents of the essential oils are -terpineol, myrcene, citronellol, methyl heptenone, dipentene, geraniol, limonene, nerol, and farnesol (14.1-9). West Indian oil differs from East Indian oil in that it is less soluble in 70 percent alcohol and has a slightly lower citral content (14.1-9).

Lemongrass is used in herbal teas and other nonalcoholic beverages in baked goods, and in confections. Oil from lemongrass is widely used as a fragrance in perfumes and cosmetics, such as soaps and creams. Citral, extracted from the oil, is used in flavoring soft drinks in scenting soaps and detergents, as a fragrance in perfumes and cosmetics, and as a mask for disagreeable odors in several industrial products. Citral is also used in the synthesis of ionones used in perfumes and cosmetics (11.1-73, 14.1-9).

As a medicinal plant, lemongrass has been considered a carminative and insect repellent. West Indian lemongrass is reported to have antimicrobial activity (1.8-84, 1.8-130). Oil of West Indian lemongrass acts as a central nervous system depressant (7.6-187). Oil of East Indian lemongrass has antifungal activity (1.8-132). The volatile oils may also have some pesticide and mutagenic activities (11.1-96, 11.1-136).

Cymbopogon nardus is a source of citronella oil. *Cymbopogon martinii* is reportedly toxic to fungi (1.8-53).

Lemongrass is generally recognized as safe for human consumption as a plant extract/essential oil (21 CFR section 182.20 [1982]).

[Note: References listed above in parentheses can be found in full in the original reference].

Last modified 6-Dec-1997

Motha or Nut Grass (*Cyperus rotundus*)

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Scientific name: *Cyperus rotundus* L. syn. *C. hexastachyos* Rottb.
Family: Cyperaceae
English Name: Nut Grass
Common Indian Names
Gujarati: Motha
Hindi: Motha, Mutha
Canarese: Koranarigadde, Tungegaddo, Tungehullu
Marathi: Bimbal, Nagarmotha, Motha
Sanskrit: Bhadramusta, Granthi, Kachhda, Mustako, Sugandhi-granthila
Tamil: Korai
Telugu: Tungagaddi

Botanical Description: A perennial, stolaniferous, rhizomatus, halophytic sedge. Rhizome many, slender; Tuber-white, succulent when young, hard and black when mature; stem-leafy at base arising from a tuber. Culm-dark green, glabrous. Leaf dark green above, with reddish brown sheaths, clustered at the base of stem. Inflorescence 3-9 spreading rays bearing tassels of few, large spikelets; spikelet 20-40 flowered, red brown to almost black. Fruit oblong ovate.

Useful Parts: Tubers

Medicinal Uses: According to the Ayurveda, root is pungent, acrid, cooling, astringent, appetizer, stomachic, anthelmintic and useful in treatment of leprosy, thirst, fever, blood diseases, biliousness, dysentery, pruritis, pain, vomiting, epilepsy, opthalmia, erysipelas etc. According to the Unani system of medicine, the root is diuretic, emmenagogue, diaphoretic, anthelmintic, vulnerary and useful for ulcers and sores, fevers, dyspepsia, urinary concretions etc.

Other Uses
Useful in checking soil erosion.
The tuber yields an essential oil (0.5-0.9%), which is used in perfumery and incense.

Other Links

Interactions with the traditional healers of Bagbahera region specialized in use of Gondla (Cyperus rotundus) as medicine botanical.com/site/column_poudhia/133_gondla.html

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Cyperus papyrus L.

Cyperaceae
Papyrus

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Very important in ancient Egypt (as early as 2,400 BC), papyrus was used for food, medicine, fiber and shelter. According to Tackholm and Drar (1973), Egyptians have used papyrus additionally for formal bouquets funeral garlands, boats, cordage, fans, sandals, mattings corkage, boxes, and paper. It was one of the most favorite plants of Ancient Egypt. The pith of papyrus was recommended for food, while the starchy rhizomes and lowermost parts of the stem were cut off and consumed raw, boiled or roasted. They were also chewn, sucked, and spit out, much as sugar cane is done today. Papyrus was also a favorite ornament in ancient art and craft. Umbel impressions were often used as handles for mirrors, fans, doors, chairs and various household furniture. Papyrus stems were used for caulking seams in wooden ships. Papyrus mats are used for making fences and huts. For paper, the ancients stripped the fibrous coverings off the stem, and slit the inner pith into waferlike strips. Laid side by side, with others placed crosswise on top, the strips were dampened, pressed, so the glue-like sap cemented them together, and dried into a sheet. (NAS, 1976)

Folk Medicine

Galen, Dioscorides and later Islamic pharmacologists, e.g. Ibn Gulgul and El Ghafiqi, included papyrus among medicinal plants. The pith was recommended for widening and drying of fistula. The main use, anyhow, seems to have been confined to burnt papyrus sheets, the ash of which was reputed to have the action of pulverised charcoal and used for certain eye diseases. Dioscorides (in 78 AD) writes that its ash checks malignant ulcers from spreading in the mouth or elsewhere. Galen (129-200 AD) says that the plant is not used in a raw state but if macerated in vinegar and burnt, the ash heals wounds. Europeans also list this among their folk cancer cures.

Chemistry

Glucose, fructose, unreduced polysaccharides and xylan are (List and Horhammer, 1969-1979). A sample of the stems of papyrus representing the new growth of 1917 was forwarded to the Imperial Institute, London, by the Ministry of Agriculture next year. The Institute reported that the results of the investigation indicated that these stems only furnish a moderate yield of pulp of fair quality which contained a quantity of parenchyma and was rather difficult to bleach. Pulp suitable for brown paper was prepared from the stems by mild treatment, but only cream-colored paper could be produced by treating the stems under more drastic conditions similar to those employed technically for the manufacture of white paper.

Description

Tall, robust, leafless aquatic, up to 4 m high. Culms stout, smooth, trigonous, surrounded at base with coriaceous, large acuminate sheaths. Umbel-rays numerous, filiform, 10-45 cm long, each surrounded at base with a narrow, brown, cylindrical sheath, up to 3 cm long. Secondary umbels 3-5-rayed, supported by narrow, elongated bracts. Spike 1-2 cm long, 6-10 mm broad. Spikelets 6-10 mm long, 1 mm broad, 6-16-flowered.

Germplasm

The plant cultivated in Egypt belongs to the subsp. *antiquorum* (Willd.) Chiov. It differs from the type by its lax, shortly peduncled spikes, also by the connective which is not or hardly exserted above the anther halves (in type producing a point 1-3 times as long as the breadth of the anther). ($2n$ = ca 102)

Distribution

The papyrus reeds form vast stands in swamps, in shallow lakes, and along stream banks throughout Africa. It is considered a weed in the Sudan, Dahomey and Egypt. Uganda has ca 6,500 km^2 of permanent swamp or wetlands, much of it covered in papyrus. Occurs also in Sicily and Palestine. According to Baumann (1960) the plant grows over a wide area bounded roughly by the

38th and 26th parallels on the north and south, and by the 65th and 32nd on the east and west, but is virtually absent in the lower Nile marshes where it flourished in ancient times.

Ecology

Many African swamps known as the Sudd in Central Africa, are dominated by papyrus thickets, which totally block navigation. It is estimated that the Sudd areas of the White Nile, and the "Papyrus Swamps" around Lake Kioga and Victoria are responsible for the loss of 50% of that river's water through evaporation and plant transpiration. Engineers plan to shortcut the Sudd and hence increase Egypt's summer water supply. In Egypt the plant flowers throughout the year, except winter. Papyrus is estimated to range from Subtropical to Tropical Desert to Wet Forest Life Zones, tolerating annual precipitation of 1-42 dm, annual temperatures of 20-30°C, and pH of 6.0-8.5.

Cultivation

Propagation is done in Egypt by rootstock divisions any time in spring and summer. It is recorded, however, to produce fertile seeds under our climatic conditions. In Egypt, it is sufficient to keep seed pots under boxes covered with glass to obtain the required result. Seedlings can be raised from seed. No escape seedlings, however, have been found in Egypt, and it is said that under the most favorable conditions seeds do not germinate without the intervention of man. The rootstock should remain submerged under water, especially during summer, or at least, the soil must be kept sufficiently moist during the growing season to obtain a remunerative crop of fairly thick and long shoots. Plants grown in ordinary field beds are weaker than those grown in deeper channels at the same garden.

Harvesting

No data available.

Yields and Economics

A C4 plant, this species has reported to produce above-ground biomass of 30-50 MT/ha/yr, highest of ten emergent species studied by Kresovich et al. (1981), and higher than the 15-33 MT they report for corn and sweet sorghum. They estimate, in 1979 dollars, the costs of cultivating such emergents as $70-580/ha for planting 138-297 for crop maintenance, 37-199 for harvesting, and 55-234/ha for drying and densification.

Energy

Since early this century, Egypt has devoted great effort to clear the swamp vegetation which could, of course, be converted to an energy resource. Cleared channels are blocked again with the vegetation. Still harvesting papyrus for commercial use is seldom seriously considered, Westlake (1963) reports standing DM biomass as high as 70 MT/ha.

Biotic Factors

No data available.

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Complete list of references for Duke, Handbook of Energy Crops

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last update July 9, 1996

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Cyphomandra betacea (Cav.) Sendt.

syn. *Solanum betaceum* Cav.

Solanaceae

Tamarillo, Tomarillo, Tree tomato, Palo de tomate, Tomate de arbol

NewCROP has Tamarillo - Tree tomato information at:

Tree Tomato—Julia Morton, Fruits of Warm Climates

New Horticultural Crops in New Zealand—Errol W. Hewett

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

"New" Solanums—Charles Heiser and Gregory Anderson

Magness J.R. et al. 1971. Food and feed crops of the United States.

Outside links:

Tamarillo can be found in Lost Crops of the Incas from National Academy Press

TREE TOMATO "FRUIT FACTS" (Fruit Facts are a series of publications of the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Tamarillo info from the Department of Food and Agriculture, California.

Fruit nutritional information from Freida's Inc.

There are about 30 *Cyphomandra* species from the American tropics. Other *Cyphomandra* species sometimes cultivated are:

- *Cyphomandra casana* - Casana
- *C. crassifolia* - Mountain tomato
- *C. fragrans* - Guava tamarillo

Ladyslipper

(1) *Cypripedium pubescens* Willd.; (2) *C. parviflorum* Salisb.

Figure 71.—Common yellow ladyslipper (*Cypripedium pubescens*)

Other common names.—(1) Common yellow ladyslipper, large yellow ladyslipper, yellow ladyslipper, yellow moccasin flower, Venus's-shoe, Venus's-cup, yellow Indian shoe, American valerian, nerveroot, male nervine, yellow Noah's-ark, yellows, monkeyflower, umbil-root, yellow umbil; (2) small yellow ladyslipper.

Habitat and range.—Both of these species frequent bogs and wet places in deep shady woods and thickets. The large yellow ladyslipper may be found from Nova Scotia south to Alabama and west to Nebraska and Missouri. The range for the small yellow ladyslipper extends from Newfoundland south along the mountains to Georgia and west to Missouri, Washington, and British Columbia.

Description.—These plants are readily recognized by the peculiar shape of their flowers. These appear in May and June, are very showy, and have a curiously formed lip which resembles an inflated bag, pale or bright yellow in color, variously striped or blotched with purple. In Cypripedium pubescens this lip is 1 to 2 inches in length, while in C. parviflorum it is smaller and somewhat more prominently striped. Both species grow from 1 to 2 feet in height and have rather large leaves from 2 to 6 inches long and from 1 to 3 inches wide, with numerous parallel veins. The rootstock is horizontal, crooked, and fleshy with numerous fibrous roots. It has a heavy disagreeable odor and a sweetish, bitter, and somewhat pungent taste.

Part used.—The rootstock and roots, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

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Dalbergia sissoo Roxb. ex DC.

Fabaceae
Sisu, Sissoo, Indian rosewood

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Timber tree, the young branches and foliage eaten by livestock. After teak, it is the most important cultivated timber tree in India, planted on roadsides, and as a shade tree for tea plantations. Sissoo makes first class cabinetry and furniture. It is used for plywood, agricultural, and musical instruments, skis, carvings, boats, floorings, etc. The leaves are used for fodder. In the U.S. (Arizona, Florida) it is said to be one of the most desirable shade trees for streets and backyards. It is grown in the sewage-irrigated greenbelt arount Khartoum, Sudan.

Folk Medicine

Reported to be stimulant, sissoo is a folk remedy for excoriations, gonorrhea, and skin ailments (Duke and Wain, 1981). Ayurvedics prescribe the leaf juice for eye ailments, considering the wood and bark abortifacient, anthelmintic, antipyretic, apertif, aphrodisiac, expectorant, and refrigerant.

They use the wood and bark for anal disorders, blood diseases, burning sensations, dysentery, dyspepsia, leucoderma, and skin ailments. Yunani use the wood for blood disorders, burning sensations, eye and nose disorders, scabies, scalding urine, stomach problems, and syphilis. The alterative wood is used in India for boils, eruptions, leprosy and nausea (Kirtikar and Basu, 1975).

Chemistry

Per 100 g, the leaves contain on a zero-moisture basis 12.6-24.1 g protein, 2.0-4.9 g fat, 42.1-54.8 g N-free extract, 12.5-26.1 g fiber, 6.6-12.0 g ash, 840-2870 mg Ca, 120-420 mg P. On a dry basis, the silage contain 14.0% CP 3.6% EE, 30.0% CF, and 34.1% NFE. Fresh leaves from Nigeria contained (ZMB) 21.8% CP, 15.6 g CF, 8.7 g ash, 3.6 g EE, 50.3 g NFE, 1,180 mg Ca, and 250 mg P per 100 g (Gohl, 1981). Pods contain 2% tannin.

Description

Tree 15-35 m tall, deciduous, the sometimes >2m, the clearbole up to 12 m, more often with crooked trunk and light crown. Leaves alternate, imparipinnate, the leaflets 3-5, alternate, orbicular, abruptly acuminate, puberulous but glabrescent, 3.5-6.5 cm long, not quite so broad. Flowers sessile, or short-stalked in axillary panicles shorter than the leaves. Sepals 4-5 mm long, pubescent, the lobes short. Petals yellow, 6-8 mm long. Ovary pubescent; ovules 2-4. Pods to 10 cm long, 1.5 cm broad, the stipe longer than the calyx. Seeds 1-4.

Germplasm

Reported from the Hindustani Center of Diversity, sissoo, or cvs thereof, is reported to tolerate disease, drought, frost, insects, porous soils, salt, sand, savanna, sewage, and wind. On clay soils the growth is stunted. ($2n = 20$)

Distribution

Indigenous to India, Nepal, and Pakistan, the tree is now widely planted in the tropics. Said to be escaping from cultivation in tropical Florida. It is grown at Cayey, El Verde, and Guayabol in Puerto Rico.

Ecology

Ranging from sealevel to >1500 m, it can stand temperatures from below freezing to nearly 50°C. Apparently adapted to savanna woodlands where annual rainfall is 7-20 dm with droughts of 3-4 months duration (NAS, 1979). Sometimes gregarious in alluvial forests along the rivers of the subhimalayan tract (C.S.I.R., 1948-1976). Ranging from Subtropical Thorn to Moist through Tropical Dry to Moist Forest Life Zones, sissoo is expected to tolerate annual precipitation of 6 to 40 dm, annual temperature of 21 to 28°C, and pH of 6-8.

Cultivation

Directly sown seed attain 15-25 cm after the first rains, 90-120 cm after the second rains in India. For seedling transplantation, only tender plants with small taproots should be used. Root suckers transplant satisfactorily in dry climates. Planting should be in spring (March in India). Raising of monocultural sissoo is discouraged. Stump planting is widely employed in irrigated plantations in India. Trenches are dug ca 1.5 m apart, earth thrown a little away from the trenches and the berms used for sowing seed or pod segments. Sowing is done on both sides of the trenches, between middle March and middle June, earlier sowing being preferred. Plants are big enough by the beginning of the next season to yield stumps. Plants are pulled out and stems and roots chopped off leaving 3-5 cm of the former and 22-35 m of the latter; ther lateral roots are also removed. Stumps thicker than 2.5 cm and thinner than 2 cm diam. at the collar are rejected. The yield of stumps is 160,000 per ha. For transport over long distances, stumps are made into bundles, wrapped in leaves or grass, sprinkled with water, and carried in gunny bags. Stumps are planted in spring, not earlier than the third week of March, perhaps April. In no case should it be put off to August. Where subsoil water is low or rainfall poor and uncertain, irrigation is essential. Stumps are planted along trenches or on berms of pits and the field is irrigated. Shallow and frequent irrigation or constant flooding is harmful and induces superficial root formation. Depending upon the weather and the condition of plants, 10-15 irrigations are adequate in the first season and 4-6 in the second. Under proper irrigation, sissoo roots tap the subsoil water within 2 years. Irrigation in later years is required only for supplementing subsoil water supplies.

Harvesting

Trees may be grazed or cut as needed. Young trees coppice vigorously and reproduce vigorously from suckers.

Yields and Economics

According to the Wealth of India, irrigated plantations yield fair quantities of timber and high returns of fuel. In irrigated plantations trees may attain a girth of 1.2 m in ca 25 years. A height of 7 m has been reported in 20 months. Based on studies of 40 natural riverine sites, it was concluded that 10 year stands yield about 10 m^3/ha, 20 year ca 100 m^3/ha (5m^3/ha/yr), 30 year old stands ca 210 m^3/ha (7 m^3/ha/yr), 40 year old stands ca 2 80 m^3/ha (7 m^3/ha/yr), 50 year old stands 370 m^3/ha (7.5 m^3/ha/yr), and 60 year old stands 460 m^3/ha (ca 7.5 m^3ha/yr) (C.S.I.R., 1948-1976). Pakistan has more than 100,000 ha of sissoo plantation.

Energy

The calorific value of the sapwood is 4,908 calories or 8,835 Btu, the heartwood 5,191 calories or 9,326 Btu (probably per cu. ft., but not specified in WOI). The wood is an excellent fuel, eminently suitable for making charcoal. Heartwood yields 5.35% of an oil which, on cooling, approaches the texture of vaseline. It is suitable as a lubricant for heavy machinery.

Biotic Factors

Roots are said to be so astringent as not to be eaten by ants or rodents, at least rats. Browne (1968) lists: Fungi. *Auricularia auricula-judae, Colletoglocum sissoo, Diplodia dalbergiae, Fomes durissimus, Fomes robiniae, Fusarium oxysporum, Ganoderma applanatum, Ganoderma lucidum, Hypoxylon hypomiltum, Hypoxylon investiens, Hypoxylon rubiginosum, Irpex flavus, Marasmius equierinis, Maravalia achroa, Meliola bicornis, Mycosphaerella dalbergiae, Nectria haematococca, Phellinus gilvus, Phyllachora dalbergiae, Phyllachora spissa, Phyllactinia guttata, Phyllosticta sissoo, Polysporus anebus, Poria ambigua, Rosellinia aquila, Schizophyllum commune, Thanatephorus cucumeris, Trametes corrugata, Uredo sissoo.* Angiospermae. *Cuscuta reflexa, Dendrophthoe falcata, Loranthus pulverulentus, Tapinanthus dodoneifolius, Tapinanthus* sp., *Tolypanthus involucratus.* Coleoptera. *Adoretus caliginosus, Amblyrrhinus poricollis, Anomala dalbergiae, Apate monachus, Apate terebrans, Apoderus blandus, Apoderus sissu, Aulacophora foveicollis, Batocera rufomaculata, Bruchus pisorum, Dorysthenes hugeli, Gonocephalum depressum, Halyzia sanscrita, Illeis cincta, Mimastra cyanura, Myllocerus blandus, Myllocerus cardoni, Myllocerus discolor, Myllocerus lefroyi, Myllocerus sabulosus, Myllocerus setulifer, Myllocerus transmarinus, Myllocerus undecimpustulatus, Perissus dalbergiae, Platymycterus sjoestedti, Rhinyptia indica, Sinoxylon anale, Tanymecus hispidus.* Hemiptera. *Acaudaleyrodes rachipora, Aleurolobus marlatti, Aonidiella orientalis, Aspidoproctus bifurcatus, Atelocera stictica, Dialeuropora decempuncta, Drosicha dalbergiae, Drosicha mangiferae, Drosicha octocaudata, Drosicha stebbingi, Gargara mixta, Gargara varicolor, Hemaspidoproctus cinerea, Hemiberlesia lataniae, Kerria lacca, Myzus persicae, Nipaecoccus vastator, Oxyrhachis formidabilis, Oxyrhachis mangiferana, Toxoptera aurantii.* Isoptera. *Bifiditermes beesoni*. Lepidoptera. *Anomis sabulifera, Archips micaceanus, Ascotis selenaria, Bucculatrix mendax, Buzura suppressaria, Caloptilia tetratypa, Charaxes fabius, Cladobrostis melitricha, Cusiala raptaria, Cydia jaculatrix, Dasychira dalbergiae, Dasychira mendosa, Dichomeris eridantis, Eresia hylas, Euproctis scintillans, Euproctis sulphurescens, Euproctis virguncula, Hamodes propitia, Heliothis zea, Hypena iconicalis, Hypoglaucitis benenotata, Hyposidra talaca, Leucoptera stenograpta, Pandesma anysa, Philodoria laeta, Plecoptera ferrilineata, Plecoptera reflexa, Sataspes scotti, Thosea cana, Trichoplusia orichalcea*. Orthoptera. *Brachytrupes portentosus, Chrotogonus* spp., *Gymnogryllus erythrocephalus, Gymnogryllus humeralis, Kraussaria angulifera, Schistocerca gregaria*. Mammalia. *Bos taurus, Ovis aries, Presbytis entellus.* Nematoda. *Meloidogyne javanica*. The tree is sometimes killed by mistletoe. Fusarium wilt is often fatal in India, especially in monoculture, or in polyculture with other susceptible species (C.S.I.R., 1948-1976).

References

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- C.S.I.R. (Council of Scientific and Industrial Research). 1948-1976. The wealth of India. 11 vols. New Delhi.
- Duke, J.A. and Wain, K.K. 1981. Medicinal plants of the world. Computer index with more

than 85,000 entries. 3 vols.

- Gohl, B. 1981. Tropical feeds. Feed information summaries and nutritive values. FAO Animal Production and Health Series 12. FAO, Rome.
- Kirtikar, K.R. and Basu, B.D. 1975. Indian medicinal plants. 4 vols. 2nd ed. Jayyed Press, New Delhi.
- N.A.S. 1979. Tropical legumes: resources for the future. National Academy of Sciences, Washington, DC.

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Dallisgrass

Gramineae *Paspalum dilatatum* Poir.

Source: Magness et al. 1971

This is a major pasture grass in the Cotton Belt. It was introduced from South America around 1875. It is an upright-growing bunchgrass, which requires moist soil. It is not hardy north of the Cotton Belt. It does not form a dense sod, so is well suited to mixed planting with legumes or other grasses. It is palatable and nutritious. It tolerates fairly close grazing, and should be grazed to prevent accumulation of dead leaves and stems. It is susceptible to ergot fungus which is poisonous to livestock.

Last update February 18, 1999 by ch

Taraxacum officinale Wiggers

Asteraceae (Compositae)

Dandelion

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, April 20, 1998 by aw

Ziziphus jujuba Mill.

Rhamnaceae

Jujube, Ber, Chinese Date, Chinese jujube,
Chinese red date, Common jujube, Cottony jujube, Indian jujube, Tsao

NewCROP has Jujube information at:

Magness J.R. et al. 1971. Food and feed crops of the United States.

Chinese Medicinals—Albert Y. Leung

And outside links to more Jujube info:

JUJUBE "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Phoenix dactylifera L.

Arecaceae

Date, Bahri date, Date palm, Deglet Noor date, Dry date, Madjool date, Red date, Semisoft date, Soft date, Zahidi date

We have information from several sources:

Date—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Datura spp.

Datura stramonium L.

Solanaceae

NewCROP has the following information:

Jimson weed —A.F. Seivers, The Herb Hunters Guide

Datura or Dhattura, *Datura stramonium* L.—Pankaj Oudhia

Pongamia pinnata (L.) Pierre

Syn.: *Pongamia glabra* Vent.
Derris indica Bennet
Fabaceae
Pongam, Indian beech

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The pongam tree is cultivated for two purposes: (1) as an ornamental in gardens and along avenues and roadsides, for its fragrant Wisteria-like flowers, and (2) as a host plant for lac insects. It is appreciated as an ornamental throughout coastal India and all of Polynesia. Well-decomposed flowers are used by gardeners as compost for plants requiring rich nutrients. In the Philippines the bark is used for making strings and ropes. The bark also yields a black gum that is used to treat wounds caused by poisonous fish. In wet areas of the tropics the leaves serve as green manure and as fodder. The black malodorous roots contain a potent fish-stupefying principle. In primitive areas of Malaysia and India root extracts are applied to abscesses; other plant parts, especially crushed seeds and leaves are regarded as having antiseptic properties. The seeds contain pongam oil, a bitter, red brown, thick, non-drying, nonedible oil, 27–36% by weight, which is used for tanning leather, soap, as a liniment to treat scabies, herpes, and rheumatism and as an illuminating oil

(Burkill, 1966). Also used for lubrication and indigenous medicine. Pongam oil showed inhibitory effects on *Bacillus anthracis, Bacillus mycoides, Bacillus pulilus, Escherichia coli, Pseudomonas mangiferae, Salmonella typhi, Sarcina lutea*, *Staphylococcus albus*, *Staphylococcus aureus*, and *Xanthomonas campestris*, but did not inhibit *Shigella* sp. (Chaurasia and Jain, 1978). The oil has a high content of triglycerides, and its disagreeable taste and odor are due to bitter flavonoid constituents, pongamiin and karanjin. The wood is yellowish white, coarse, hard, and beautifully grained, but is not durable. Use of the wood is limited to cabinetmaking, cart wheels, posts, and fuel (Allen and Allen, 1981). Both the oil and residues are toxic. Still the presscake is described as a "useful poultry feed." Seeds are used to poison fish. Still it is recommended as a shade tree for pastures and windbreak for tea. The leaves are said to be a valuable lactagogue fodder, especially in arid regions. It is sometimes intercropped with pasture, the pasture grasses said to grow well in its shade (NAS, 1980a). Dried pongam leaves are used in stored grains to repel insects. Leaves often plowed green manure, thought to reduce nematode infestations. Its into ground as spreading roots make it valuable for checking erosion and stabilizing dunes. Twigs are used as a chewstick for cleaning the teeth. The ash of the wood is used in dyeing.

Folk Medicine

According to Hartwell (1967–1971), the fruits and sprouts are used in folk remedies for abdominal tumors in India, the seeds for keloid tumors in Sri Lanka, and a powder derived from the plant for tumors in Vietnam. In sanskritic India, seeds were used for skin ailments. Today the oil is used as a liniment for rheumatism. Leaves are active against *Micrococcus*; their juice is used for colds, coughs, diarrhea, dyspepsia, flatulence, gonorrhea, and leprosy. Roots are used for cleaning gums, teeth, and ulcers. Bark is used internally for bleeding piles. Juices from the plant, as well as the oil, are antiseptic. It is said to be an excellent remedy for itch, herpes, and pityriasis versicolor. Powdered seeds are valued as a febrifuge, tonic and in bronchitis and whooping cough. Flowers are used for diabetes. Bark has been used for beriberi. Juice of the root is used for cleansing foul ulcers and closing fistulous sores. Young shoots have been recommended for rheumatism. Ayurvedic medicine described the root and bark as alexipharmic, anthelmintic, and useful in abdominal enlargement, ascites, biliousness, diseases of the eye, skin, and vagina, itch, piles, splenomegaly, tumors, ulcers, and wounds; the sprouts, considered alexeteric, anthelmintic, apertif, and stomachic, for inflammation, piles and skin diseases; the leaves, anthelmintic, digestive, and laxative, for inflammations, piles and wounds; the flowers for biliousness and diabetes; the fruit and seed for keratitis, piles, urinary discharges, and diseases of the brain, eye, head, and skin, the oil for biliousness, eye ailments, itch, leucoderma, rheumatism, skin diseases, worms, and wounds. Yunani use the ash to strengthen the teeth, the seed, carminative and depurative, for chest complaints, chronic fevers, earache, hydrocele, and lumbago; the oil, styptic and vermifuge, for fever, hepatalgia, leprosy, lumbago, piles, scabies, and ulcers.

Chemistry

Reported to contain alkaloids demethoxy-kanugin, gamatay, glabrin, glabrosaponin, kaempferol, kanjone, kanugin, karangin, neoglabrin, pinnatin, pongamol, pongapin, quercitin, saponin, β-sitosterol, and tannin. Air-dry kernels have 19.0% moisture, 27.5% fatty oil, 17.4% protein, 6.6% starch, 7.3% crude fiber, and 2.4% ash. Fatty acid composition: palmitic, 3.7–7.9%, stearic 2.4–8.9, arachidic 2.2–4.7, behenic 4.2–5.3, lignoceric 1.1–3.5, oleic, 44.5–71.3, linoleic 10.8–18.3, and eicosenoic 9.5–12.4%. Destructive distillation of the wood yields, on a dry weight basis: charcoal 31.0%, pyroligneous acid 36.69, acid 4.3%, ester 3.4%, acetone 1.9%, methanol 1.1%, tar 9.0%, pitch and losses 4.4%, and gas 0.12 cu m/kg. Manurial values of leaves and twigs are respectively: nitrogen 1.16, 0.71; phosphorus (P_2O_5), 0.14, 0.11; potash (K_2O), 0.49, 0.62; and lime (CaO), 1.54, 1.58%. Such manure reduces the incidence of *Meloidogyne javanica*.

Description

Fast growing, glabrous, deciduous, tree to ca 25 m tall, branchesdrooping; trunk diameter to 60 cm; bark smooth, gray. Leaves imparipinnate, shiny; young leaves pinkish red, mature leaves glossy, deep green; leaflets 5–9, the terminal leaflet larger than the others; stipels none; stipules caducous. Flowers fragrant, white to pinkish, paired along rachis in axillary, pendent, long racemes or panicles; calyx campanulate or cup-shaped, truncate, short-dentate, lowermost lobe sometimes longer; standard suborbicular, broad, usually with 2 inflexed, basal ears, thinly silky-haired outside; wings oblique, long, somewhat adherent to the obtuse keel; keel petals coherent at apex; stamens monadelphous, vexillary stamen free at the base but joined with others into a closed tube; ovary subsessile to short-stalked, pubescent; ovules 2, rarely 3; style filiform, upper half incurved, glabrous; stigma small, terminal. Pod short stalked, oblique-oblong, flat, smooth, thickly leathery to subwoody, indehiscent, 1-seeded; seed thick, reniform (Allen and Allen, 1981).

Germplasm

Reported from the Hindustani Center of Diversity, pongam, or cvs thereof, is reported to tolerate drought, frost, heat, limestone, salinity, sand, and shade. ($2n$ = 22)

Distribution

An Indomalaysian species, a medium-sized subevergreen tree, common on alluvial and coastal situations from India to Fiji, from sealevel to 1200 m. Now found in Australia, Florida, Hawaii, India, Malaysia, Oceania, Philippines, and Seychelles, for example.

Ecology

Probably ranges from Tropical Dry to Moist through Subtropical Dry to Moist Forest Life Zones. Withstanding temperatures slightly below 0°C to 50°C and annual rainfall of 5–25 dm, the tree grows wild on sandy and rocky soils, including oolitic limestone, but will grow in most soil types, even with its roots in salt water.

Cultivation

Seeds, remaining viable for sometime, require no special scarification. Direct sowing is usually successful. Seedlings transplant easily from the nursery after about a year. Root suckers are rather plentiful as well. It is a rapid-growing coppice species that can be cloned.

Harvesting

Pods are collected and shells removed by hand. Grown in 30-year rotations for fuel in West Bengal.

Yields and Economics

Trees of ten reach adult height in 4 or 5 years, bearing at the age of 4–7 years. A single tree is said to yield 9–90 kg seed per tree, indicating a yield potential of 900—9000 kg seed/ha, 25% of which might be rendered as oil (assuming 100 trees/ha). In general, Indian mills extract 24–27.5% oil, village crushers, 18–22% oil.

Energy

Wherever it is grown, the wood (calorific value 4,600 kcal/kg) is burned for cooking fuel (NAS, 1980a). The thick oil from the seeds is used for illumination, as a kerosene substitute, and lubrication. It would seem that with upgraded germplasm one could target for 2 MT oil and 5 MT firewood per hectare per year on a renewable basis. The oil has been tried as fuel in diesel engines, showing a good thermal efficiency (C.S.I.R., 1948–1976).

Biotic Factors

Two rhizobial strains produced nodules on 18 species of 12 different genera in the cowpea miscellany. The strains, culturally and physiologically typical of slow-growing rhizobia, elicited ineffective responses on *Clitoria ternatea* and *Stizolobium utile*. One was ineffective on *Lespedeza stipulacea* and *Samanea saman*. Browne (1968) lists: Viruses. Sandal Spike Virus. Fungi. *Fusicladium pongamiae, Ganoderma lucidum, Phyllachora pongamiae, Ravenelia hobsoni, Ravenelia stictica.* Angiospermae. *Cuscuta reflexa, Loranthus* sp. (?). Acarina. *Eriophyes cheriani.* Diptera. *Microdiplosis pongamiae, Myricomyia pongamiae.* Hemiptera. *Coptosoma cribrarium, Drosicha stebbingi, Drosichiella tamarinda.* Lepidoptera. *Acrocercops anthracuris, Amphion floridensis, Cydia balanoptycha, Cydia perfricta, Eresia jumbah, Indarbela tetraonis, Jamides celeno, Phyllonorycter virgulata.* Orthoptera. *Schistocerca gregaria.* Thysanoptera. *Megalurothrips distalis.*

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Complete list of references for Duke, Handbook of Energy Crops

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Last update January 8, 1998 by aw

Dichanthium annulatum (Forsk.) Stapf.

Poaceae

Diaz bluestem, Marvel

We have information from several sources:

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update August 23, 1996 by aw

Digitalis spp.

Scrophulariaceae

Foxglove

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Monday, April 20, 1998 by aw

Digitaria decumbens Stent

Poaceae

Pangola grass, Slenderstem, Transvala digitgrass

We have information from several sources:

African Grasses—Glenn W. Burton

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update October 27, 1997

Dimocarpus longan Lour.

syn: *Euphoria longan* (Lour.) Steud.

Sapindaceae

Cat's-eye, Dragon's-eye, Longan, Long an, Longyen, Lungan

We have information from several sources:

Longan—Julia Morton, Fruits of warm climates

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Dimorphotheca pluvialis (L.) Moench

Asteraceae or Compositae

We have information from several sources:

Dimorphotheca pluvialis: A new source of hydroxy fatty acid. Lysbeth Hof, 1996.In: J. Janick (ed.), Progress in new crops. p. 372-377. ASHS Press, Arlington, VA.

See: Dimorphotheca In: Economic evaluation of new oilseed crops for The Netherlands. Boswinkel, G., J.T.P. Derksen, and F.P. Cuperus. 1996. In: J. Janick (ed.), Progress in new crops. p. 296-299. ASHS Press, Alexandria, VA.

Dimorphotheca See: Perspective from Europe, by Louis J.M. van Soest Centre for Plant Breeding and Reproductive Research

Dimorphotheca See: Characterization and Processing Research for Increased Industrial Applicability of New and Traditional Crops: A European Perspective W.M.J. van Gelder, F.P. Cuperus, J.T.P. Derksen, B.G. Muuse, and J.E.G. van Dam

Dimorphotheca seeds contain about 20% oil, with 60-65% of dimorphecolic acid - a highly reactive C18 fatty acid with one hydroxy-group and two conjugated double bonds. Experimental seed yields are about 1.2-1.7 tons/hectare.

last update April 23, 1998 by bha

Dioscorea batatas Deene.

Dioscorea alata L.

Dioscorea cayenesis Lam.

Dioscorea rotundata Poir.

Dioscoreaceae

Yam

We have information from several sources:

Tropical Root and Tuber Crops—Stephen K. O'Hair

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside Links:

Yam—FAO/IPGRI Technical Guidelines for the Safe Movement of Yam Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Yam—Descriptors for Yam—Link to the publication on the International Plant Genetic Resources Institute web site

Name Mapuey

Cush Cush, Yampie, Napi

Dioscoreaceae *Dioscorea trifida* L.f.

Source: Magness et al. 1971

Tropical herb with large leaves which are 10 inches in length and 3 to 5 lobed. The edible subterranean tubers are small but of superior quality.

Last update February 18, 1999 by ch

Wild Yam

Dioscorea villosa L.

Figure 120.—Wild yam (*Dioscorea villosa*)

Synonym.—*Dioscorea paniculata* Michx.

Other common names.—Dioscorea, colicroot, rheumatism root, devil's-bones.

Habitat and range.—Wild yam grows in moist thickets, trailing over adjacent shrubs and bushes, its range extending from Rhode Island to Minnesota and south to Florida and Texas. It is most common in the central and southern portions of the United States.

Description.—The wild yam is a vine growing to a length of 15 feet with a smooth stem and heart-shaped leaves from 2 to 6 inches long and 1 to 4 inches wide, hairy on the under side, borne on long, slender stems. The small, greenish-yellow flowers are produced from June to July, the male flowers being borne in drooping clusters about 3 to 6 inches long and the female flowers in drooping, spikelike heads. The fruit, which is a yellowish-green 3-lobed capsule, ripens in September and remains on the vine for some time during the winter. The rootstock runs horizontally underneath the surface of the ground. It is only about one-fourth to one-half inch in diameter.

Part used.—The rootstock, generally collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Diospyros kaki L.f.

Ebonaceae

Kaki, Japanese Persimmon, Oriental Persimmon, Sharon Fruit

NewCROP has Kaki information at:

Japanese Persimmon—Julia Morton, Fruits of Warm Climates

Mediterranean Fruits—Joan Tous and Louise Ferguson

New Subtropical Tree Crops in California—Louise Ferguson and Marylu Arpaia

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Kaki info:

KAKI "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Growing Oriental Persimmons in North Carolina

Link to Diospyros virginiana,

the American Persimmon:

Diospyros virginiana L.

Ebonaceae

Persimmon

NewCROP has Persimmon information at:

Persimmons HO-108 Purdue University Cooperative Extension Service

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Persimmon info:

Statistical Persimmon Information

Link to Diospyros kaki, Kaki, or the Japanese or Oriental Persimmon:

Index|Search|Home

Diplotaxis tenuifolia (L.) DC.

Diplotaxis muralis (L.) DC.

Brassicaceae = Cruciferae

Arrugula, Rocket, Roquette, Rucola, Rughetta

Two species along with *Eruca sativa* known under the collective name Arrugula, Rocket, Roquette, Rucoloa, Rughetta.

We have information from several sources:

Arugula: A Promising Specialty Leaf Vegetable—Mario Morales and Jules Janick

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Outside links:

Rocket: A Mediterranean Crop For The World from the International Plant Genetic Resources Institute

Diplotaxis tenuifolia (L.) DC.: a diploid and perennial species, in the sense that the roots can survive winters and produce new sprouts in the next spring; it flowers from late spring to autumn and its seeds are generally ready for collecting in autumn. It seems to be very well adapted to harsh and poor soils, and often it can compete well with other species in calcareous shallow soils. This species has succulent leaves and is much apprciated in cuisine. In some Italian areas *D. tenuifolia* is also cultivated, but it is mostly collected from the wild and sold in small bunches in local markets.

Diplotaxis muralis (L.) DC.: polyploid and perennial, in the same sense as *D. tenuifolia*. It flowers from summer to autumn and its seeds are ready for sollecting in autumn. It grows in similar habitats as *D. tenuifolia* and is also collected from the wild to be sold in the markets. It seems less adapted to cultivation because of its procumbent growth habit, which is the main character distinguishing it from*D. tenuifolia*.

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Tonka bean oil

Leguminosae *Dipteryx odorata* (Aubl.) Willd.

Source: Magness et al. 1971

The oil is obtained from the seed of the above species, a tree native to Central and South America, but now cultivated to some extent in other tropical areas. The fruit is a pod about 2 inches long, containing a single fragrant seed. The seed after curing is used chiefly for scenting tobacco and snuff. The non-drying oil is used in flavoring.

Last update June 27, 1996 bha

DITTANY OF CRETE

Family: Lamiaceae (Labiatae), *Origanum dictamnus* L.

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Dittany of Crete, *Origanum dictamnus* L. (formerly *Amaracus dictamnus* Benth. or *Amaracus tomentosus* Moench.), is one of the best-known healing herbs of folklore. Native to the mountains of Crete and also called dittany or dictamnus, this perennial plant can reach a height of 0.3 meters. Procumbent white, woolly stems, usually trailing, develop pink or purplish flowers in the summer. The small gray leaves have a velvety texture.

Of minor importance today, dittany of Crete is primarily used as a potted plant or as an ornamental plant in garden borders. The flowers have been used in herbal teas, but the plant has no culinary value. As a medicinal plant, the herb has been utilized to heal wounds, soothe pain, cure snake bites, and ease childbirth. In addition, it has been used as a renedy against gastric or stomach ailments and rheumatism.

Dictamnus albus L. (*Dictamnus fraxinella* Pers.), known as dittany and fraxinella, is often confused with dittany of Crete. This perennial plant is of the Rutaceae family and reaches a height of approximately one meter. Grown as a garden plant with showy pink, purple or white flowers, its dried leaves can be used in teas. The plant has been used medicinally as a diuretic, emmenagogue, and expectorant. However, the seed pods can cause contact dermatitis. The plant is known as the gas plant because it will often give a burst of flame when a lighted match is held beneath the flower cluster (14.1-3).

Cunila origanoides Britt. is called dittany, Maryland dittany, and stone-mint. This low-growing perennial with a minty flavor is native to the eastern United States. The plant, which has been classified as *Satureja origanoides* L. and *Cunila mariana* L., is primarily used as an ornamental border in gardens, although the leaves may be used in herbal teas.

Dittany of Crete is generally recognized as safe for human consumption as a natural flavoring (21 CFR section 172.510 [1982]).

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Dock

Spinach dock, Herb patience

Polygonaceae *Rumex patientia* L.

Source: Magness et al. 1971

Spinach dock is a strong growing perennial, reaching 5 feet when in flower. Rosette leaves are 8 to 12 inches long, tapering at both ends. Stem leaves are rounded at the base. Leaves are used as greens, especially leaves which develop in early spring. Leaf exposure is similar to that of spinach.

Season, seed to harvest: 4 to 5 months. Leaves available in early spring from established roots.

Production in U.S.: No data. Negligible.

Use: Pot herb greens.

Part of plant consumed: Leaves only Last update February 18, 1999 by ch

Dronpushpi or Guma (*Leucas cephalotes*): A Useful Weed

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Leucas cephalotes (Roxb.) Spreng, Labiatae. is one of the common weeds found in Central and South India. It is upland rainy season weed. In India, it is commonly known as Dronpushpi (Dron = bunds, Pushpi = flowering plant). It is commonly occur in Drona (earthen berm). Other names in different Indian languages include *Barahalkura* (Bengali); *Gubo, Kubi* (Gujrati); *Dhurpisag*, *Guma*, *Gumma*, *Goma* (Hindi); *Devakhumba* (Marathi) and *Peedalumni* (Telugu) (Krishnamurthy, 1993). The genus *Leucas* includes about 100 Asiatic and African species. Common species found in India are *L. aspera* Spreng., *L. linifolia* Spreng, and *L. uritcaefolia* R. Br. (Caius 1986). Although Dronpushpi is a problematic weed for farmers, it is a tasty potherb for many rural people and a valuable medicinal herb for herbalists and is cultivated for herbal drugs in some parts of India. In village markets. Dronpushpi can be seen easily in rainy season. (Oudhi 1999, 2000; Oudhia and Tripath 1998, 1999, 2000; Oudhia et al. 1999). In tribal regions of India, Dronpushpi is a valuable drug for snake bite. a property reported in ancient Indian literatures, and is used both externally and internally. In many parts of India, people plant this weed in front of their homes to repel snakes and other venomous animals. The juice extracted from leaves is used to cure skin problems. In rainy season, many Indian tribal communities take bath with water having Dronpushpi leaf extract. They also wash their cattle and other domestic animals with this water. According to *Ayurveda*, the plant is mild stimulant and diaphoretic and used in fevers and coughs. The flowers mixed in honey is used as domestic remedy for cough and colds (Caius 1986). The seed also yields medicinal oil. Labellenic acid (Octadeca – 5, 6-dienoic acid) has been reported in seed oil. Beta sitosterol have been isolated from the plant of *Leucas cephalotes.* Anti bacterial activity of *Leucas aspera* leaf extract against *Micrococcus pyogenes* and *Escheria coli* have also been reported (Rastogi and Mehrotra 1991). Dronpushpi is valuable homoeopathic drug and as such is used for the treatment of chronic malaria and asthama (Ghosh 1988). In many parts of India particularly in North India.

References

Caius, J.F. 1986. The medicinal and poisonous plants of India. Scientific Publ., Jodhpur, India. p 397-399.

Ghosh, N.C. 1988. Comparative materia medica. Hanneman Publ. Co. Private Ltd. Kolkata, India.

Krishnamurthy, T. 1993. Minor forest products of India. Oxford and IBH Publ. Co. Pvt. Ltd., Mumbai, India .p.69.

Oudhia, P. 1999. Medicinal weeds in groundnut fields of Chhattisgarh (India). Int. Arachis Newslett. 19:62-64.

Oudhia, P. 2000. Medicinal weeds in Kodomillet fields: A source of an additional income for Chhattisgarh farmers. Ecol. Env. Conserv. 6(2):171-174.

Oudhia, P. and R.S. Tripathi. 1998. Medicinal weeds of Kharif crops in the plains of Chhattisgarh. Bhartiya Krishi Anusandhan Patrika. 13(1/2):33-38.

Oudhia, P. and R.S. Tripathi. 1999. Medicinal weeds of Raipur and Durg (Madhya Pradesh) region. p.71-78. In: Proc. National Conference on Health Care and Development of Herbal Medicines, IGAU, Raipur. India, 29-30 Aug. 1997

Oudhia, P and R.S. Tripathi. 2000. Medicinal weed flora of brinjal (*Solanum melongena* L.) fields in Chhattisgarh (India) Crop Res. 20(3):482 – 488.

Oudhia, P; R.S. Tripathi, S. Puri, and D.S. Chandel. 1999. Traditional knowledge about medicinal weeds in Chhattisgarh. Vasundhara. The Earth 1(1):12-15.

Rastogi, R.P. and B.N. Mehrotra. 1991. Compendium of Indian medicinal plants (vol. II, 1970-1979). Central Drug Res. Inst. Lucknow and Publications and Information Directorate, New Delhi.

Prunus sp.

Rosaceae

Stone Fruit

We have information from several sources:

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Stone Fruits—FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No.16—Link to the publication on the International Plant Genetic Resources Institute web site

Leather Woodfern

(1) *Dryopteris marginalis* (L.) A. Gray; (2) *D. filixmas* (L.) Schott.

Synonyms.—(1) *Aspidium marginale* Sw.; (2) *A. filixmas* Sw.

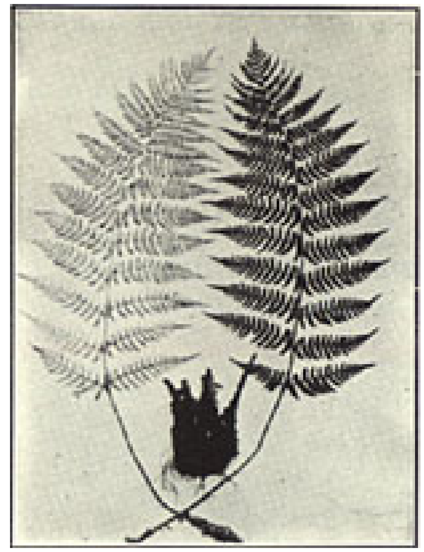

Figure 72.—Leather woodfern (*Dryopteris marginalis*)

Other common names.—(1) Marginal-fruited shield fern, evergreen woodfern; (2) male fern, male shield fern, sweet brake, knotty brake, basket fern, bear's-paw root.

Habitat and range.—These ferns are found in rocky woods, the male shield fern inhabiting the region from Canada westward to the Rocky Mountains and Arizona. The marginal-fruited shield fern, one of our most common ferns, occurs from Canada southward to Alabama and Arkansas.

Description.—Both of these plants are tall handsome ferns. They differ little in their general appearance, although the male shield fern, which grows to a height of about 3 feet, is somewhat larger than the other. The principal difference is in the arrangement of the fruit dots on the backs of the fern leaves. In the male shield fern these are located along the midrib, while in the marginal-fruited shield fern they are placed on the margins of the divisions of the fronds. These ferns have stout, erect rootstocks from 6 to l2 inches in length and 1 to 2 inches thick, covered with brown, closely overlapping leaf bases and soft, brown, chaffy scales. The inside of the rootstock is pale green. It has a disagreeable odor and a bitter-sweet, astringent, nauseous taste.

Part used.—The rootstock, collected from July to September, which should be carefully cleaned, but not washed, dried out of doors in the shade as quickly as possible, and marketed at once. The drug deteriorates rapidly unless carefully preserved,

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Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Durio zibethinus L.

Bombacaceae

Durian, Civet-cat fruit, Lahong, Tutong

Also: *D. dulcis* - Lahong, Tutong. From Kalimantan *D. graveolens* - Tabelak, Durian Mah. From Indonesia *D. kutejensis* - Lai. Southeast Asia *D. species* - Isu. From Kalimantan

---

We have information from:

Durian—Julia Morton, Fruits of warm climates

Durian—Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

And outside links:

DURIAN POSTHARVEST INFORMATION BULLETIN

A comprehensive list of Durian varieties - from Malaysia.

DURIAN ONLINE:

"The best durian I think, comes from Sarawak, Malaysia [I am biased because I used to live there], where they are naturally grown. The cultivated varieties are not as tasty as the wild ones. A lot of people find the smell disgusting. A tourist brochure compared eating durian to 'eating custard in a dirty public lavatory'!

- Kron Aken from Australia

Triticum species

Poaceae or Graminae

Alaska wheat, bearded wheat, bread wheat, bulgur, common wheat, cone wheat, cracked wheat, durum wheat, emmer, English wheat, farina, German wheat, hard wheat, macaroni wheat, Mediterranean wheat, non-bearded wheat, Poulard wheat, red wheat, rice wheat, river wheat, rivet wheat, rolled wheat, soft wheat, spring wheat, starch wheat, two-grained spelt, two-grained wheat, wheat flakes, white wheat, wild emmer wheat, wild wheat, winter wheat

---

Common Wheat, *Triticum aestivum* L. subsp. *aestivum*.
Club Wheat, *T. aestivum* subspecies *compactum* (Host)MacKey.
Durum wheat, *T. durum* Desf.
Spelt, *T. spelta* L.
Emmer, *T. dicoccon* Schrank.
Wild Emmer, *T. dicoccoides* (Koern. ex Ascb. & Graebn.)Aaronsohn.
Poulard Wheat, *T. turgidum* L.
Polish Wheat, *T. polonicum* L.
Persian Wheat, *T. carthlicum* Nevski.
Macha Wheat, *T. aestivum* subsp. *macha* (Dek. and Men.) MacKey
Vavilovi Wheat, *T. aestivum* subsp. *vavilovi* (Tuman)Sears.
Shot Wheat, *T. aestivum* subsp. *sphacrococcum*(Perc.) MacKey.
Oriental Wheat, *T. turanicum* jakubz.
Timopheevi Wheat, *T. timopheevii* (Zbuk.) Zbuk.
Einkorn, *T. monococcum* L.
Wild Einkorn, *T. boeoticum* Boiss.

NewCROP has WHEAT information at:

Alternative Wheat Cereals as Food Grains: Einkorn, Emmer, Spelt, Kamut, and Triticale—G.F. Stallknecht, K.M. Gilbertson, and J.E. Ranney

Triticum aestivum L., Common wheat, Bread wheat. Poaceae. Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Kamut®: Ancient Grain, New Cereal—Robert M. Quinn

International Repercussions of New Crops—Lowell S. Hardin

Durum Wheat in Virginia. See: Alternative Crops Research in Virginia—Bhardwaj, H.L., A. Hankins, T. Mebrahtu, J. Mullins, M. Rangappa, O. Abaye, and G.E. Welbaum

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

Wheat, durum wheat, winter wheat, spelt and triticale in New Crops for Canadian Agriculture—Ernest Small

Spelt: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness J.R. et al. 1971. Food and Feed Crops of the United States.

And outside links to more wheat info:

Wheat Production and Fertilization in Indiana

Lost Crops of Africa: Volume I: Grains
Emmer
Einkorn
Spelt

KAMUT—A Variety of Ancient Wheat for Wheat-Sensitive Allergy Patients.

Hulled Wheat—Promoting the conservation and use of underutillized and neglected crops. 4. Proceedings of the First International Workshop on Hulled wheats 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy—Link to the publication on the International Plant Genetic Resources Institute web site

---

Petroselinum crispum (Mill.) Nym.

Apiaceae (Umbelliferae)

Curly parsley, Italian parsley, Parsley

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Midwest Vegetable Production Guide for Commercial Growers 2000

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Parsley
Turnip Rooted Parsley

Essential Oils and Culinary Herbs—James E. Simon

Parsley: A Production Guide—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Echinacea species

Compositae

Echinacea

We have information from several sources:

A Review of the Taxonomy of the Genus *Echinacea*—Kathleen A. McKeown

Assembling and Characterizing a Comprehensive *Echinacea* Germplasm Collection—Mark P. Widrlechner and Kathleen A. McKeown

Echinacea angustifolia: An Emerging Medicinal—Ali O. Sari, Mario R. Morales and James E. Simon

Cichoric Acid and Isobutylamide Content in *Echinacea purpurea* as Influenced by Flower Developmental Stages—W. Letchamo, J. Livesey, T.J. Arnason, C. Bergeron, and V.S. Krutilina

Factors Affecting *Echinacea* Quality—W. Letchamo, L.V. Polydeonny, N.O. Gladisheva, T.J. Arnason, J. Livesey, and D.V.C. Awang

The Use of RAPDs for Assessment of Identity, Diversity, and Quality of *Echinacea*—J. Kapteyn and J.E. Simon

In Vitro Regeneration and *Agrobacterium* Transformation of *Echinacea purpurea* Leaf Explants—A. Koroch, J. Kapteyn, H.R. Juliani, and J.E. Simon

Immune Stimulants and Antiviral Botanicals: *Echinacea* and Ginseng—Dennis V.C. Awang

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

The Herb Hunters Guide—Sievers, A.F. 1930.

Outside links:

Echinacea Southern Crop Protection and Food Research Centre Agriculture & Agri-Food Canada

Bhringraj or Bhengra [*Eclipta alba* (L.) Hassk.]

Contributor: Pankaj Oudhia

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Common (Indian) Names:
Hindi: Balari, Bhangra, Bhringraj, Bhengra, Mochkand.
Gujerati: Bhangro, Dadhal, Kalobhangro
Canarase: Ajagara, Garagadasoppu, Kadigga-garaga
Marathi: Bhangra, Maka
Sanskrit: Bhringraj, Markara, Pitripriya, Sunilaka, Keshrangana

Family: Compositae

Habitat/Occurrence: In paddy growing areas of India, it occur as common weed. In many parts of India it is grown commercially as a medicinal crop.

Related Species: Four species have been reported so far in warmer parts of America, Africa, Asia and Australia.

Botany: An annual herb.

Stem: Stems and branches are strigose and hairy.

Leaves: Opposite, sessile, oblong- lanceolate; also strigose and hairy.

Flowers: In heads, involucral bracts, axillary, ray flowers ligulate; disk ones tubular.

Fruit: Achene.

Flowering Time: October to December in Indian conditions.

Useful Parts: Whole plant.

Medicinal Properties and Uses: The herb is an Ayurveda and Yunani medicine. According to Ayurveda philosophy Eclipta is bitter, hot fattening, alterative, anthelminticum, and alexipharmic. It is useful in inflammations, hernia, eye diseases, bronchitis, asthama, leucoderma, anaemia, heart and skin diseases, right blindness, syphilis etc. It is reported as beneficial for complexion, hair, eyes, and teeth.

Popular Ayurvedic Formulations: Bhringraj ghrit, Bhringraj taiil, Bhringrajadi churana etc.

Chemical Constituents: The plant contains the alkaloid ecliptine. Other chemicals identified are

wedelolactone, wedelic acid, apigenin, luteolin, β-amyrin etc.
Cultivation

Season: Kharif (June–July in Indian conditions)

Propagation: Through seeds

Seed Rate: 3 kg/ha

Major Insects & Diseases: No major insect and diseases have been reported in India conditions.

Manures: In India, Bhringraj is grown organically. No chemical inputs are used, only 15–20 tonnes farm yard manure/ha at the time of sowing is applied.

Maturity: 3–3.5 months after sowing.

Yield: Average yield 5 tonnes dry herbage/ha.

Resource Person:
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E-mail: pankajoudhia@usa.net
Homepage: www.celestine-india.com/pankajoudhia
Phone : 91-771-253243
Mobile : 91-98271-15642
Fax : 91-771-536312

Glycine max (L.) Merr.

Fabaceae

Soya, Soybean, Edamame

NewCROP has soybean information at:

Soybeans: The Success Story—Theodore Hymowitz

The Importance of Biological Nitrogen Fixation to New Crop Development—Peter M. Gresshoff

New Markets for Agriculture—Shelby F. Thames and Thomas P. Schuman

Diversifying U.S. Crop Production,—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

New Crops or New Uses for Old Crops: Where Should the Emphasis Be?—Shelby F. Thames and Thomas P. Schuman

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

Intercropping Stokes Aster: Seedling Growth under a Soybean Canopy—E.J. Callan and C.W. Kennedy

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

New Crops for Canadian Agriculture—Ernest Small

Soybean—Magness, J.R. et al. 1971. Food and feed crops of the United States.

Soybean Oil—Magness, J.R. et al. 1971. Food and feed crops of the United States.

Edamame, tofu, soyfood:

Potential New Specialty Crops from Asia: Azuki Bean, Edamame Soybean, and Astragalus—T.A. Lumpkin, J.C. Konovsky, K.J. Larson, and D.C. McClary

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Edamame: A Vegetable Soybean for Colorado—Duane Johnson, Shaoke Wang, and Akio Suzuki

Edamame: A Nutritious Vegetable Crop—S.R. Mentreddy, A.I. Mohamed, N. Joshee, and A.K. Yadav

Transforming Soybeans to Improve Tofu—Dan Evans

Special Purpose Soybean Varieties—Niels Nielsen, Evan Evans, and James Wilcox

Edible Soybeans —Niels Nielsen

Modification of Protein Content in Soybean to Improve Seed Quality—Niels C. Nielsen

New Technology for Making Tempeh: A Cultured Soyfood—Gunter Pfaff and Betsy Shipley. In: J. Janick (ed.).1996. Progress in New Crops ASHS Press, Alexandria Va.

Outside Links:

Purdue University (Indiana) Extension Publications

Stratsoy—(The Strategic Soybean System) Stratsoy is a U.S. communication and information system about soybean organizations, resources, and databases.

Soy Stats—Soy Stats has links to soybean information about uses, trade, prices.

Edamame production, harvesting, and marketing information from Washington State University

Edamame: The Vegetable Soybean

Edamame a Pacific Northwest Extension Publication

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Perennial veldtgrass

Gramineae, Poaceae *Ehrharta calycina* J.E. Smith

Source: Magness et al. 1971

This is a cool season bunchgrass native to South Africa and introduced via Australia in 1929. It is a highly palatable, drought resistant grass adapted to light soils. The leafy stems reach to 3 feet in height. It has proved valuable on sandy, coastal soils in California where it is used for range reseeding.

Last update February 18, 1999 by ch

Leucaena leucocephala (Lam.) deWit.

Mimosacea

Leadtree, Loa haole, Ekoa, Hediondilla, Zarcilla, Tanta, Jumbie bean

We have information from several sources:

FactSHEET contributed by: James L. Brewbaker

Commercializing Mesquite, Leucaena, and Cactus in Texas—Peter Felker

New Tree Crops from Interspecific *Leucaena* Hybrids—James L. Brewbaker and Charles T. Sorensson

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update October 2, 1996 by aw

Sambucus canadensis L.

Caprifoliaceae

American Elder, American elderberry, Blueberry elder, Blue elderberry, Eastern elderberry, Red elderberry, Western elderberry

We have information from several sources:

Temperate Berry Crops—Chad Finn

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Inula helenium L.

Compositae

Elecampane

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, April 20, 1998 by aw

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Water chestnut

Jesuit nut, Water caltrops, Ling

Cyperaceae *Eleocharis dulcis* (Burm. f.) Trin. ex Henschel, *Trapa natans* L.

Source: Magness et al. 1971

Two types of aquatic plants are grown under the name water chestnut: One, *E. dulcis*, is a rush-like plant grown extensively in China for its near round turnip-shaped tubers. They are grown in ponds, and the tubers are harvested by scooping them off the bottom with forks. This is the water chestnut or "ling" widely used in Chinese foods. The other plant also called water chestnut, or Jesuit nut, or Water caltrops, is *T. natans*, a water plant with large leaves that float on the water surface. It is grown to some extent in Southern Europe and Asia. The edible part is the nutlike fruit, 1 to 2 inches in diameter, with 4 spined angles, which grows below the leaf blade. It is roasted and eaten like chestnuts. Neither type of water chestnut is produced commercially in the U.S., although there has been some effort with *E. dulcis*.

Season: Perennial plants, with a crop harvested annually.

Production in the U.S.: No data. Negligible.

Use: Cooked, eaten out of hand, or in other foods.

Parts consumed: Tuberous bulbs in *E. dulcis*; nut-like fruits in *T. natans*.

Last update June 27, 1996 bha

Pennisetum purpureum K. Schumach.

Poaceae, Gramineae

Elephant grass, Napier grass, Uganda grass

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

NapiergrassIn: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

African Grasses—Glenn W. Burton

Last update October 27, 1997

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Israelsen, L.D. 1993. Phytomedicines as a new crop opportunity. p. 669-671. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Phytomedicines as a New Crop Opportunity

Loren D. Israelsen

Phytomedicines, simply defined, are a special category of plant drugs. They are standardized, which means that certain compounds in the plant material are quantified and elucidated so as to have a replicable final product, batch after batch. One of the criticisms traditionally leveled against natural medicines is the lack of standard levels of biological materials from the natural plants.

In many parts of the world, the United States is considered a third world country when it comes to phytomedicines. Unfortunately, our European colleagues are far ahead of us; they have a multi-billion dollar industry in phytomedicines, whereas ours is only a two hundred million dollar industry. Even so, there are a lot of exciting developments in the United States. Over the last five years, I estimate that the American medicinal herb industry has grown at a rate exceeding 20% per year and this trend continues today.

Phytomedicines represent new crop opportunities for several reasons. First, the companies who use these products are very keen to get high quality, sanitary material. This is becoming quite a serious problem. One example we have seen quite recently relates to problems in Eastern Europe, the source of many of these plants. Would you buy plant material which has been growing next to a steel plant in Eastern Europe? Most people would not. The United States is a good growers market because it has a stable political environment, has many different growing climates and conditions, excellent choice of growers, and the ability to grow according to industrial specifications. The Appalachian region, in particular, is very rich in medicinal flora.

Of growing concern is the extinction of medicinal plant species in this country. Given the growing demand for these botanicals and current problems in over-collecting, it is quite likely that some of the last populations of these plants will be collected over the next five to ten years if we don't begin to cultivate them commercially. Finally, these specialty crops could provide profitable growing opportunities for small farmers. Some of these crops appear to be ideally suited to the small farmer.

IMPORTANT MEDICINAL PLANTS

***Ginkgo biloba*.** The nuts of this tree are quite tasty when properly roasted. An extract (Fünfgeld 1988) derived from the leaf of this tree is the single largest selling drug in Germany and France today (Foster 1991). The extract is used for peripheral circulation and has the unique property of making red blood cells more elastic and selectively dilating capillaries. Consequently, this extract is used in Europe for treating conditions of tinnitus, vertigo, cold hands, cold feet, macular degeneration, and dementia. In order to meet the demand for the leaf, there is a 400 hectare farm in South Carolina which produces over a million kilograms of dried leaves a year. There are other plantations now being developed to meet the international demand for this product.

American ginseng (*Panax quinquifolium*). In Marathon County, Wisconsin, alone, this crop represents a one hundred million dollar a year crop (raw and finished product) which is primarily exported to China where it is widely used and appreciated. Oddly enough, we buy *Panax ginseng* from China because Americans prefer their material and they ours.

Saw palmetto (*Serenoa repens*). The berries of the Saw Palmetto are quite useful for benign prostatic hypertrophy. This is a very big pharmaceutical in Germany and France. There is a well developed industry in Florida which produces berries for export to Europe.

***Goldenseal* (*Hydrastis canadensis*).** This is one of the fastest growing products in the United States in the natural products industry and used to be in the United States Pharmacopoeia until about 40 years ago. It is native to Appalachia and is one of the crops that is most threatened by extirpation because of growing demand. Ginseng growers in Wisconsin have been contacted to see if they could grow Goldenseal. To date, the project is showing signs of success, and it seems likely that a large percentage of this product will come from cultivated plots rather than naturally occurring populations.

Bloodroot (*Sanguanaria canadensis*). This is very popular and is the active ingredient in a toothpaste product called Viadent. It is used to control plaque and gingivitis (Bennet et al. 1990).

Siberian ginseng (*Eleutherococcus senticosus*). This is a very popular and interesting product. It is called an adaptogen. It was developed in Russia by Dr. Breckman. Adaptogens are body regulators which promote proper balance. Many medical doctors question this hypothesis, but there is a significant amount of empirical and clinical data from Russia to support this (Farnsworth et al. 1985).

***Echinacea* (*Echinacea purpurea*).** This is a popular nonspecific immunostimulant in Germany and much of Europe. There are hundreds of hectares of cultivated Echinacea in Europe. There is also a large organic farm, Trout Lake Farm in Washington State, which grows significant amounts of this product. Echinacea is used as a preventative for colds and flues and is quite effective when used in this way. It is one of Europe's most popular natural products.

Milk thistle (*Silybum marianum*). This is used in Europe for liver conditions, treatment of acute mushroom poisoning, and other hepatoxic compounds.

Black cohosh (*Cimicifuga racemosa*). This is an interesting native American plant. It has a rich tradition among Native Americans and by people who live in the Appalachian region. It is used by women for regulation of hormonal cycles (Foster and Duke 1990).

Valerian (*Valeriana officinalus*). This is one of the more popular sleep aids in Europe and has been widely used for hundreds of years. There is no reason why this cannot be grown in the United States.

Feverfew (*Tanacetum parthenium*). Research in England has shown promising results in the treatment of migraine. A small amount of feverfew when taken orally can reduce the frequency and severity of migraine. It has great medical potential and could most definitely be grown in this country (Awang 1989).

St. John's wort (*Hypericum perforatum*). This is a popular European product. It has antiviral properties and also antidepressant properties (Hobbs 1988/1989).

Catnip (*Nepeta cataria*). Not only is it my cat's favorite play thing, but it is also used as a mild sedative (Tyler 1987). This is currently being grown in the United States as a sedative, although not commercially.

Pacific yew (*Taxus brevifolia*). At the moment, this is a most controversial and interesting phytomedicine. The pacific yew tree is the source of taxol which shows great promise for the treatment of ovarian and other cancers. However, there are not enough trees. These trees grow very slowly, and if harvested for taxol, the natural stands of the yew tree would be exhausted. The ability to obtain taxol from ornamental sources of *Taxus* as well as planting nurseries of the western yew for taxol extraction are underway.

Ginger (*Zingiber officinale*). It is not only a well known spice, but it has been proven to be as effective as dramamine in reducing nausea and motion sickness (Holtman et al. 1989). It has also been quite useful for pregnant women who are suffering nausea in early pregnancy and is quite safe (Bone et al. 1990).

CONCLUSIONS

In the United States, the policies of the Food and Drug Administration (FDA), historically, have been unhelpful to natural products. These plant products are polypharmaceutics, meaning they have multiple compounds, and FDA is not presently prepared to review products containing more than one compound. Demanding evidence that each individual component in an extract is safe and effective is a matter of scientific curiosity, but has little to do with the inherent questions of safety and effectiveness of the extract. Unfortunately, FDA still struggles with this concept.

The natural healthcare market is a very fast growing one. It is projected that at current inflation rates for health care, by the year 2030, health care costs could consume 100% of the gross national product. Something must be done. People are turning more and more to prevention and wellness programs, including natural medicines. As this trend develops, phytomedicines could become an important new alternative crop in the United States.

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- Fünfgeld, E.W. (ed). 1988. Rökan (*Ginkgo biloba*), recent results in pharmacology, and clinic. Springer-Verlag, Berlin.
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Giant wild-rye

Gramineae *Elymus condensatus* Presl

Source: Magness et al. 1971

This grass, native throughout the western states, is the most robust of the native rye grasses, reaching to 10 feet. It is a perennial bunchgrass, forming large clumps. Leaves are large, up to 2 feet long and 0.75 inch wide. It grows abundantly on wet and saline soils, but also occurs on moderately dry soils. Giant rye is suitable for grazing while succulent. The ripened clumps provide winter sustenance feed for cattle and horses. Propagation is by seed.

Last update February 18, 1999 by ch

Russian wild-rye

Gramineae, Poaceae *Elymus junceus* Fisch.

Source: Magness et al. 1971

This is a cool season bunch grass introduced in 1927 from Russia. It has proved adapted to the Northern Great Plains and Intermountain Regions, where it is used primarily for pasture. Growth starts early in spring. Plants are leafy and nutritious, with dense basal leaves. Seedling vigor is low, but once established, plants are deep rooted, drought resistant and salt tolerant.

Last update July 1, 1996 bha

Wild-rye grasses

Gramineae *Elymus* sp.

Source: Magness et al. 1971

Wild-rye species are well distributed among the native grasses of the Western States. Most species are perennial bunch growers, but some form sods. These grasses are coarse and of low palatability for livestock. Because of their vigor and ease of establishment they form a quick cover and are useful in mixtures with slower growing kinds. Wild-rye grasses are susceptible to ergot fungus, which replaces the seed kernel and is highly toxic to livestock. The most useful wild-rye species are Canada wild-rye, giant wild-rye, blue wild-rye, Russian wild-rye, and basin wild-rye.

Index | Search | Home | Aromatic, Spice and Medicinal Plants

Ephedra species

Ephedraceae

Ma huang

We have information from several sources:

Chinese Medicinals—Albert Y. Leung

Herbs Affecting the Central Nervous System—Varro E. Tyler

Trailing-Arbutus

Epigaea repens L.

Trailing-arbutus

Figure 108.—Trailing-arbutus (*Epigaea repens*)

Other common names.—Gravel plant, Mayflower, shadflower, ground laurel, mountain pink, winter pink.

Habitat and range.—Trailing- arbutus spread out on the ground in sandy soil, being found from Newfoundland to Michigan and Saskatchewan and south to Kentucky and Florida.

Description.—This plant, generally referred to in the drug trade as gravel plant but more popularly known as "trailing-arbutus" spreads on the ground with stem 6 or more in length. It has rust-colored, hairy twigs bearing leathery, evergreen leaves from 1 to 3 inches long and about half as wide. The flower clusters, which appear from March to May, consist of fragrant, delicate, shell pink, waxy blossoms.

Part used.—The leaves, gathered at flowering time.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Eragrostis curvula (Schrad.) Nees

Poaceae

Weeping lovegrass

We have information from several sources:

African Grasses—Glenn W. Burton

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update October 27, 1997

Lehmann lovegrass

Gramineae *Eragrostis lehmanniana* Nees

Source: Magness et al. 1971

This is a warm season, slightly spreading grass introduced from South Africa in 1932. It is used for range reseeding in the warm semidesert areas of Southwestern United States. It forms prostrate stems which root at the nodes and is readily established by seeding. The plants are smaller and less cold-tolerant than Boer or Weeping lovegrasses.

Last update September 22, 1997

Sand lovegrass

Gramineae, Poaceae *Eragrostis trichodes* (Nutt.) Wood

Source: Magness et al. 1971

This is a vigorous, long-lived, native bunchgrass occurring on sandy soils of the Central and Southern Great Plains. it is drought resistant, with a deep root system. Stems may reach to 6 feet. Leaves are abundant, slightly hairy, 12 inches long and 0.25 inch wide. Plants start growth early in spring and continue through the summer. This grass is highly palatable and nutritious, and often is overgrazed. It is easily established from seed.

Last update February 19, 1999 by ch

Horseweed

Erigeron canadensis L.

Horseweed

Figure 68.—Horseweed (*Erigeron canadensis*)

Synonym.—*Leptilon canadense* (L.) Britton.

Other common names.—Erigeron, mare's-tail, Canada erigeron, butterweed, bitterweed, cow's-tail, colt's-tail, fireweed, bloodstanch, hogweed, prideweed, scabious.

Habitat and range.—Horseweed is common in fields and waste places and along roadsides throughout almost all of North America.

Description.—This weed varies greatly in height according to the soil it grows in. The erect stem, sometimes smooth, but usually bristly hairy, is generally branched near the top. The leaves are usually somewhat hairy, the lower ones 1 to 4 inches long and toothed, those scattered along the stem are rather narrow and smooth. From June to November the plant produces numerous heads of small, inconspicuous white flowers, followed by an abundance of seed.

Part used.—The entire herb, collected during the flowering period. Oil of erigeron, obtained from the plant by distillation, is produced commercially in Michigan and Indiana.

Information on the extraction of volatile oils from plants is contained in the following publication: Sievers, A.F. Methods of extracting volatile oils from plant material and the production of such oils in the United States. U.S. Dept. Agr. Tech. Bul. 16, 36 p. illus. 1928

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

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Eriobotrya japonica (Thunb.) Lindl.

Rosaceae

Advance, Champagne, Early Red, Japanese medlar, Japanese plum, Loquat, Nispero, Premier, Tanaka, Thales

NewCROP has Loquat information at: Loquat—Julia Morton, Fruits of warm climates

Mediterranean Fruits—Joan Tous and Louise Ferguson

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Loquat info: LOQUAT "FRUIT FACTS"(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Loquat Information from the University of California Fruit & Nut Research and Information Center

Loquat, *Eriobotrya japonica* from Mark Reiger, Dept of Horticulture, University of Georgia.

Loquat nutritional information provided by Frieda's

Yerba Santa

Eriodictyon californicum (Hook. and Arn.) Greene.


Figure 128.—Yerba santa (*Eriodictyon californicum*)

Synonym.—*Eriodictyon glutinosum* Benth.

Other common names.—Mountain balm, consumptive's weed,* bear's-weed, gum plant, tarweed.

Habitat and range.—Yerba santa is common on the Pacific coast along the coastal ranges from central California north to Oregon.

Description.—This evergreen shrub, which reaches a height of from 3 to 4 feet, has a smooth stem which exudes a gummy substance. The narrow, dark-green, leathery leaves are from 3 to 4 inches in length and are covered with a resinous substance which makes them appear as if varnished. The rather showy, whitish, or pale-blue flowers are borne in clusters at the top of the plant.

Part used.—The leaves.

*This is a popular but misleading name.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Eruca sativa Miller

Brassicaceae = Cruciferae

Rocket, Roquette, Arrugula

We have information from several sources:

Arugula: A Promising Specialty Leaf Vegetable—Mario Morales and Jules Janick

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside links:

Rocket: A Mediterranean Crop For The World from the International Plant Genetic Resources Institute

Eruca sativa Miller: a diploid, annual, species which flowers in spring and whose seeds are ready for collecting in late spring. It seems to prefer rather rich soils even through it can be found mixed with ruderal flora in very marginal areas. It is frequently cultivated, although demestication cannot be considered complete. A wild type, known as subspecies *vesicaria* (L.) Cav., is also rather well represented in the Mediterranean flora.

Erythrina poeppigiana (Walp.) O.F. Cook

Fabaceae
Poro

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Allen and Allen (1981) describe the tree as invaluable shade for coffee and cocoa. Since they are readily propagated from cuttings, they are also used for living fence posts. Both the shade trees and fence posts can be lopped as green manure, a system in use in Costa Rica and perhaps elsewhere. With its handsome orange-red f lowers, it is sometimes planted as an ornamental. Unpruned trees grew too large for coffee shade trees in Puerto Rico, according to Little and Wadsworth (1964), so its recommendation for coffee shade has been discontinued in Puerto Rico. It is still a popular coffee shade tree in the Andes. Flowers are said to be eaten in salads and soups (Little and Wadsworth, 1964).

Folk Medicine

According to Little and Wadsworth (1964), the bark, twigs, and seeds of various *Erythrina* species, more or less toxic, have provided local drugs and medicines. I have no specific data on this species.

Chemistry

Per 100 g, the seed is reported to contain 36.8 g protein, 12.4 g fat, and 5.5 g ash. The seeds, possibly poisonous, proved negative for starch test, alkaloid test, and tannin test (Earle and Jones, 1962). Willaman and Schubert (1961) report the alkaloids erysodine, erysopine, erysothiovine, erysovine, and hypaphorine from the seeds.

Description

Deciduous tree to as much as 25 m tall, 1 m DBH, the crown spreading. Bark is greenish brown to gray brown, smooth or slightly furrowed, warty, or spiny. Leaves trifoliate, 20–30 cm long including the pubescent petioles, the leaflets with paired cupular glands near the bases of the lateral leaflets. Racemes 10–20 cm long, the flowers caducous, orange red; petals 5; stamens 10, the anthers brown. Pods 12–25 cm long, several seeded, falcate, slightly depressed between the seeds, long-stalked, pointed at both ends. Seeds 1–2 cm long, weighing ca .183 g each.

Germplasm

Reported from the South American Center of Diversity, poro, or cvs thereof, is reported to tolerate acid soils as well as moist limestone soils. ($2n = 42$)

Distribution

Probably native from Venezuela to Panama, south to Bolivia, Brazil, Ecuador, and Peru. Cultivated in Florida, Guatemala to Costa Rica, the West Indies, and the Old World Tropics.

Ecology

I estimate that the species ranges from Tropical Moist to Tropical Wet through Subtropical Dry to Subtropical Rain Forest Life Zones, where annual precipitation is 15 to 40 dm, annual temperature is 20 to 28°C, and pH is 4.0 to7.5. Studied at Turrialba, mean annual temperature 22.3°C, the annual precipitation 2639 mm with only one month with less than 100 mm. The relative humidity is 87.6%, the mean monthly evaporation 92.3 mm, and the mean daily radiation 432 cal/m^2/day. Soils were alluvial with moderate to deficient drainage, the pH 4.6, organic matter 6.7–7.2%, nitrogen 0.25–0.43% exchangeable potassium 0.45.

Cultivation

In Costa Rica, the trees are spaced roughly at 6 x 6 m, with > density of ca 280 trees/ha, interspersed with ca 4300 coffee plants/ha (Russo, 1982).

Harvesting

The trunks, some nearly 30 cm in diameter, are lopped ca head height or higher twice a year. The prunings are added to the soils as green manure (Russo, 1982).

Yields and Economics

The addition of organic matter due to the biennial loppings can run to 10 MT/yr, improving, if anything, the yield of the coffee intercrop (Russo, 1982).

Energy

Although not producing very good fuel, the biomass production could probably approximate or surpass 25 MT/ha/yr in monoculture, fixing N all the while.

Biotic Factors

The following diseases are reported from species of *Erythrina: Cercospora erythrinae* (on leaves), *Cercospora erythrinicola*, *Clitocybe tabescens* (root rot), *Colletotrichum erythrinae* (on leaves), *Dicheirinia binata* (rust), *Meliola bicornis*, *Meliola crenatissima*, *Meliola erythrinae* (black mildew), *Meloidogyne* sp. (root knot nematodes), *Mycosphaerella erythrinae* (on leaves), *Nectria cinnabarina* (on stems), *Pellicularia kolerogna* (thread blight), *Phoma erythrinicola* (on stems), *Phyllosticta erythrinicola* (leaf spot), *Phymatotrichum omnivorum* (root rot), *Rhizoctonia ramicola* (thread blight), and *Verticillium* sp. (probably *albo-atrum*) (wilt) (Agriculture Handbook 165).

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- Allen, O.N. and Allen, E.K. 1981. The Leguminosae. The University of Wisconsin Press. 812 p.
- Earle, F.R. and Jones, Q. 1962. Analyses of seed samples from 113 plant families. Econ. Bot. 16(4):221–250.
- Little, E.L., Jr., and Wadsworth, F.H. 1964. Common trees of Puerto Rico and the Virgin Islands. Ag. Handbook 249, USDA, Washington, DC.
- Russo, R.O. 1982. Resultados preliminares de biomesa de la poda de *Erythrina poeppigiana*

(Walpers) O.F. Cook (poro) en Turrialba, Costa Rica. Typescript. CATIE, Turrialba, Costa Rica.

- Willaman, J.J. and Schubert, B.G. 1961. Alkaloid-bearing plants and their contained alkaloids. USDA Tech. Bul. 1234.

Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, January 6, 1998 by aw

Xylopia aethiopica (Dunal) A. Rich

Annonaceae

Ethopian pepper

We have information from several sources:

Identification of the Key Aroma Compounds in Dried Fruits of *Xylopia aethiopica*—A.O. Tairu, T. Hofmann, and P. Schieberle

New Antimicrobials of Plant Origin—Maurice M. Iwu, Angela R. Duncan, and Chris O. Okunji

Eucalyptus sp.

Myrtaceae

Eucalyptus

We have information from several sources:

Woody Fiber Crops—Stanley L. Krugman

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links:

Eucalyptus spp.—FAO/IPGRI Technical Guidelines for the Safe Movement of germplasm No. 17—Link to the publication on the International Plant Genetic Resources Institute web site

Eucalyptus camaldulensis Schlecht.

Myrtaceae
Redgum eucalyptus

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Important timber, firewood, shelter belt, and honey tree. In the Sudan, it is planted to protect crops from blowing sands. The wood, durable, easy to saw, yet resistant to termites, is widely used in Australia for strong durable construction, interior finish, flooring, cabinetry, furniture, fenceposts, cross-ties, sometimes pulpwood. Australian aborigines made canoes from the bark. Survivalists in Australia and elsewhere might learn how the aborigines obtained water from the superficial roots, usually those ca 3 cm in diameter. The roots were excavated or lifted to the soil surface. Then the root was cut into segments ca 45 cm long, debarked, held vertically, and blown into, the water then draining into the receptacle provided.

Folk Medicine

Reported to be anesthetic, antiseptic, astringent, the redgum eucalyptus is a folk remedy for colds, colic, coughs, diarrhea, dysentery, hemorrhage, laryngalgia, laryngitis, pharyngitis, sore throat, spasm, trachalgia, and wounds (Duke and Wain, 1981).

Chemistry

Leaves contain 0.1–0.4% essential oil, 77% of which is cineol There is some cuminal, phellandrene, aromadendren (or aromadendral), and some valerylaldehyde, geraniol, cymene, and phellandral (C.S.I.R., 1948–1976). Leaves contain 5–11% tannin. The kino contains 45% kinotannic acid as well as kino red, a glucoside, catechol, and pyrocatechol. Leaves and fruits test positive for flavonoids and sterols. The bark contains 2.5–16% tannin, the wood 2–14%, and the kino 46.2–76.7% (Watt and Breyer-Brandwijk, 1962).

Description

Large evergreen tree 24–40(-50) m high with stout trunk often short and crooked, to 2 m in diameter; crown open, widely spreading, irregular. Bark smoothish, white, gray, or buff. Twigs reddish, long, slender, angled, drooping. Trunk can form air roots. Root system deep and spreading. Leaves alternate, drooping, narrowly lanceolate, 8–22 cm long, 1–2 cm wide, often curved or sickle-shaped, tapering to long point, short-pointed at base, entire glabrous, dull pale green on both surfaces or occasionally grayish. Umbels single at leaf base, ca 2.5 cm long on slender stalk 6–19 mm long. Flowers 5–10, each on slender stalk 5–12 mm long from ovoid buds 6–10 mm long, 4–5 mm wide. Stamens many, threadlike, white, 5–6 mm long; anthers with small round gland. Pistil with inferior, long-pointed, 3–4-celled ovary and long, stout style. Capsules several, clustered, hemiglobose or ovoid, 7–8 mm long, 5–6 mm wide, light brown, with wide raised disk and 3–4 prominent triangular teeth almost 2 mm long. Seeds many, tiny, 1.5 mm long, light brown (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, redgum eucalyptus, or cvs thereof, is reported to tolerate alkali, drought, fire, light frost, heat, high pH, poor soil, salt, savanna, and waterlogging. It is rather intolerant of weeds. The NAS catalogs four outstanding provenances, 'Katherine' and 'Petford' for tropical climates, 'Lake Albacutya' for Mediterranean climates, and 'Broken Hill' for arid climates. Some Provenances can tolerate -5°C and up to 20 frosts per year. ($2n = 22$)

Distribution

This is said to be the most widely distributed eucalypt, ranging over 23° lat. in most of arid and semiarid Australia but not the humid eastern and southwestern coasts. It is regarded as one of the most widely planted eucalypts in the world (ca 500,000 ha planted) (NAS, 1980a). Plantations occur in Argentina, Arizona, California, Egypt, Kenya, Morocco, Nigeria, Pakistan, Senegal, Sierra Leone, Spain, Sri Lanka, Sudan, Tanzania, Upper Volta, Uruguay, and Zimbabwe.

Ecology

Ranges from tropical through subtropical and warm temperate, and from arid to semiarid. Tolerates temperatures from 3° to 5°C in winter with 0–50 frosts according to locality. Annual rainfall from minimum of about 250–625 mm to as high as 1000–1250 mm (Little, 1983). In Duke's ecogeographic data base, redgum eucalyptus is estimated to range from Tropical Thorn Forest to Dry through Warm Temperate Desert to Dry Forest Life Zones, and is reported to tolerate annual precipitation of 10.3 to 20.6 dm (mean of 9 cases = 15.9) and annual temperature of 18.0 to 26.6°C (mean of 9 cases = 24.7). It is reported in areas with only 2 dm rainfall, but the lower limit for commercial plantations is 4 dm. Some provenances tolerate many different soil conditions, high calcium, high salt, periodic waterlogging. Occasionally pure stands may develop naturally along flood plains and stream banks. The mean maximum temperature of the warmest month where it grows well is ca 29°C. The dry season lasts 4–8 mos or more and may be severe. Frosts are rare (5–20 days/yr) (Mariani et al., 1981).

Cultivation

Seeds, long lived when sealed in dry cold storage, are usually started in nursery containers, then transplanted to the field (as close as 2 x 2 m for firewood). Extensive weeding may be mandatory. During the seedling stage, this species develops gall-like structures, at least in the Philippines, which offer resistance to drought and fire (Agpaoa, 1980).

Harvesting

Some provenances coppice well for six or more rotations, on good sites, plantations are managed on coppice rotations of 7–10 years.

Yields and Economics

According to NAS (1980a), annual wood yields or 20–25 m^3/ha in Argentina, 30 m^3 from Israel, 17–20 from Turkey in the first rotation, and 25–30 in subsequent coppice rotations. On poor arid sites, yields are only 2–11 m^3 (ca 1–5 cords) on 14 or 15 year rotations. Litterfall ran about 3.6–5.8 MT/ha/yr in an Australian redgum swamp (Briggs and Maher, 1983).

Energy

According to the phytomass files (Duke, 1981b), standing biomass in an Israeli plantation is ca 110 MT/ha. At Calistoga, California, this was calculated to yield 4.3 m^3/ha/yr or 2 cords and total energy yields of 15,000,000 kcal/ha/yr (Standiford and Donaldson, 1982). "As firewood, the timber from *Eucalyptus camaldulensis* has few equals. It is also a good charcoal wood, and the steel industry in Argentina, for example, relies on its charcoal for steel-making. The fuel value of the wood (sp. grav. 0.6) is 4,800 kcal/kg. In World War II, Australians used the charcoal for their producer gas plants." (C.S.I.R., 1948–1976).

Biotic Factors

According to Browne (1968), the following affect *Eucalyptus camaldulensis:* (Bacteria) *Agrobacterium tumefaciens*. (Fungi) *Cercospora eucalypti, Corticium salmonicolor, Fomes setulosus, Gymnopilus junonius, Hypholoma fasiculare, Inonotus chondromyelus, Polyporus portentosus, Sclerotinia fuckeliana*. (Angio-spermae) *Tapinanthus* sp. (Coleoptera) *Alcidodes biangulatus, A. haemopterus, Anaemerus tomentosus, Apate monachus, Chrysolagria neavei, Dicasticus affinis, Gonipterus scutellatus, Opseotrophus sufflatus, Phoracantha recurve, P. semipunctata, Siderodactylus sagittarius, Sinoxylon transvaalense, Systates pollinosus, Xyleborus truncatus.* (Hemiptera) *Agonoscelis pubescens, Atelocera stictica.* (Hymenoptera) *Perga affinis, Phylacteophaga eucalypti.* (Isoptera) *Ancistrotermes amphidon, Odontotermes feae.* (Lepidoptera) *Archips occidentalis, Cleora dargei, Desmeocraera cyprianrii, Eumeta cervina, Kotochalia junodi, Nadasia amblycalymma, Nola lugens, ophiusa tirhaca, Orgyia basalis, Parasa ananii, Strepsicrates rhothia.* (Orthoptera) *Staurocleis magnifica.* (Mammalia) *Lepus whytei.* Young and/or drought-weakened shrubs can be badly infested by the eucalyptus snout beetle, eucalypt borer, moth larvae, and termites. Even the young trees are not favored by livestock and wildlife. The tree is said to kill other tree species (NAS, 1980a). This is one of the few species whose leaves are eaten by sheep (Watt and Breyer-Brandwijk, 1962). The litter may provide an important food source for detritivorous invertebrates and hence for waterfowl in redgum swamps (Briggs and Maher, 1983).

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 19.42 to 18.23 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the wh.plant contained 81.42% volatiles, 0.76% ash, 17.82% fixed carbon, 49.00% C, 5.87% H, 43.97% O, 0.30% N, 0.01% S, 0.13% Cl, and undetermined residue.

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Complete list of references for Duke, Handbook of Energy Crops

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Eucalyptus citriodora Hook.

Myrtaceae
Lemon-scented gum

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Leaves yield a lemon-scented oil rich in citronellal, and favored in perfumery. The wood is good for saw-timber, used for general construction, poles, railroad ties, and tool handles. Bark may contain up to 12% tannin. Kenyans favor the honey produced by this species.

Folk Medicine

Reported to be antiseptic and fumigant. Cubans place the leaves under the sheets of fever patients, and inhale the steam from boiled leaves for cold and various pulmonary problems. Cubans also poultice the leaves onto ulcers, wounds, and other skin ailments. Guatemalans decoct the leafy shoots for coughs (Morton, 1981). Orally administered leaf extracts in rabbits artifically diabetic, produced temporary hypoglycemia and reduced the blood sugar levels (Watt and

Breyer-Brandwijk, 1962). Myrtillin, in the leaf extract, is said to induce a temporary hypoglycemia (Atal and Kapur, 1981).

Chemistry

Dayal reported betulinic and ursolic acids, eucalyptin and β-sitosterol in the leaves. Glabrous leaves may contain oil with 65.5% citronellal, 12.2% citronellol, and 3.6% isopulegol; hairy leaves contain more oil with 86.6–90.1% citronellal, 4.6–6.0% citronellol, and 0.7–0.8% isopulegol, 1-pinene, β-pinene, and isovaleric aldehyde are also recovered (Morton, 1981). Bark contains ca 9% tannin (Watt and Breyer-Brandwijk, 1962). The young leaf is reported to contain citric-, glutaric-, malic-, quinic-, shikimic- (carcinogenic), and succinic-acids (Watt and Breyer Brandwijk, 1962). Leaves and fruits test positive for flavonoids and sterols.

Toxicity

Citronellal found in Eucalyptus and Melissa is reported to be mutagenic (Lewis and Elvin-Lewis, 1977).

Description

Evergreen tree 24–40 m high with tall straight trunk 0.6–1.3 m in diameter, and thin, graceful crown of drooping foliage. Bark smooth, gray, peeling off in thin irregular scales or patches and becoming mottled, exposing whitish or faintly bluish inner layer with powdery surfaces appearing dimpled. Twigs slender, slightly flattened, light green, tinged with brown. Leaves alternate, narrowly lance-shaped, 10–20 cm long, 1–2.5 cm wide, apically acuminate, basally acute, entire, glabrous, thin, light green on both surfaces, with many fine parallel straight veins and with vein inside edge. Corymbs terminal and at leaf ba"s, to 6 cm long, branched. Flowers many, 3–5 on equal short stalks (umbels) from ovoid buds 8–12 mm long, 5–8 mm wide. Stamens many, threadlikes, white, 6 mm long, spreading ca 12 mm across, anthers with long gland. Pistil inferior 3-celled ovary and long, stout style. Capsules few, urn-shaped or ovoid, narrowed into short neck, 10–12 mm long, 8–10 mm wide, brown with scattered raised dots. Seeds few, irregularly ellipsoid, 4–5 mm long, shiny black (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, lemon-scented gum, or cvs thereof, is reported to tolerate clay, drought, gravel, laterites, light frosts, podzols, poor soil, and slopes, but is not very tolerant of waterlogging. The hybrid with *E. torelliana* is showing promise in Nigeria (NAS, 1980a). Gupta et al. (1981) obtained multiple shoots from 20-year old terminal bulbs in culture. Shoots were also obtained from seedling explants. They estimate they can produce 100,000 plants from one mature tree bud in one year.($2n$ = 20, 22, 28)

Distribution

Said to occur naturally only on the central and northern coasts of Queensland, Australia, but to fare well in much of Africa, Brazil, California, Hawaii, India, even Portugal.

Ecology

Said to grow where the rainfall, mostly summer, is 6 to 13 dm, with 5–7 month dry season, withstanding high temperatures (29–35°C mean monthly maximum) and light frosts. In tropical and subtropical arid to semiarid zones, in infertile clays, laterites, poor and gravelly soils and podzols, preferrably well drained.

Cultivation

In Zimbabwe, seeds are broadcast successfully on the ashes of recently burned tracts. More usually seedlings are transplanted from the nursery. Seed require no special treatment.. Though needing protection from frost and weeds when young, older saplings show more tolerance to both. According to Irvine (1961), seedlings transplant badly.

Harvesting

For oil extraction, trees are not allowed to mature to the timber stage. Instead, they are lopped for the foliage; sucker shoots produce copious foliage.

Yields and Economics

Tanzania plantations, harvested on an 8-year coppice, produced an annual 15 m^3/ha. Back in 1925, the essential oil from this species commanded twice the price of that of *E. globulus* (MacMillan, 1946).

Energy

Firewood yields run 10–21 m^3/ha/yr (Fenton et al., 1977). The hard heavy wood (sp. grav. 0.75–1.1) burns steadily and makes a good charcoal with an ash content of 1–2%. This is the chief charcoal species of the Brazililan steel industry.

Biotic Factors

Browne (1968) lists the following as affecting this species: (Bacteria) *Agrobacterium tumefaciens.* (Fungi) *Armillaria mellea*, *Fusarium* spp., *Ganoderma colossum, G. lucidum, Phytophthora parasitica, Polyporus rubidus, Puccinia psidii, Sclerotinia fuckeliana*, *Trametes cubensis,* *Verticillium albo-atrum.* (Coleoptera) *Anomala cupripes, Dicasticus affinis, Elytrurus griseus, Entypotrachelus meyeri, Systates surdus, Xyleborus truncatus.* (Hemiptera) *Atelocera stictica, Eucalyptolyma maideni.* (Isoptera) *Ancistrotermes amphidon, Coptotermes truncatus, Microtermes* spp., *Pseudacanthotermes militaris.* (Lepidoptera) *Carea angulata, Colocleora divisaria, Neocleora nigrisparsalis, Nudaurelia krucki, Strepsicrates holotephras, Sylepta balteata, Thalassodes sp., Uzucha borealis.* (Orthoptera) *Schistocerca gregaria*.

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Eucalyptus globulus Labill.

Myrtaceae
Eucalypt, Tasmanian bluegum

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

A handsome ornamental shade, most widely planted of the subtropical/eucalypts. Grown for firewood in India (C.S.I.R., 1948 1976). This is one of the best eucalypts for pulp production. The timber is used for carpentry, construction, fences, piles, platforms, plywood, poles, sheds, and stations, tool handles, veneer, etc. Essential oil, widely used in cough drops, is antiseptic, rubefacient, and stimulant (Morton, 1981). A type of kino extracted from the tree in Argentina. Eucalyptus hybrid 'Mysore' is a promising source of pinenes, which are used in synthetic camphor, pine oil, terpineol, and in dry cleaning fluids, solvents, and cheap deodorants (Verma et al., 1978). The leaves have proven antibiotic acitivty. Their decoction is used for repelling insects and vermin (Morton, 1981). Africans use finely powdered bark as an insect dust. Mexicans chew the leaves to strengthen the gums. Said to be a good honey plant, Portuguese bee farmers like to raise their bees near this eucalyptus.

Folk Medicine

Reported to be anodyne, antiperiodic, antiphlogistic, antiseptic, astringent, deodorant, diaphoretic, expectorant, febrifuge, hemostat, inhalant, insect repellant, rubefacient, sedative yet stimulant, suppurative, and vermifuge, the bluegum eucalyptus is a folk remedy for abscess, arthritis, asthma, boils, bronchitis, burns, cancer, catarrh, cold, cough, croup, cystitia, diabetes, diptheria, dysentery, dyspepsia, fever, flu, grippe, inflammation, laryngitis, leprosy, malaria, miasma, phthisis, rhinitis, sores, sorethroat, spasms, tuberculosis, tumors, vaginitis, wounds, and worms (Watt and Breyer-Brandwijk, 1962; Duke and Wain, 1981; List and Horhammer, 1969–1979; Morton, 1981). Venezuelans take leaf decoction for cheat airments or colds, inhaling the vapors or drinking the decoction. Guatemalans use the leafy shoots for coughs and grippe, Jamaicans put the leaves in the bed, the bath, or the teapot for colds and fever. Cubans use the essential oil for bronchitis, bladder and liver infections, lung ailments, malaria, and stomach trouble. Mexicans chew the fresh leaves to strengthen the gums. Mexicans also use the leaf decoction as a vaginal douche. They argue that daily drinking of the leaf infusion can reverse diabetes in 8 days. Leaves are placed in the bath for rheumatism (Morton, 1981). Homeopaths use the plant for bronchitis, colds, flu, laryngitis, and rheumatism. In Asia, the leaf oil, clearly poisonous in large quantities, is regarded as anesthetic, antibiotic, antiperiodic, expectorant, febrifuge, and vermifuge, and it is used for asthma, bronchitis, influenza, and tuberculosis (Perry, 1980). In Australila, the leaves of the bluegum are still widely used as a household remedy in the treatment of many diseases and minor complaints. In Britain and Europe the essential oil, which is powerfully antiseptic, was given for fevers and febrile conditions, for pulmonary tuberculosis, and was applied or inhaled for relieving asthma, bronchitis, sorethroat, croup, whooping-cough, scarlet fever, and even diptheria and typhoid. The dried leaves were also smoked like cigarettes for asthma while the oil in the form of an aperitif was taken as a digestive (Brooker et al., 1981). Europeans in Africa and Africans themselves may wear the leaf in the hat or place it around the residence as a flu preventative. It is also regarded as a malaria preventitive. African herbalists believe the root is purgative.

Chemistry

Leaves contain 70–80% eucalyptol (cineol). Also includes terpineol, sesquiterpene alcohols, aliphatic aldehydes, isoamyl alcohol, ethanol, and terpenes (Morton, 1981). Tannin is not so copious in the leaves as of many other *Eucalyptus* species. The kino, containing 28.7% kino-tannin and 47.9% catechin contains the very antibiotic citriodorol (Watt and Bryer-Brandwijk, 1962). Verma et al. (1978) found 20.2% α-pinene, 25.2% β-pinene, and only 16.8% cineole in the cv 'Mysore'. Fresh leaves contain caffeic and gallic acids, dry leaves, ferulic and gentisic (Boukef et al., 1976), and quercetol, quercitrine, rutin, and a mixture of quercetol hyperoside and glaucoside. N-titriacontan-16, 18-dione was identified as the compound responsible for antioxidant activity in the leaf wax (Osawa and Namik, 1981).

Toxicity

In large doses, oil of eucalyptus, like so many essential oils has caused fatalities from intestinal irritation (Morton,1981). Death is reported from ingestion of 4–24 ml of essential oils, but recoveries are also reported for the same amount. Symptoms include gastroenteric burning and irritation, nausea, vomiting, diarrhea, oxygen deficiency, ,weakness, dizziness, stupor, difficult respiration, delirium, paralysis, convulsions, and death, usually due to respiratory failure (Duke, 1984b). Reported to cause contact dermatitis (Brooker et al, 1981). Sensitive persons may develop urticaria from handling the foliage and other parts of the plant (Watt and Bryer- Brandwijk, 1962).

Description

Evergreen tree 40–70 m tall with straight massive trunk 0.6–2 m in diameter with narrow, irregular crown of large branches and drooping aromatic, camphoraceous foliage. Root system deep and spreading. Bark smoothish, mottled gray, brown, and greenish or bluish, peeling in long strips, at base becoming gray, rough and shaggy, thick, and finely furrowed; inner bark light yellow within thin green layer. Leaves alternate, drooping on flattened yellowish petioles 1.5–4 cm long, narrowly lanceolate, 10–30 cm long, 2.5–5 cm wide, mostly curved, acuminate at tip, acute at base, entire, glabrous, thick, leathery, with fine straight veins and vein inside marlin, shiny dark green on both surfaces. Flowers 1 (rarely 2–3), at leaf base, more than 5 cm across, the very numerous, white stamens ca 12 mm long. Buds top-shaped, 12–15 mm long, 12–25 mm wide. Stamens many, threadlike, white, anthers oblong opening in broad slits with round gland. Pistil with inferior 3–5-celled ovary and long stout style. Capsules single at leaf base, broadly top-shaped or rounded, 1–1.5 cm long, 2–2.5 cm wide, 4-angled, warty. Seeds many, irregularly elliptical, 2–3 mm long, dull black (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, bluegum, or cvs thereof is reported to tolerate narrower extremes of temperature and soil than many of the more tropical species. ($2n$ = 20, 22, 28)

Distribution

The most extensively planted eucalypt species in the world...a total of 800,000 ha in dozens of countries...About half the world's plantation area is in Portugal and Spain (Little, 1983). Also cultivated in California, Arizona, and Hawaii.

Ecology

Ranging from Cool Temperate Moist to Wet through Subtropical Dry to Moist Forest Life Zones, bluegum eucalyptus is reported to tolerate annual precipitation of 8 to 16 dm and annual temperature of ca 16 to 20°C. Major successes have been in mild temperate climates and in cool highlands. Elsewhere it fails (NAS, 1980a).

Cultivation

Propagated by seed and basket transplants ca 6 mos old. No seed treatment is required. Fresh seeds germinate well but deteriorate rapidly. The tree is readily established, easily reproducing from self-sown seed. In California, seed collections from a single tree exhibit wide variation (2–80%) in germinative capacity after a 30-day germination period (Ag. Handbook 450). Seedlings like the adults are susceptible to drought, fire, and frost. Grasses need to be weeded, as the tree does not compete well with grasses (NAS, 1980a). Tree grows rapidly and coppices readily (reaching a meter or more in a few months).

Harvesting

Usually grown on rotations of 5–15 years. In India's Nilgiris, bluegum plantations are worked for fuel purposes on a 15-year coppice (C.S.I.R., 1948–1976).

Yields and Economics

Annual wood production of 10–30 m^3 has been reported from sites in Italy, Peru, Portugal, and Spain (NAS, 1980a). Verma et al (1978) estimated essential oil yields between ca 40 and 45 kg/ha from 6–8 MT green leaves. Completely dry leaves contain 1.27% oil in the cv 'Mysore'. The Wealth of India suggests 30 MT biomass/ha/yr in the Nilgiris (C.S.I.R., 1948–1976).

Energy

About 30 MT/ha biomass are reported. Verma et al. (1978) calculated little more than 7 MT leaves per hectare, green, or 6–8 MT for the cv 'Mysore', 3–4 MT dry leaves. In his compilation, Cannell (1982) cites data on trees 9.5 years old, spaced at 2,196 trees/ha. The stem wood on a DM basis weighed 19–58 MT/ha, the stem bark 5–11, the branches 2.6–5.5, the foliage 4.0–6.7, for a total standing aerial biomass of 35–110 MT/ha. The CAI (current annual increment) of stem wood was 2.9–7.7 m^3/ha/yr, stem bark 0.7–1.5, branches 0.5–0.7, foliage 2.6–ca 6 for a total aerial CAI of 6.7–15.6 MT/ha/yr, the low figures representing unfertilized trees, the high reflecting ca 200 kg/ha N and 90 kg/ha P. These data were taken at Victoria, Australia (38°20'S, 146°20'E, elev. 150 m). The wood burns freely, leaving little ash, and carbonizes easily, making good charcoal. With calorific value of 4,800 kcal/kg, the heavy wood (sp. grav. 0.8–1.0) is widely used for fuelwood and charcoal (NAS, 1980). Even the dead leaves and fallen bark are highly flammable. The charcoal is used for producer gas plants (C.S.I.R., 1948–1976). Cromer and Williams (Austr. J. Bot. 30:265. 1982) report that it took 9.5 years to accumulate 30 MT/ha biomass unfertilized, but only 4 years in heavily fertilized plots.

Biotic Factors

Listed as affecting *Eucalyptus globulus* are the following: *Actinopelte dryina, Armillaria mellea, Cercospora epicoccoides, C. eucalypti, Corticium salmonicolor, Cryptosporium eucalypti, Cytospora australiae, C. eucalyptina, Diaporthe medusaea, Didymosphaeria circinnans, Diplodia australiae, Fomes applanatus, F. scruposus, Fusarium oxysporum* var. *aurantiacum, Ganoderma lucidum, Harknessia uromycoides, Hendersonia eucalypticola, Laetiporus sulphureus, Macrophoma molleriana, Macrophomina phaseoli, Monochaetia desmazierii, Mycosphaerella molleriana, Pestalotia truncata, Pestalotiopsis funerea, Pezizella carneo-rosea, Pezizella oenotherae, Phellinus gilvus, Phyllostica extensa, Physalospora latitans, P. rhodina, P. suberumpens, Polyporus gilvus, P. hirsutus, P. schweinitzii, P. sulphureus, P. versicolor, Poria cocos, P. versipora, Sclerotinia fuckeliana, Septonema multiplex, Septosporium scyphophorum, Stereum hirsutum,* and *Valsa eucalypti* (Ag. Handbook 165; Browne, 1968). Also listed in Browne (1968) are the following: Angiospermae: *Dendrophthoe, neelgherensis,* and *Viscum album.* Coleoptera: *Gonipterus scutellatus, Paropsis obsoleta, Phoracantha semipunctata,* and *Triphocaris mastersi.* Hemiptera: *Ctenarytaina eucalypti* and *Eriococcus coriaceus.* Hymenoptera: *Rhinopeltella eucalypti.* Lepidoptera: *Metanastria hyrtaca, Mnesampela privata,* and *Spilonota macropetana.* Foliage unpalatable to livestock. The oil rich wood is resistant to termites (NAS, 1980a).

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Eucalyptus gomphocephala A. DC.

Myrtaceae
Tuart

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Widely planted as a windbreak and sandstabilizer, as well as an avenue and shade tree. Seasoning well, the wood works nicely and is good for boxcars, construction, fenceposts, stakes, trucks, and wagons (NAS, 1980a; Little, 1983). Bees working the flowers produce a choice light creamy honey.

Folk Medicine

No data available.

Chemistry

The leaf is reported to contain only 0.03% essential oil, rich in α-phellandrene and α-pinene (C.S.I.R., 1948–1976); the bark and kino contain tannin (Watt and Breyer-Brandwijk, 1962).

Description

Evergreen tree 12–42 m high. Trunk short, 1–2.3 m in diameter; crown dense, broad, with large spreading to nearly upright branches. Bark light ashy-gray, fibrous, finely fissured, not shedding. Leaves alternate, narrowly lanceolate, 12–17 cm long, 1.5–2.5 cm wide, slightly curved, acuminate, acute at base, entire, glabrous, thick, both surfaces shiny gray-green with faint regular veins. Umbels single at leaf base, with broad flat stalk 2.5–3.5 cm long and 1–1.5 cm wide. Flowers 3–7, stalkless from buds 20–25 mm long. Stamens many, long, threadlike, white, with oblong anthers and oblong gland. Pistil with inferior 4-celled ovary and short style. Capsules 13–20 mm long, 11–15 mm in diameter. Seeds many, tiny, 2–3 mm long, light brown (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, tuart, or cvs thereof, is reported to tolerate calcareous soil, limestone, salt, sand, and wind (NAS, 1980a). While tolerating slightly saline soils, it will not tolerate water-logging. This species is one of the best for winter rainfall areas.

Distribution

Grows naturally in pure or almost pure stands, less commonly in mixed forests with other eucalypts, restricted to a narrow sandy coastal plain behind the coastal dunes near Perth, from sea level to 30 m. Cultivated and/or promising in Cyprus, Ethiopia, Greece, Israel, Italy, Libya, Morocco (66,000 ha), Tunisia, Turkey, and Uruguay (NAS, 1980a).

Ecology

Tuart is reported to tolerate annual precipitation of 3 to 10 dm and annual temperature of ca 16 to 18°C, with 6 dry summer months. It grows naturally on neutral yellow or brown sand over limestone. Growing well on coarse, well-drained sands, it will tolerate 25% active Ca. Still it is said to be unsuitable for high lime soils and for frosty areas. It tolerates lower fertility than *E. camaldulensis*.

Cultivation

Easily propagated from seed and coppice (Little, 1983). Cultivation by dry farming techniques is best in the first year or two to suppress weed growth.

Harvesting

Rotations of 7–10 years are used. Trees regenerate readily from coppice.

Yields and Economics

Irrigated fertile Moroccan soils have yielded annually 21–44 m^3/ha, but yields of 6–7 are more usual on difficult sites.

Energy

One of the densest woods known (sp. grav. 1.17), tuart burns well and makes good firewood.

Biotic Factors

The eucalypt borer (*Phoracantha semipunctata*) may be a pest, especially in drier sites. In addition, Browne (1968) lists the following as affecting this species: (Fungi) *Armillaria mellea*, *Fusarium oxysporum*. (Coleoptera) *Systates surdus*, *Triphocarisa acanthocera*. (Hemiptera) *Apiomorpha egeria*.

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 19.23 to 18.03 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the wh. plant contained 81.60% volatiles, 1.10% ash, 17.30% fixed carbon, 48.18%C, 5.92%H, 44.18% O, 0.39% N, 0.01% S, 0.20% Cl, and undetermined residue.

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Eucalyptus grandis Hill ex Maiden

Myrtaceae
Flooded gum

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

This is a rather widely planted ornamental shade tree, also useful as a honey plant. The pale red timber is softer and lighter than that of many eucalypts. Easily worked, the wood is extensively used for medium-quality joinery in offices and hotels. They are good for crafts, and older trees, for telephone poles. It is occasionally used for veneer.

Folk Medicine

No data available.

Chemistry

The bark and kino contain tannins (Watt and Breyer-Brandwijk, 1962).

Description

Evergreen tree 40–60 m high with a tall straight trunk and 1–2 m in diameter. Crown spreading and thin in open; small and compressed in dense plantations. Bark white, gray or green, smooth, shedding in long narrow strips. Leaves alternate, lanceolate, 10–20 cm long, 2–4 cm wide, acuminate, inaequilateral, wavy, glabrous. Umbels single at leaf base, 2.5–3 cm long with flattened stalk of 12 mm. Flowers 5–12, short-stalked or stalkless. Buds pyriform, 10 mm long, 5 mm wide. Stamens many, threadlike, white, anthers oblong with large round gland. Pistil with inferior 4–6-celled ovary. Capsules several, short-stalked, pyriform or conical, 8 mm long, 6 mm wide (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, flooded gum, or cvs thereof, is reported to tolerate frost, heat, and poor soil. Adapted to a rather wide range of soil types, the species is relatively free of disease but somewhat frost tender. The tree grown in Africa and Brazil, possibly a hybrid with *E. saligna*, is superior to wild types in yield and bole straightness (NAS, 1980a).

Distribution

Ranging spottily from 17°S to 30°S in Australia, the plant is widely planted. It is so important in Brazil that it is said to be planted at the rate of 100,000 ha/yr. Mariani et al. (1981) mention its cultivation in Angola, Argentina, Australia, Brazil, Cuba, Ghana, Indonesia, Papua, Peru, Sri Lanka, and Zimbabwe.

Ecology

Seedlings of *E. grandis* are more resistant to waterlogging than those of *E. robusta*, which are more resistant than those of *E. saligna.* Estimated to range from Tropical Thorn to Moist through Warm Temperate Thorn to Moist Forest Life Zones, flooded gum is reported to tolerate annual precipitation of (6.0-)7.0 to 17.3(-25) dm (mean of 3 cases = 11.8), annual temperature of 18.8 to 27.5°C (mean of 3 cases = 23.2), and pH of 5.0 to 7.5 (mean of 2 cases = 6.2). Grows where summer temperatures reach 40°C, winter minima -1 to -3°C. While tolerating gradual temperature falls to frost, sudden freezing is very damaging. Does best where the rain is mostly in summer/fall with a spring dry period. Does well in moist, well-drained soils from shales, slates, sandstones, even granites and basalts. Seems to tolerate poor soils with low P content.

Cultivation

Since weeds severely limit growth, mechanical or chemical site preparation is essential if rapid rates of growth are to be achieved and maintained." (NAS, 1980a). The plant is sensitive to boron deficiency. Fertilizer applied at the time of planting can have a spectacular effect. Seedlings 2–5 months old are outplanted, best at the beginning of the wet season, spaced at 2 x 2 m to 5 x 5 m (NAS, 1980a).

Harvesting

Usual rotations in Kenya are 6 years for domestic fuelwood, 10–12 years for industrial fuelwood, 7–8 years for telephone poles. Forests are commonly regenerated by coppice from stumps, sprouting within 3 months, then thinned to 2–3 shoots per stump.

Yields and Economics

In Kenya, the initial crop averages ca 30 m^3/ha/yr over the first 6 years, the coppice crop closer to 46 m^3/ha/yr over the same period. Irrigated stands in Zimbabwe yield; 40 m^3, good stands in Uganda 17–45, and up to 35 m^3/ha in S. Africa. At Dehra Dun the MAI was 22 m^3/ha (Fenton et al., 1977). Webb et al. (1980) report yields of 24–70 m^3/ha/yr.

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges to 22 MT/ha in California. Introduced into E. Africa as railroad fuel early this century, flooded gum provides a lightweight (sp. grav. 0.40–0.55) fuelwood. In New South Wales, total biomass increases with age to 394 MT at 27 yrs. old, with foliage biomass increasing gradually to 6.2 MT. Though variable, understory biomass increased through recruitment to 42 MT at 27–yrs-old, the stick and bark component having reached a steady state 7 MT at age 15, the leaf component rather steady around 2, the humus content stabilizing at 17–18 (Bradstock, 1981). The Sri Lanka apellation turpentine-gas certainly suggests energy implications. Although this species produces more wood than *Acacia mearnsii*, it is inferior to that species for fuel and charcoal (Duke, 1981a). Eucalyptus scored lower than Melaleuca on yield (ca 6 MT/ha/yr cf 28 MT/ha/yr) and nothing had as high a heating value as the bark of Melaleuca (>25,000 kj/kg). The bark of *Eucalyptus grandis* has a relatively low heat value (14,683 kj/kg), perhaps due to a plethora of inorganic noncombustibles in the bark. The average ash content is 10.1%. The stem wood had a heat value of 19,213 kj/kg.

Biotic Factors

In Brazil, the fungus *Diaportha cubensis* attacks the flooded gum. Termites may be a problem in savanna plantations. Root rot is a serious problem (Fungi) in Zambia. Browne (1968) lists the following as affecting this species: *Cylindrocladium scoparium, Daldinia concentrica.* (Coleoptera) *Anomala cupripes, Automolus depressus, Phoracantha recurva, P. semipunctata, Triphocaris acanthocera, T. mastersi.* (Hemiptera) *Cardiaspina fiscella, C. maniformis.* (Isoptera) *Macrotermes natalensis.* (Lepidoptera) *Neocleora herbuloti, Nola lugens, Xyleutes boisduvali.* (Mammalia) *Trichosurus vulpecula.*

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 19.35 to 18.15 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the wh. plant contained 82.55% volatiles, 0.52% ash, 16.93% fixed carbon, 48.33% C, 5.89% H, 45.13% O, 0,15% N, 0.01% S, 0.08% Cl, and undetermined residue.

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Eucalyptus occidentalis Endl.

Myrtaceae
Swamp yate

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Reported as one of the hardest and straightest timbers of the world, with a tensile strength only slightly below that of wrought iron. The wood is used for wheelwright work (frames, vehicles, wheel parts) and construction. In Western Australia, the tree is recommended as a shade tree, suitable for parks because its light shade doesn't prevent grass. The bark was once used as a source of tannin.

Folk Medicine

No data available.

Chemistry

The leaf is reported to contain 0.95% oil with aromadendren (or aromadendrol), pinene, cineol, and sesquiterpenes. The bark is reported to contain 35–52% tannin (Watt and Breyer Brandwijk, 1962).

Description

Evergreen tree 15–28 m high, with stout erect trunk to 80 cm diameter; flat-topped or umbrellalike crown. Bark dark gray or almost black, thick, rough, fissured, fibrous, not shedding. Leaves alternate, narrowly to broadly lanceolate, 10–14 cm long, 2–3 cm wide, acute at both ends, sides nearly equal, entire, glabrous, thick, shiny dark green on both surfaces, petiole to 2 cm long. Umbels single at leaf base, the stalk 15–25 mm long. Flowers 3–7, short-stalked, the bud to 20 mm long. Stamens many, long, 8–20 mm long, yellowish-white, thread-like, with tiny gland-dots, oblong anthers with oblong gland. Pistil with inferior conical 4-celled ovary and long slender style. Capsules short-stalked, bell-shaped, 10–18 mm long, 8–12 mm wide. Seeds few, tiny, 2 mm long, brown (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, swamp yate, or cvs thereof, is reported to tolerate alkalinity, drought, heavy soils, salinity, sand, and brief waterlogging (NAS, 1980a; Little, 1983). It is reported to fare well on soils with 8% chlorides. ($2n = 22$)

Distribution

Native to the southwestern part of Western Australia (elev 50–300 m), the species has been introduced to northern Africa and southwestern Asia. Successful plantations are reported from Algeria, California, Hawaii, Iran, Israel, Morocco, and Sri Lanka (NAS, 1980a).

Ecology

Estimated to range from Subtropical Thorn to Dry through Warm Temperate Thorn to Dry Forest Life Zones, swamp yate is estimated or reported to tolerate annual precipitation of 3 to 10 dm, annual temperature of 16 to 23°C, and pH of 6.0 to 8.2. Summers where the species naturally grows may attain 38°C, with a dry season up to 7 months; the winters may dip down to 2°C, with up to 20 frosts. Trees often occur in seasonally flooded alluvial flats and adjacent to salt lakes, on clays.

Cultivation

No data available.

Harvesting

No data available.

Yields and Economics

Compared to other species of eucalypt, this is a slow grower. Webb et al. (1980) reported wood yields of 3–8 m^3/ha/yr.

Energy

The wood burns steadily with a hot fire.

Biotic Factors

NAS (1980a) reports no pests or diseases.

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Last update Tuesday, January 6, 1998 by aw

Eucalyptus robusta Sm.

Myrtaceae
Swamp mahogany, Iron bark

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

One of the most widely planted eucalypts, this has moderately hard and heavy wood (sp. grav. 0.51) which is strong but brittle and stiff, elastic, coarse-textured, and fairly straight-grained but with some interlocking. Difficult to season and split, it works well and takes a good polish, and is durable in contact with the ground. The wood is employed in general construction, for underground piling, utility poles, fenceposts, and firewood. An attractive ornamental honey-producing tree, it is also planted as a windbreak. The plant is used as an insecticide in China (Perry, 1980).

Folk Medicine

Reported to be preventitive, swamp mahogany is a folk remedy for abscesses, boils, cellulitis, colds, dysentery, encephalitis, enteritis, erysipelas, flu, gangrene, mastitis, and sores (Duke and Wain, 1981).

Chemistry

The kino contains the antibiotic citriodorol. Leaves and fruits were positive for flavonoids, sterols, and tannins. The bark contains only 1.4% tannin, while the leaves may contain 12% (Watt and Breyer-Brandwijk, 1962). Leaves contain 0.16% essential oil, with aromadendren (or aromadendral) and pinene.

Description

Evergreen tree 24–40 m with relatively large, short, straight, trunk 1–1.2 m in diam. ca half the height of the tree. Trunk may have air roots. Bark gray or brown, reddish brown beneath surface, very thick, rough, deeply furrowed, fibrous. Leaves alternate, blades broadly lanceolate, 10–18 cm long, 3–6 cm wide, acuminate, acute at base and often with curved, unequal sides, glabrous, thick, leathery, stiff, shiny or dull dark green upper surface, dull light green beneath. Petiole to 25 mm, umbels single at leaf base, to 6 cm long, peduncle 2–3 cm. Flowers 5–10, equally short-stalked, large, 3 cm across. Buds pyriform, 12–20 mm long, 7–10 mm wide. Stamens many, threadlike, spreading, white or cream-colored, ca 12 mm long, anthers oblong with large oblong gland. Pistil with inferior 3–4-celled ovary and straight, stout style. Capsules several in rounded cluster, stalked, 12–15 mm long, 10–12 mm wide. Seeds tiny, dull light brown, 1–2 mm long (Little, 1983).

Germplasm

The hybrid with *E. grandis* is regarded as having better firewood potential.

Distribution

Native to southeastern Australia on a very narrow coastal strip (0–100 m elev.), but now widely introduced in tropical and subtropical areas. According to Little (1983), it is the best adapted species to Puerto Rico. Cultivated, for example, in Angola, Argentina, Arizona, Brazil, California, Cameroon, China, Congo, Costa Rica, Florida, Ghana, India, Indonesia, Israel, Ivory Coast, Malagasy, Malaysia, Mauritus, New Hebrides, Nigeria, Peru, Philippines, Puerto Rico, Sri Lanka, Tanzania, and Vietnam.

Ecology

Estimated to range from Tropical Dry to Moist through Frostfree Subtropical Very Dry to Moist Forest Life Zones, swamp mahogany is estimated to tolerate annual precipitation of 8 to 15 dm, annual temperature of 18 to 25°C, and pH of 5 to 7.5. Where native, this species is found mainly in swamps and at the edge of brackish estuaries. It grows better on slopes, but doesn't compete as well as the mixed forest species (Little, 1983).

Cultivation

Out of a gram of seed, about 100 germinate. Seed is usually sown, immediately after collecting and sundrying.

Harvesting

In Malaysia, it starts fruiting as early as year 4. Fruits take two years to ripen in China. Fruits are collected when the capsules start to turn black.

Yields and Economics

In Argentina, 5 year old stands 9 m tall (1,583 trees/ha) had a basal area of 10 m^2 and a volume of 89 m^3 for an average of 18 m^3/ha/yr. Webb et al. (1980) report wood yields of 14–28 m^3/ha/yr. In Malaysia, the MAI was 4 cm planted under shade, 6 planted in slash/burn situation, and 11 planted in an abandoned vegetable garden (Fenton et al., 1977).

Energy

Little (1983) mentions the use of the species for fuel, but it was not recommended by NAS (1980a). Planted for fuel reserves at 1,000–2,000 m elevation in Sri Lanka (MacMillan, 1925). Comparing potential energy trees for Panama, Curtis and Duke (1982) cite Puerto Rico studies showing green weight of 14,556 kg/ha for *Eucalyptus robusta*, 8,922 for *Albizia procera*, 6,932 for *Casuarina equisetifolia*, 4,360 for *Leucaena* (K-8), 599 kg only for native *Leucaena*, and only 402 for *Cassia siamea*. The data from Puerto Rico were provided by a team promoting energy grasses as energy sources. They concluded that energy grasses will produce 6–7.5 times more green biomass. They cited 53 MT for sordan, 82 for napier grass, and 84 MT/ha DM for sugarcane (in 12 months). Perhaps the data of Smith and Dowd, in Florida, are equally reliable. They projected only ca 6 MT/ha for Eucalyptus (perhaps *E. grandis*, *robusta*, or *viminalis*) with ca 60 for napier grass, 32–54 for sugarcane, and 16–37 for sorghum, only 22 for sordan. Both the Puerto Rican and Florida tabulations suggest that the energy grasses may be 10 times as productive of DM as Eucalyptus. Eucalyptus scored lower than Melaleuca on yield (ca 6 MT/ha/yr) and nothing has as high a heating value as the bark of Melaleuca (>25,000 kj/kg). The stemwood (density 0.53 g/cm^3) ofi *E. robusta* had a heat value of 19,628 kj/kg, the stembark (0.22 g/cm^3), 18,074 (Wang et al., 1982).

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Complete list of references for Duke, Handbook of Energy Crops

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Eucalyptus saligna Sm.

Myrtaceae
Saligna eucalypt

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Often confused with *E. grandis*, a bottomland species, this slope species is an important general purpose hardwood and construction timber in Australia. Also used for cabinetry, crossties, furniture, shipbuilding, turnery, veneers. Since it is not a "greasy" wood, the Australians favor it for floorings and steps. A good honey plant, is often grown as an ornamental and/or shade tree (Little, 1983). Much used in South Africa for paper pulp and artificial silk (Watt and Breyer-Brandwijk, 1962). The oil has insecticidal properties against bedbugs, black beetles, flies, lice, and mosquitoes (Kambu et al., 1982).

Folk Medicine

No data available.

Chemistry

Leaves contain 0.12% essential oil, largely composed of α-pinene and p-cymene. Kambu et al. (1982) add 1,8-cineole, borneol, α-terpineol, and linalol. The bark contains 5.9-8.4% tannin.

Description

Evergreen tree 40–70 m high with open, spreading, irregular crown. Trunk 1.2–1.8 m in diameter, straight. Bark dull, bluish or greenish-gray, smooth, peeling off slightly and exposing yellow layer. Roots may have lignotubers near the surface. Leaves alternate, lanceolate, 10–20 cm long, 1.5–3 cm wide, often curved, acuminate, acute at base, glabrous, dull green or dark green above, dull light green below. Petiole 12–25 mm long. Umbels single at leaf bases and along twigs, 2–2.5 cm long. Flowers 3–9, usually 7, equally short-stalked or nearly stalkless, 12–19 mm across. Buds 8–9 mm long, 4–5 mm wide. Stamens many, threadlike, white, anthers oblong with large round gland. Pistil with inferior 3–5-celled ovary and short style, Capsules on short stalk or subsessile, campanulate or conical, 5–6 mm long and wide, dark brown. Seeds many, tiny, 1–2 mm long, dull light brown (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity and is reported to tolerate slopes. ($2n = 22$)

Distribution

Native to southeastern Australia, from sea level to 1,000 m. Introduced in Argentina, Brazil, California, Guyana, Hawaii, India, Indonesia, New Zealand, South Africa, and Sri Lanka.

Ecology

Estimated to range from Subtropical Dry to Moist through Warm Temperate Dry to Moist Forest Life Zones, saligna eucalypt is reported or estimated to tolerate annual precipitation of 8 to 15 dm, annual temperature of 16 to 22°C, and pH of 6.0 to 8.0. Inhabits soils derived from shales and deep well drained clays in valleys.

Cultivation

No data available.

Harvesting

No data available.

Yields and Economics

This is the fastest growing eucalypt in Hawaii where one 71 m specimen represents the tallest hardwood species in the US.

Energy

A 4-year old stand in Brazil had standing biomass of 56 MT/ha (38 aboveground, 8 litter, and 10 belowground). But annual biomass productivity was estimated at 15–17 MT/ha (Andrae and Krapfenbauer, 1979). Fenton et al. (1977) report wood yields of 19 m^3/ha/yr; Webb et al. (1980), 20–38.

Biotic Factors

Browne (1968) lists the following as affecting this species: (Fungi) *Fomes robustus, Sclerotinia fuckeliana, Thanataphorous cucumeris.* (Coleoptera) *Chaetastus tuberculatus, Doliopygus kenyaensis, Entypotrachelus meyeri, Nematocerus lindblomi, Phoracantha semipunctata, Triphocaris acanthocera, T. solida, Xyleborus truncatus.* (Hemiptera) *Cardiaspina pinnaeformis, Glycaspis baileyi.* (Hymenoptera) *Phylacteophaga eucalypti.* (Isoptera) *Macrotermes natalensis, Pseudacanthotermes militarism* (Lepidoptera) *Acrocercops laciniella, Agrapha limbirena, Axiologa pura, Cleora dargei, Eumeta junodi, Nola lugens, Nudaurelia gueinzii, Oenetus virescens, Pachypasa subfascia, Spilonota macropetana, Spodoptera littoralis, Strepsicrates rhothia, Zelotypia staccyi.* (Orthoptera) *Brachytrupes membranaccus.* (Mammalia) *Lepus whytei, Tragelaphus scriptus.*

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, January 6, 1998 by aw

Eucalyptus tereticornis Sm.

Myrtaceae
Forest redgum

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Recommended as a fuelwood species for arid and semiarid tropical regions, this shade and shelterbelt species has heavy wood (sp. grav. 0.75–1.05), is hard, durable, and strong but difficult to work. It is used for fuel, pulp, pilings, fiberboard, and construction; also for crossties and fenceposts.

Folk Medicine

No data available.

Chemistry

Leaves contain 0.48–0.66% essential oil, 0–10.4% of which is cineol. The bark and kino contain tannin.

Description

Evergreen tree 18–46 m high with straight stout trunk 1–1.8 m in diameter, large and open or fairly dense crown. Bark smooth, whitish, peeling in irregular thin sheets or large flakes, becoming mottled with white, gray, or blueish patches. Leaves alternate, lanceolate, 10–21 cm long, 12–25 mm wide, often curved, acuminate, acute at base, slightly thickened, shiny green on both surfaces, glabrous. Umbels single at leaf base, 2.5–3 cm long including the rounded stalk of 1 cm. Flowers 5–12, spreading on equal stalks on 5–7 mm. Buds 12–16 mm long, 5 mm wide. Stamens many, threadlike, white, 10–12 mm long, anthers small and elliptical, with small round gland. Pistil with inferior 4–5-celled ovary and long stout style. Capsules several, hemiglobose or turbinate, 6–9 mm long, 8–10 mm in diameter. Seeds many, tiny, 1 mm long and broad, shiny dark brown to black (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, forest redgum, or cvs thereof, is reported to tolerate drought and light frosts. It does not tolerate acidic soils or waterlogging. ($2n = 22$)

Distribution

With a wide latitudinal range (6–38°S) of ca 3,000 km from sea level to 1,800 m, the forest redgum is native from eastern Australia into New Guinea and Papua, the species is widely introduced, faring notably in South Africa for example. Reported in Argentina, Botswana, Brazil (national average yield 18 m^3/ha/yr), Congo, Cuba, Fiji, Ghana, Guyana, India, Indonesia, Pakistan, Papua, Paraguay, Peru, Sudan, Uruguay, and Zimbabwe (Mariani et al., 1981; Fenton et al., 1977).

Ecology

Estimated to range from Tropical Very Dry to Moist through Warm Temperate Dry to Moist Forest Life Zones, forest redgum is reported to tolerate annual precipitation of 5 to 20 dm, annual temperature of 16 to 25°C, and pH of 6.5 to 7.5. Where it grows naturally, it may tolerate 0–15 frosts a year. The dry season may extend for 7 months. The mean maximum temperature of the warmest month is ca 27°C, while the mean minimum of the coolest month is 7°C. Soils, usually not acidic, are rather rich, moist, alluvial, sandy loams and gravels, not usually waterlogged (Mariani et al., 1981).

Cultivation

No data available.

Harvesting

In Argentina it is harvested on 7–8-year rotations for charcoal, 9–12-year cycles for construction timber (Mariani et al., 1981).

Yields and Economics

On good sites in Argentina, an MAI of 18–30 m^3/ha/yr is obtainable, but in poor sites in India, the MAI may be closer to 3. At Dehra Dun, the 'Mysore' hybrid yielded only 3 m^3/ha/yr compared to 22 for *E. grandis* (Fenton et al., 1977).

Energy

In his compilation, Cannell (1982) cites data showing that trees 5 years old, spaced at 1,670 trees/ha, averaged a basal area of 18 m^2/ha. The stemwood and bark on a DM basis weighed 53.7 MT/ha, the branches 10.1, the foliage 6.7, and the roots were estimated at 10.6 MT/ha for a total standing biomass of 81.1 MT/ha. Nine-year olds spaced at 840 trees/ha averaged basal area of 42 m^2/ha. The stemwood and bark weighed 139.2 MT/ha, the branches 30.9, the foliage 8.0, and the roots were estimated at 18.6 for a total standing biomass of 196.7; suggesting an annual increment exceeding 20 MT/ha. The wood is used for firewood and charcoal. In Argentina, it is grown for the charcoal iron industry on a 7–8-year rotation. Calorific values were measured of different parts of 5–9-year old trees and their litter. Values for living material ranged from 3.2 to 5.7 kcal/g, similar to published values for forest communities. Energy content, annual production, retention and release through litter fall are tabulated for each stand age. Net annual production (in kcal/ha x 108) increased from 0.93 (of which 0.83 is retained in the tree and 0.10 released as litter) at 5 yr old to 1.56 (1.32 retained and 0.24 released) at 9 yr old. Energy fixation by *E. tereticornis* appears more efficient than in some other tree species reported in the literature (Singh, 1980).

Biotic Factors

Fenton et al. (1977) mention *Alternaria tenuissima, Corticium salmonicolor, Cylindrocladium scoparium, Ganoderma lucidum*, and *Sclerotinia fuckeliana* among diseases. Scarab beetles may defoliate this and other species. The coreid, *Amblypelta cocophaga,* has been associated with trees suffering dieback.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Tuesday, January 6, 1998 by aw

Eucalyptus viminalis Labill.

Myrtaceae
Manna eucalyptus

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The wood (51 lb/cu ft) is used for building, construction, joinery, and vehicles. It is considered suitable for paper pulp (C.S.I.R., 1948–1976). The red gum or manna exuding from cracks in the bark is eaten eagerly by South African boys and has been used for making adhesives and birdlime (Watt and Breyer-Brandwijk, 1962). Eucalyptus manna, which exudes from punctures in summer months, is sometimes consumed. The essential oil shows the same antiviral (influenza) effect as that of *E. dalrympleana* (Vichkanova et al, 1973). Leaves inhibit *Staphylococcus aureus*.

Folk Medicine

The leafy twig decoction was used to bathe rheumatic limbs in South Africa.

Chemistry

Leaves contain 0.35–0.75% essential oil, of which 50–65% is cineol, 5% is pinene, and 10% is eudesmol. The "manna" contains arabinose, raffinose, dextrose, and sucrose. The bark contains 4.8–8% tannin, the kino 92.7% (Watt and Breyer-Brandwijk, 1962). The kino contains 7.1% moisture, 0.25% ash, and 92.7% catechin + tannin (C.S.I.R., 1948–1976).

Toxicity

The species is suspected to cause poisoning in koala bears, perhaps due to HCN (0.09% HCN has been reported) (Watt and Breyer-Brandwijk, 1962).

Description

Seedling phanerocotylar, the cotyledons reniform.

Germplasm

Reported from the Australian Center of Diversity, manna eucalyptus, or cvs thereof, is reported to tolerate more frost than most species of eucalypt. ($2n$ = 22)

Distribution

Native to Southeastern Australia, but cultivated in Argentina, California, Hawaii, India, Peru, et al.

Ecology

No data available.

Harvesting

No data available.

Yields and Economics

At Calistoga, California, Standiford and Donaldson (1982) calculated 7.8 m^3/ha/yr, equivalent to 3.2 cords or 20 million kcals/ha/yr.

Energy

NAS (1980a) suggested this as a promising firewood species. Webb et al. (1980) report wood yields of 10–30 m^3/ha/yr.

Biotic Factors

Browne (1968) reports the following as affecting this species: (Fungi) *Fomes robustus, F. setulosus, Inonotus chondromyelus, Phytophthora parasitica, Polyporus portentosus, P. zonatus.* (Coleoptera) *Entypotrachelus meyeri, Gonipterus scutellatus, Paropsis obsoleta, Phoracantha semipunctata, P. tricuspis.* (Hemiptera) *Eriococcus coriaceus.* (Lepidoptera) *Spilonota macropetana.*

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- Watt, J.M. and Breyer-Brandwijk, M.G. 1962. The medicinal and poisonous plants of southern and eastern Africa. 2nd ed. E.&S. Livingstone, Ltd., Edinburgh and London.
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Last update Tuesday, January 6, 1998 by aw

Syzygium jambos (L.) Alston

Syn. *Eugenia jambos* L.

Myrtaceae

Jambos, Jambu, Malabar plum, Plum rose, Pomarosa, Rose apple, Wax apple

---

NewCROP has Pomarosa information at:

Rose Apple—Julia Morton, Fruits of Warm Climates

Magness—J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Rose apple info:

ROSEAPPLE "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Eugenia luschnathiana

Klotzsch ex O. Berg.

Myrtaceae

Pitomba

We have information from several sources:

Pitomba—Julia Morton, Fruits of warm climates

Myrtaceae—R.J. Campbell, South American fruits deserving further attention

Syzygium malaccense (L.) Merrill & L.M. Perry

syn. *Eugenia malaccensis* L. not Lour.
syn. *Jambosa malaccensis* (L.) DC.

Myrtaceae

Malay Apple, Rose apple, Large-fruited rose apple, Pomerac Jambos, Malay Pomarosa, Tahiti apple, Jambu merah (tree)

NewCROP has Malay Apple information at:

Malay Apple Julia Morton, Fruits of Warm Climates

Magness J.R. et al. 1971. Food and feed crops of the United States.

Eugenia uniflora L.

Myrtaceae

Surinam Cherry

We have information from several sources:

Surinam Cherry—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Wahoo

Euonymus atropurpureus Jacq.

Other common names.—Burningbush, spindle tree, Indian arrowwood, bursting-heart, strawberry-tree, strawberry bush, American spindle tree, bitter ash, pegwood.

Figure 113.—Wahoo (*Euonymus atropurpureus*)

Habitat and range.—Wahoo is found in woods and thickets from Ontario and the eastern United States to Montana.

Description.—This shrub or small tree, which is from 6 to 26 feet in height, more often reaching only 10 feet, has an ashy gray bark and rather thin, pointed leaves from 1 1/2 to 5 inches in length and about half as wide. The purple flowers are produced in June in loose, slender-stemmed clusters of from 6 to 15 flowers each. The pale-purple fruit consists of four deeply cleft, flattened lobes. In autumn the capsules open and disclose the seed surrounded by a red, false seed coat, giving the bush a bright and showy appearance

The name wahoo is applied indiscriminately to *Euonymus atropurpureus* and *E. americanus* L., the latter a low and trailing bush having roughened, crimson capsules, to which the name burningbush more properly belongs.

Part used.—The bark of the root and the stem.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Euphorbia lagascae L.

Euphorbiaceae

We have information from several sources:

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Potential of Fanweed and Other Weeds as Novel Industrial Oilseed Crops—Patrick M. Carr

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

last update October 23, 1997

Vitis vinifera L.

Vitaceae

Old world, European, or California grapes

We have information from several sources:

Establishing New Crops Industries: The Indiana Grape and Wine Industry Model—Bruce Bordelon, Theresa Browning, and Cheri Wagner

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

The Indiana Wine Grape Council

Growing Grapes in Indiana—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Grape Varieties for Indiana—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Outside Links:

Grapevine—FAO/IBPGR Technical Guidelines for the Safe Movement of Grapevine Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Grapevine—Descriptors for Grapevine—Link to the publication on the International Plant Genetic Resources Institute web site

Grapes—from Mark Reiger, Dept of Horticulture, University of Georgia.

Grape Information from the University of California Fruit & Nut Research and Information Center

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Eustoma

Gentiaceae

We have information from several sources:

New Floral Crops in the United States—Mark S. Roh and Roger H. Lawson

New Floricultural Crops—Mark S. Roh and Roger H. Lawson

New Flower Crops—Abraham H. Halevy

Wasabia japonica (Miq.) Matsumara

syn= *Eutrema wasabi* (Sieb.) Max.; *Eutrema japonica*; *Cochlearia wasabi* Sieb.; *Alliaria wasabi* Prantl.; *Lunaria japonica* Miq.)

Brassicaceae or Cruciferae

Wasabi, Japanese horseradish, mountain hollyhock

A related species, *Eutrema tenuis* syn. *Wasabia tenuis* Matsum. is yuri-wasabi, a smaller version of cultivated wasabi.

Wasabi. See: New Crop Development in New Zealand by James A. Douglas In: New crop development in New Zealand. p. 51-57. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York. 1993.

Outside Wasabi links:

Wasabi (Wasabia japonica)

New Zealand Wasabi Limited - The Home of Namida Wasabi - Clean, Green & Hot.

Vicia faba L.

Fabaceae

Broadbean, Fava bean, Horsebean, Windsorbean, Tickbeans (small types)

We have information from several sources:

FactSHEET—contributed by F.J. Muehlbauer and Abebe Tullu

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Fababean—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Chickpea, Faba Bean, Lupin, Mungbean, and Pigeonpea: Potential New Crops for the Mid-Atlantic Region of the United States—Harbans L. Bhardwaj, Muddappa Rangappa, and Anwar A. Hamama

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Growing Beans In The Home Vegetable Garden—HO-175 Purdue University Cooperative Extension Service

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

American False-Hellebore

Veratrum viride Ait.

Figure 5.—American false-hellebore (*Veratrum viride*)

Other common names.—True veratrum, green veratrum American veratrum green hellebore, swamp hellebore, big hellebore, false hellebore, bear corn, bugbane, bugwort, devil's-bite, earth gall, Indian poke, itchweed, tickleweed, duck-retter.

Habitat and range.—American false-hellebore is native in rich wet woods, swamps and wet meadows, its range extending from Canada, Alaska, and Minnesota south to Georgia and Tennessee.

Description.—The large bright-green leaves of this plant make their way through the ground early in spring, followed later in the season by a stout, erect leafy stem, sometimes growing as tall as 6 feet. It is round and solid, pale green, closely surrounded by the sheathing bases of the leaves and unbranched except in the flowering head. The large leaves, the lower ones of which are from 6 to 12 inches in length and 3 to 6 inches in width, are hairy and pleated like a fan. The numerous greenish-yellow flowers are produced from May to July in rather open clusters. The plant is very poisonous.

Part used.—The rootstock, dug in autumn when the leaves have died down.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Wednesday, March 11, 1998 by aw

Small, E. 1999. New crops for Canadian agriculture. p. 15–52. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

New Crops for Canadian Agriculture

Ernest Small

The designation "new crop" may be applied to virtually any useful plant that in some respect is new. The following categories of newness (which are not all mutually exclusive) are economically important in discussing new crops: (1) gathering new wild crops from nature; (2) cultivating an undomesticated plant not previously grown; (3) domesticating (changing genetically) an undomesticated plant; (4) breeding improved cultivars of domesticated plants; (5) growing crops in new areas; (6) growing crops for new uses; (7) growing crops with new management techniques; (8) selling crops in new markets.

Category 2 and (especially) category 3 represent "new crops" in the narrow sense perhaps most widely understood. Although all domesticated crops originally came from the wild, in recent times the domestication of wild plants relatively infrequently produces crops of notable economic significance. Based on 160 crops grown and/or imported in the US that had a value of at least $1 million, Prescott–Allen and Prescott–Allen (1986) found that only six crops with this value were domesticated since 1900, a rate of success of less than 7 per century. Almost all potentially important new crops for a political or agronomic region are cultivated elsewhere, and indeed the leading domesticated crops of Canada all originated in foreign lands. Crop diversification, especially involving new crops, is considered to be a fundamental area deserving support in Canada (Small, in 1999; note Fig. 1).

The following reviews what is significantly new (for any of the eight kinds of newness pointed out above) with respect to the major classes of crops in Canada, such as cereals, oilseeds, forages, vegetables, and fruits. These crop classes represent arenas of competition, and new crops generally can only compete within one of these arenas. As will be noted, some of these arenas thrive on the introduction of new entities, while others are like clubs that are very hostile to the entry of new members. Given the breadth of the topic, only a limited amount of detail and selected examples will be presented for the crop categories, and minor crops that either have had very limited success in Canada or show little potential will not be discussed or will be given only incidental mention. For those seeking additional information on new crop development in Canada, it should be noted that the following present a wealth of information on the World Wide Web: (1) the federal department of agriculture, i.e. Agriculture and Agri-Food Canada (AAFC), Canada's primary plant breeding institution, which has research stations in all provinces; (2) the provincial agriculture or resource departments; and (3) a wide variety of farm-oriented organizations.

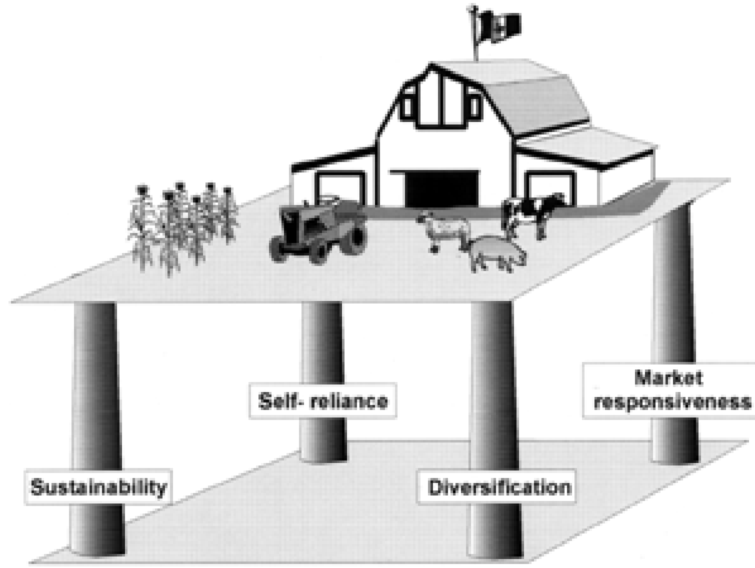


Fig. 1. A vision of agriculture in Canada, conceptualizing crop diversification as one of four essential supporting pillars (Agriculture Canada 1989).

CANADIAN AGRICULTURE

Agriculture is the most important of the industries dealing with the biological resources of Canada, exceeding the value of forestry, fishing, and trapping. Agriculture and the allied agri-food industry are respectively responsible for about 2 and 6% of the Gross National Product (GDP), and about 14% of Canada's employment. In 1996 (the year of the last comprehensive census) the agri-food industry of Canada was worth over $70 billion* (about 8.8% of Canada's GDP), of which 24% represented on-farm production, the remainder accounted for by allied food industries, commercial sales, and the food service industry. The equivalent of 70% of Canada's agricultural production, with a value of about $20 billion, was exported in 1996, while the value of imported agricultural and food products was about two-thirds of this. This overall trade surplus shows that Canadian agriculture is dependent on world markets, and suggests that new crops represent an important measure to address market fluctuations and declines. The most important commodities exported by Canada are grains and grain products (35% of total agri-food exports), red meat and live animals (20%), and oilseeds and oilseed products (13%). The US is Canada's most important trading partner, taking about half of Canada's agri-food exports. In return, about 60% of Canada's agri-food imports are from the US. Imports include fruits and nuts (19% of total agri-food imports), vegetables (10%), and red meats (8%). The relatively short growing season of Canada necessitates a wide variety of agricultural imports, most notably hot-region plantation crops such as coffee, tea and spices (10% of all imports).

Fig. 2 shows the distribution of farmland in Canada. More than 40% of Canada is forested; about half of this area is capable of producing timber, and about a quarter is currently managed for timber production. Adverse climate, soil, and other circumstances prevent profitable agriculture in most of the country. Although Canada has close to 10 million square kilometers, making it the world's second largest country, only 67.7 million ha (0.677 million square kilometers) are arable (Canadian Federation of Agriculture 1995; Reid 1995). By comparison, total land in farms in the US in 1997 was 392 million ha, about six times the area used for farming in Canada. (The value of US crops in this year was about 109 billion dollars, about 10 times the value of Canadian production.) The arable area of Canada, about 7% of the country, is equal to about three times the land area of Great Britain. However, it has been estimated that less than 5% of Canada's land is actually capable of producing crops, and most of this is already in production (Environment Bureau 1997a). Moreover, only half of this land capable of producing crops is prime agricultural land, and much of this has succumbed to urban development (Science Council 1991). Canada may already be approaching its upper limit of farmland development (Acton 1995). An additional 6% of Canada's land can be used for grazing (Environment Bureau 1997a).

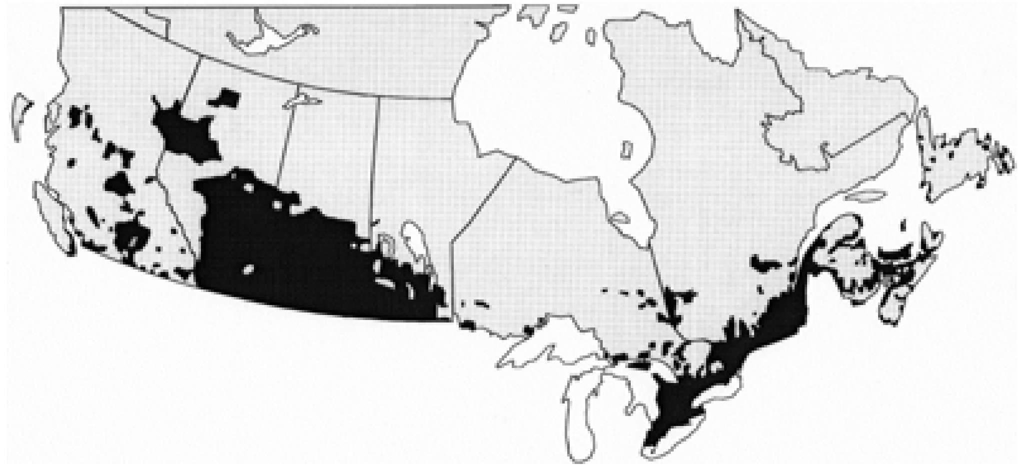


Fig. 2. Distribution of cropland in Canada (blackened area).

Limiting Factors for Agriculture in Canada

All crops grown in Canada (with the exception of greenhouse and cultured mushroom crops) and all potentially new crops are strongly constrained by climate and soil factors (Fig. 3). Of course, length of season, distribution of temperature and precipitation, soil fertility, and physical aspects of land are universal determinants of what crops can be grown. Land use inventories that assess the suitability of land for agriculture, forestry, recreation, and wildlife have been in use for several decades (Statistics Canada 1986). For example, the soil regions of Western Canada differ in the capacity to grow crops. The brown soil in the semi-arid region of the Prairies varies considerably from year to year in crop yield depending on degree of drought, while dark brown soil is not as vulnerable to drought. The black soil retains moisture better than the brown soil, is rarely subject to drought, and produces higher yields. The gray soil zone has higher moisture levels, cooler temperatures, and a shorter growing season. Management practices in the different zones are necessary, since climatic conditions influence the susceptibility of crops to disease and pest infestation.

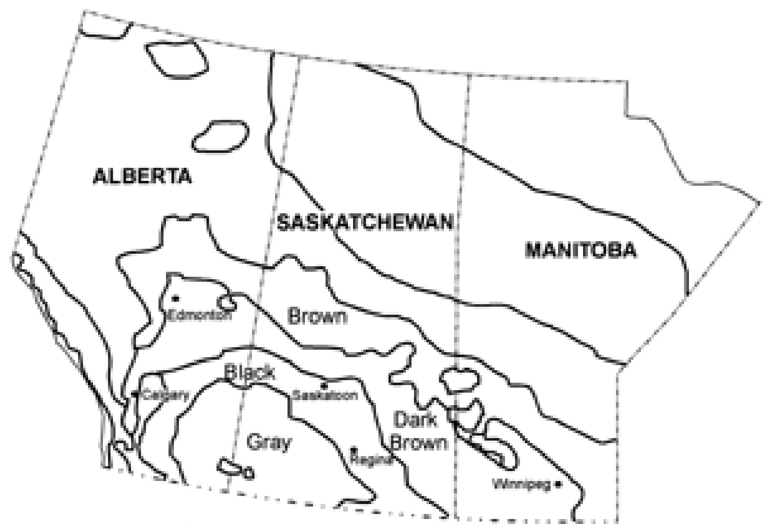


Fig. 3. Principal soil zones of the Western Canadian prairies, Canada's most important agricultural region. These zones heavily influence which crops are advisedly cultivated.

Ideally, knowledge of three factors can be used to produce an excellent identification of what crop should be grown where and when. First, an agricultural knowledge of the growth requirements of crops is necessary. Second, measures of the comparative extent to which local soil, climate, and pests and diseases match the needs of the crops. And third, predictions of markets for the crops, both domestic and foreign. In fact, such detailed budgets are issued by Canada's federal and provincial agriculture departments for various regions (Spak 1998b), and are helpful in making decisions as to what major crops should be planted, especially in the prairie regions described above, for which there are only a few major crops and detailed information is available. In theory, such elegant prediction could be done for every possible crop, so that everyone, everywhere would know exactly what crop to grow. Of course, this is a Utopian scenario, since such detailed knowledge is not available and is only acquired after fairly expensive studies. Nevertheless, it is well to keep in mind that knowledge of both old and new crops is a key to resolving the universal question of farmers, "What should I plant this year?" and indeed the NewCROP website (www.hort.purdue.edu/newcrop) of which this article is a contribution is perhaps the premier source of needed information.

History of Dominant Crops in Canada

Because cereals and oilseeds dominate Canadian agriculture, it is instructive to examine the historical importance of these during this century in Canada. As can be seen from Fig. 4, wheat, oats, barley, maize and flax have been major crops in Canada for at least the last 75 years, and while their relative importance has varied, all have

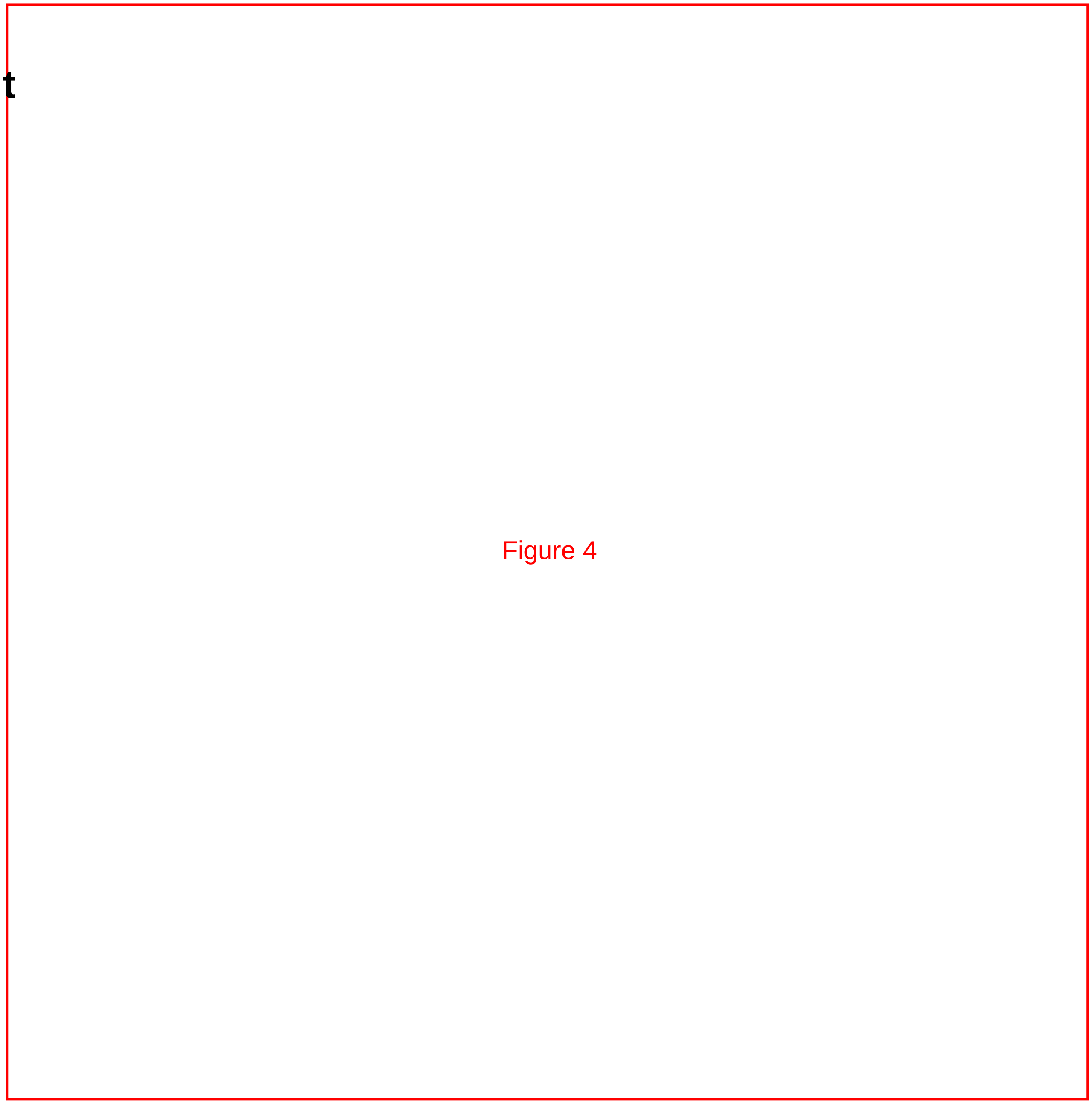


Fig. 4. Areas of the principal cereals and oilseeds grown in Canada for which records are available for all of the comprehensive 10-yearly (1921–1951) and 5-yearly (1951–present) agricultural censuses (data from Statistics Canada 1997a).

remained prominent for many years. No other cereal has become important in Canada, but canola (rapeseed) and soybeans, discussed below, have been the leading Canadian oilseeds for just the last several decades.

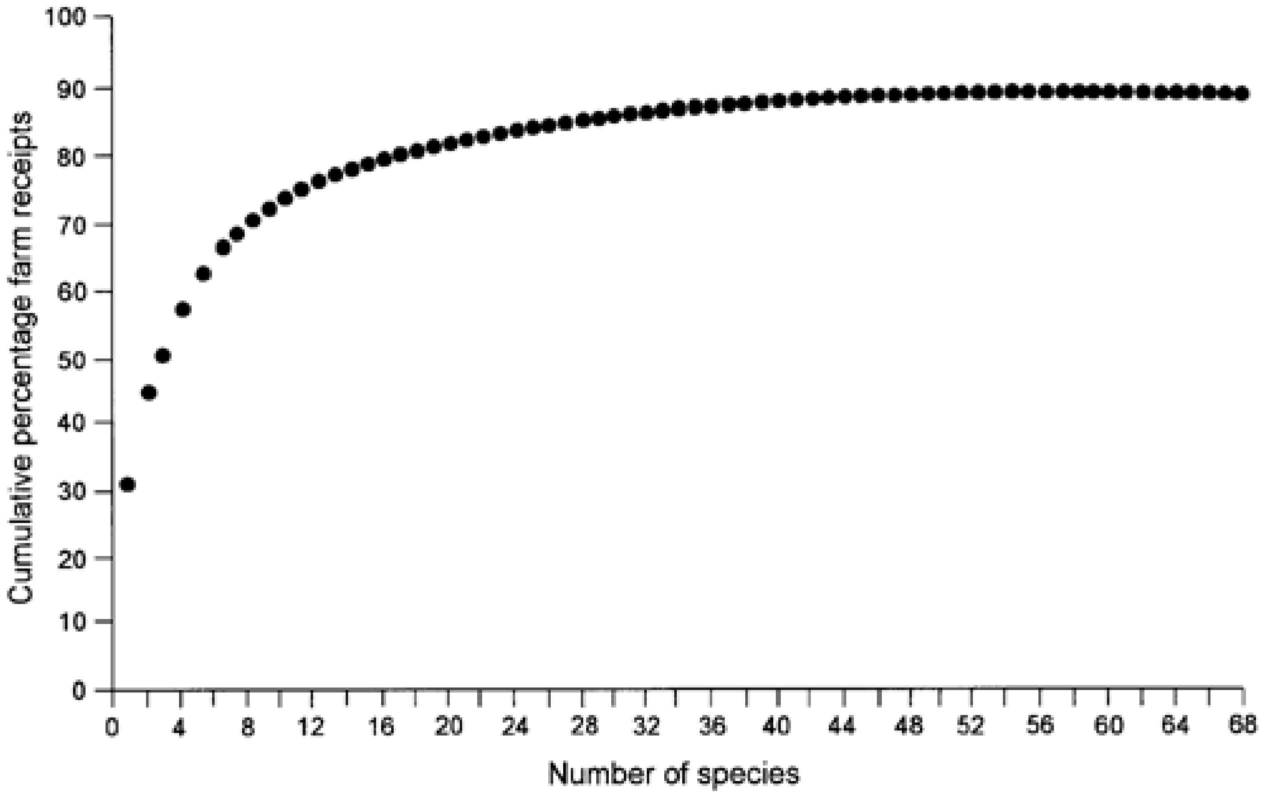


Fig. 5. Progressive cumulative values of the 68 Canadian crops for which national farm gate value or farm receipt statistics are available (compiled from Statistics Canada 1996, 1998a,b).

Fig. 5 illustrates the progressive cumulative value of the 68 Canadian crops for which national statistics are compiled (these range from over 4 billion dollars for wheat to less than 2 million dollars for apricots). This shows that the increased value becomes progressively less as one adds crops to the economy, and superficially it suggests that new crops are not needed. This is an incorrect conclusion for the following reasons: (1) one cannot predict the future value of new crops, which are needed for many reasons; (2) the crops with the highest national incomes are not necessarily profitable; (3) some of the most important crops are not suitable for some regions; (4) farm gate values do not measure the very high value of on-farm use of many crops; (5) farm gate values do not measure the very high value-added aspect of many crops.

Crop Specialization by Region

For simplicity, five regions are discussed, as follows (west to east): British Columbia specializes on fruits (particularly apples) and vegetables, and also has strong livestock and dairy production. The prairie provinces are specialized in grain and oilseeed farms, particularly wheat, oats, barley, canola, rye, and flax. Most of Canada's grazing lands occur in the prairies, and there is a very large red meat industry, with Alberta alone producing half of Canada's beef. Ontario and Quebec are the best areas for maize, and there are strong livestock, dairy, and horticultural sectors. Ontario is the center of soybean cultivation, and there is substantial greenhouse and fruit cultivation. The Maritime (Atlantic) area is particularly suitable for forage crops and an associated livestock industry, as well as potato and fruits such as blueberry. Tables 1 and 2 and Fig. 6 provide summary data for Canada's most important crops, for the five regions, based on crop area and farm receipts.

Table 1. Area of crops grown in Canada in 1996 (based on comprehensive 5-yearly census; excludes Territories; data from Statistics Canada 1997b; in some cases sums for Canada are not additive because of method of data collection).

Crop	Area (ha)					
	British Columbia	Prairie provinces	Ontario	Quebec	Maritime provinces	Canada
Grains						
Wheat	40,146	12,013,427	315,231	34,661	15,801	12,419,264
Barley	45,116	4,877,886	134,688	125,225	58,263	5,241,179
Oats	34,083	1,867,116	39,804	85,106,	18,642	2,044,748
Maize (for grain)	642	29,134	767,142	331,775	3,465	1,132,157
Maize (for silage)	9,636	17,615	119,799	40,149	4,161	191,359
Rye	2,849	156,150	26,500	4,010	2,390	191,899
Triticale	49	25,347	281	180	--	25,857
Mixed grains	2,232	134,503,	113,216	32,019	11,626	293,596
Canary seed	56	248,635	6	55	--	248,752
Buckwheat	27	13,777	2,755	2,875	292	19,726
Oilseeds						
Canola (rapeseed)	25,821	3,480,691	21,571	3,211	141	3,531,435
Soybean	--	666	776,209	96,693	3,323	876,901
Flaxseed	189	591,183	640	90	--	592,104
Mustard seed	--	238,833	13	175	--	239,021
Sunflower seed	109	36,230	433	208	121	37,099
Safflower	--	1,496	--	--	--	1,611
Forages and Fodders						
Alfalfa (including mixtures)	161,485	2,602,126	598,711	210,949	25,112	3,598,383
All other tame hay and fodder	186,487	1,160,016	419,416	670,730	175,839	2,612,488
Forage seed for seed	18,987	158,661	4,820	967	400	183,833
Vegetables						
Potato	3,642	43,883	16,149	18,722	67,912	150,309
Other vegetables (excluding greenhouse)	7,117	7,987	64,131	40,313	8,151	127,697

Dry legumes						
Dry field peas	3,606	531,872	386	388	65	536,319
Lentil	284	303,107	6	--	--	303,401
Dry field bean	27	44,543	43,927	5,133	250	93,949
Fruits and Nuts						
Tree fruits and nuts	10,453	106	19,046	7,958	4,104	41,668
Berries and grape	6,887	1,032	8,480	10,706	12,707	39,812
Miscellaneous						
Tobacco	--	--	27,597	1,831	--	29,428
Sugar beet	--	23,866	85	--	--	23,953
Other field crops	702	25,724	2,638	296	135	29,494
Nursery products	3,213	3,784	10,610	3,500,	415	21,521
Sod	936	4,251	9,525	5,689	1,562	21,964
Christmas trees	9,453	1,852	11,285	12,342	16,138	51,070
Total crop area	574,234	28,645,499	3,555,100	1,745,956	431,015	34,951,977

Table 2. Gross value of farm receipts in Canada for Canadian crops for 1997 (in thousands of Canadian dollars; based on Statistics Canada 1998a). (Note that gross farm receipts include transfer payments from governments for a few crops, and for such crops represent a slight over evaluation of farm gate value).

Crop	Value (Canadian $)					
	British Columbia	Prairie Provinces	Ontario	Quebec	Maritime Provinces	Canada
Grains						
Wheat	11,885	4,127,359	71,325	13,163	3,237	4,226,969
Barley	5,908	919,576	11,612	17,855	6,858	961,809
Maize	--	16,666	425,200	246,010	54	687,930
Oats	1,659	257,705	5,201	8,998	573	274,136
Rye	19	28,967	5,410	--	--	34,396
Canary seed	--	49,650	--	--	--	49,650
Oilseeds						
Canola	6,840	1,974,553	17,196	-	-	1,998,589
Soybean	--	--	726,158	87,403	417	813,978
Flaxseed	--	333,207	--	--	--	333,207
Mustard seed	--	91,214	--	--	--	91,214

Sunflower seed	--	16,950	--	--	--	16,950
Forages and Fodders (n.b.: mostly used on farm, and so farm receipts do not reflect large quantities grown)						
Hay and clover	13,823	63,291	4,996	3,535	141	85,786
Forage, grass seed	4,375	30,395	1,664	76	--	36,510
Vegetables						
Potato	15,839	165,096	53,292	88,018	196,770	519,015
Other vegetables	173,168	76,633	462,139	251,949	37,363	1,001,252
Dry legumes						
Dry peas	--	196,495	--	-	--	196,495
Lentil	--	99,712	--	--	--	99,712
Dry bean	--	11,874	28,640	--	--	40,514
Fruits						
Apple	32,467	--	81,270	25,104	15,160	154,001
Other tree fruits	13,852	--	42,822	-	520	57,194
Strawberry	4,481	3,355	17,351	16,376	7,811	49,374
Other berries & grapes	79,517	1,743	45,032	27,716	23,061	177,069
Miscellaneous						
Floriculture & nursery	265,254	109,660	540,893	140,899	65,189	1,121,895
Tobacco	--	--	328,727	22,437	--	351,164
Forest products	32,300	6,565	16,988	58,707	19,990	134,550
Maple products	--	--	10,108	86,457	5,043	101,608
Sugar beet	--	34,483	--	--	--	34,483
Other crops	7,019	84,172	32,354	30,651	14,473	168,669
Total crop value	709,016	8,699,321	2,973,578	1,125,354	396,660	13,903,929
Total livestock	945,324	5,963,192	3,659,289	3,367,328	603,388	14,538,521

Relative Importance of Types of Crops

The relative percentage crop area categorized by type of crop (based on Table 1) is shown in Fig. 7. Grains occupy over 60% of Canada's farmland. The oilseeds have about 15% of Canada's farmland, but are a higher-value crop. Forages and fodders occupy about 18% and, along with the coarse grains (barley, oats, maize) and presscake from the oilseeds, contribute to the feeding of the very large livestock population. Vegetables and dry legumes (peas and beans) have only about 3% of the land, but represent very high value crops. In the following discussion of what is new in the crop groups, the length of the treatment is approximately proportional to the importance of the groups in Canada.

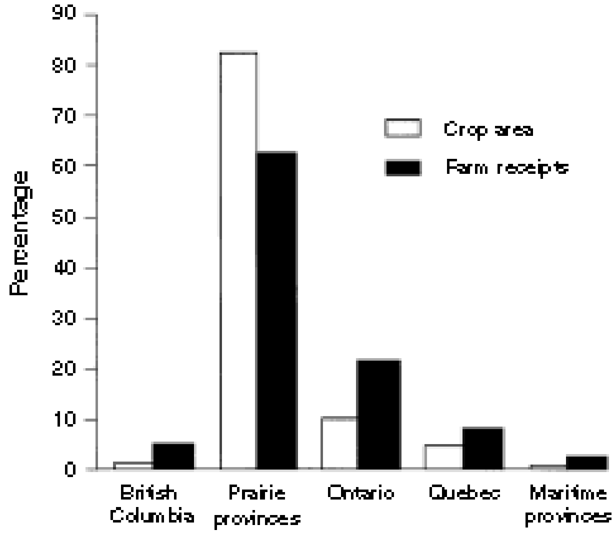


Fig. 6. Relative percentage for crop area and farm receipts for the five regions of Canada discussed in text.

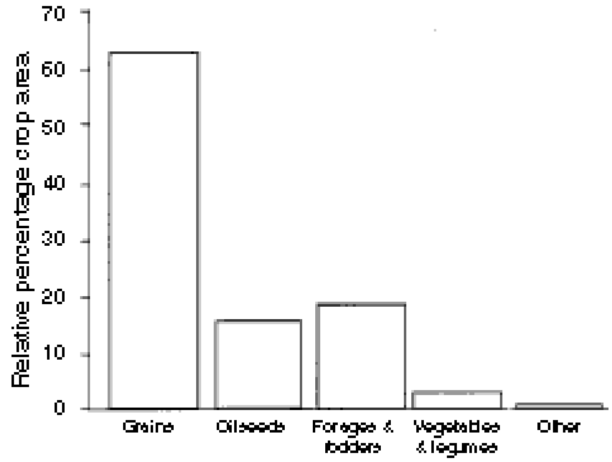


Fig. 7. Relative percentage crop area occupied by the major types of crop in Canada.

GRAINS

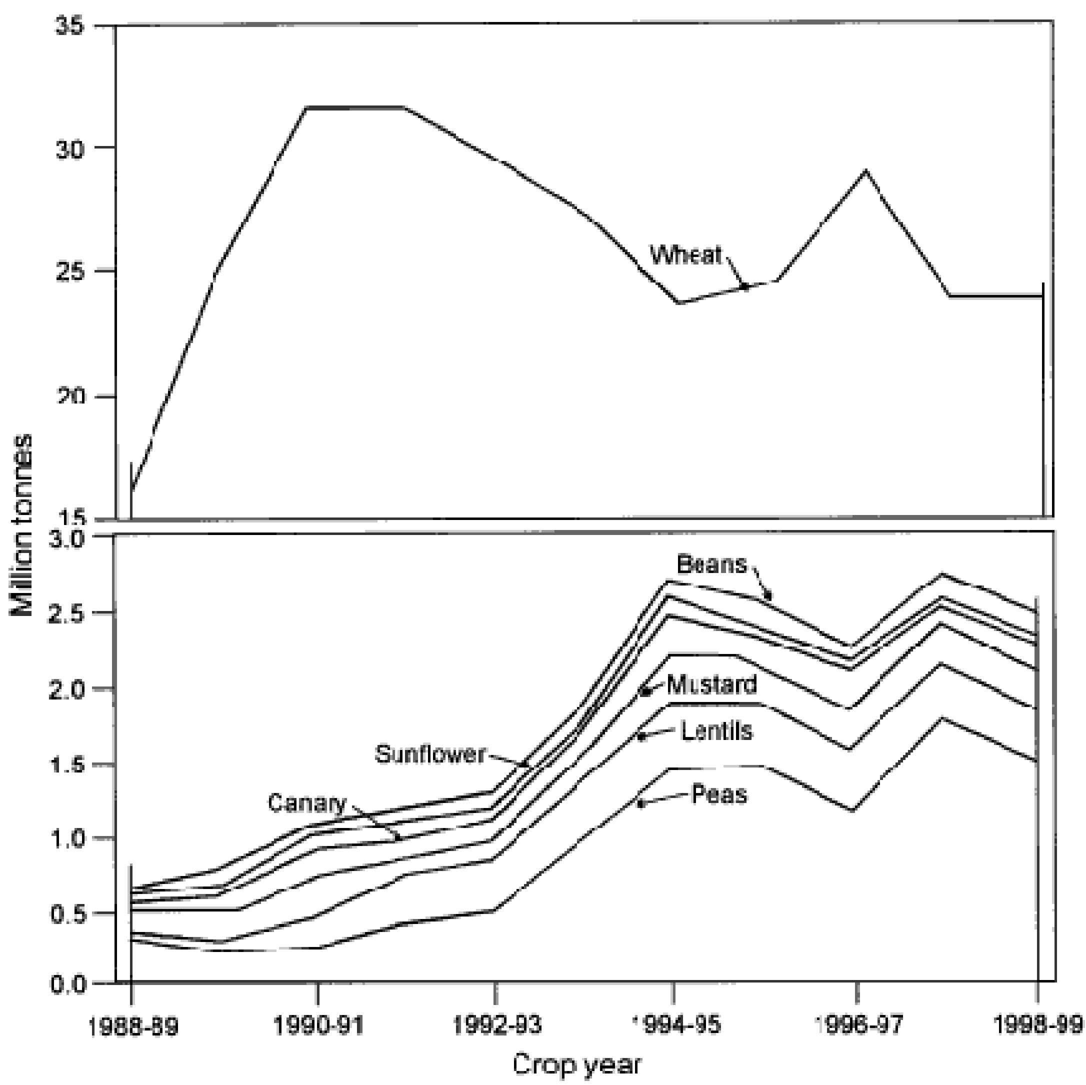
Canada produces about 5% of the world's wheat, 9.9% of the world's barley, 14% of the world's oats, and 1.4% of the world's maize. Canadian grains are used for domestic food consumption, animal feeds and industrial uses, with about half of cereal production exported. The dominance of Canadian crops by the major cereals has been overwhelming throughout this century. As shown in Fig. 4, the total area seeded to wheat increased from 8.2 million ha to 30.7 million ha between 1921 and 1996. Of the 276,548 farms surveyed in the 1996 census, 94,000 (29.4%) grew wheat. The total area of barley increased almost six times to 5.2 million ha between 1921 and 1996; the total area of maize for grain increased more than 12 times to 1.1 million ha. By contrast, the area occupied by oats decreased by over 70% to 2.0 million ha (with an associated drop in the number of horses and ponies from 3.5 million to 444,000). These four cereals represent over 60% of the area currently devoted to crops in Canada, and over 44% of current total crop farm receipts. Most of Canada's maize is grown in Ontario and Quebec, while most wheat, barley and oats are grown in theprairie provinces (Tables 1, 2). Wheat, barley, and oats account for 65.5% of the crop area and 61% of the farm receipts of the prairie region, and canola accounts for another 12.2% of the crop area and 22.7% of the farm receipts. Such dependence on only four crops in the prairies is of particular concern, and not surprisingly it is this important region, which accounts for 62.6% of crop farm receipts of Canada, that one finds the greatest support in Canada for crop diversification. Indeed, in the last decade there has been a concerted effort among grain producers to diversify production to overcome market fluctuations, drought, early frost, and trade wars.

Wheat (*Triticum aestivum* L.)

Wheat and rye are the only grains with the potential to make raised (leavened) breads because their gluten content gives strength and elasticity to bread dough; wheat by far is the most important crop for this purpose. Canada is the world's largest exporter of hard red spring wheat, well known for its excellent milling and baking qualities and for its suitability in blending with lower protein wheats. The typical

Western Canadian growing season of short cool nights and long, sunny dry days is ideal for the production of consistent, high-protein wheat, and normally this type of wheat is priced at a premium to softer and lower-protein wheats. In 1903, William Saunders developed the 'Marquis' cultivar, which set a standard not surpassed until the 1980s by 'Neepawa' of 1987–88. Canadian breeding of superior hard red spring wheat has since been constant. 'AC Barrie', a new, hard red spring wheat was recently released and has proven to be very popular. The three Canadian prairie provinces are the chief wheat-producing provinces of Canada. Canada produces about 5% of the world's wheat, but because of its relatively small population, exports over 75% of its annual production, and accounts for about 20% of the world's wheat exports.

Although hard red spring wheat dominates Western Canada, there have been concerted attempts to breed other types of wheat cultivars, to meet the changing needs of world markets (Dietz et al. 1998). Only a small amount of the class known as "Western Canadian Soft White Spring" wheat is produced in Canada, in part because it requires irrigation in Western Canada. However, there is a very good market for soft wheats, which go into cookies, cakes, crackers, specialty breads, and noodles. The cultivar 'AC Reed' was released from AAFC at Lethbridge in 1994 in an attempt to expand into the soft spring wheat market. AAFC at Swift Current, Saskatchewan, is responsible for the breeding of several recent wheat cultivars of the "Canadian Prairie Spring class:" 'AC Crystal', a high-yielding semi-dwarf red wheat with intermediate protein, and stronger gluten than its predecessors, improving its milling qualities for bread-making (due for release in 1999); and 'AC Karma' and 'AC Vista', white wheats for the oriental-noodle market.



For 1998–99, Canadian non-durum wheat area, mostly spring wheat, declined to 7.7 million ha, the smallest area since 1972 (Fig. 8). In response to wheat surpluses and associated trade problems, many western Canadian farmers have turned to alternative crops (popularly called "specialty crops"). Indeed, this has been the single most important stimulus to crop diversification in Canada, next to the trend of tobacco replacement (Loughton et al. 1991). Figure 8 shows that while wheat area was decreasing, strong compensating increases occurred in the cultivation of the chief specialty crops of the prairie provinces (common bean, sunflower, canary seed, mustard, lentil, and pea).

Fig. 8. Recent increasing cultivation of "specialty crops" (common bean, sunflower, canary seed, mustard, lentil, and pea) in response to decreasing wheat cultivation (above) in Canada.

Durum Wheat (*Triticum turgidum* L. = *T. durum*)

Most types of common wheat can be used to produce bread and Asian-style noodles. For example, bread is produced in most countries from a blend of hard and soft wheats, and where high-protein hard wheat is unavailable, wheat gluten can be added. Durum wheat has an amber yellow endosperm (from which semolina is produced), unlike the white endosperm of common wheat, so that pasta from durum semolina is amber colored. The flavor and cooking qualities of durum pasta are superior, and durum wheat is preferred for the production of pasta products, such as spaghetti and macaroni, and for couscous, the staple food in North Africa. Durum is suited to a dry climate, with hot days and cool nights, and does well under dry conditions. About 8% of the world's wheat production is durum wheat. The leading producers of durum wheat are the European Union, Canada, and the US. Canada is the leading exporter (Lennox 1998). For 1998–99, Canadian durum wheat area rose to a record high 2.9 million ha. In North America, Western North Dakota and southern Saskatchewan are particularly suited to durum wheat, and it is also grown under irrigation in Arizona and the California deserts. Durum wheat, as a crop, compares to common wheat much as alternative and new crops do. It is a relatively high-value commodity with a more stable future in Canada than common wheat. Recently, new technology and consumer taste changes have altered the pasta market toward a stronger, less elastic gluten, particularly in Italy, the main manufacturer of pasta-making equipment, and the country with the most prodigious appetite for pasta. To meet this altered market, new Canadian durum cultivars with stronger gluten content are in the process of being registered for market testing (Anon. 1998b).

Winter Wheat

Winter wheat is the fourth largest crop in Ontario (behind soybean, maize, and tobacco). Ontario is the main producer of winter wheat in Canada, producing about 1 million tonnes annually, using cultivars (e.g. 'Augusta', 'Harus') that can survive the relatively mild winters. Soft white winter wheat is most commonly grown, and this is used for producing soft gluten flour for confectionery products such as cakes, cookies, breakfast cereals, and crackers. Ontario red spring wheat is used primarily for domestic feed, and to a lesser extent for domestic human consumption. Spring wheat is grown somewhat in eastern Ontario, using Western Canadian cultivars, but the quality has often been below the standards demanded by North American millers. In recent years, Ontario wheat growers have been shifting away from traditional soft white winter wheat into both soft red winter and hard red winter wheat cultivars. The shift into hard red wheat is due to the recent availability of new cultivars able to achieve the high protein levels required by the North American milling industry. Improved soft red winter wheat cultivars have also become recently available, and although soft white winter wheat is preferred for the production of breakfast cereals, cakes, and pastry flour, the soft white winter wheat that has traditionally been grown in Ontario suffered a severe fusarium outbreak in 1996, decreasing its popularity. For a review of the changing wheat situation in Ontario, see Lennox (1996) and McKinnon (1997a).

Spelt Wheat (*Triticum spelta* L.)

Spelt is an ancient wheat that has been a staple grain in Ethiopia for centuries. It has become a top-selling organic and health food, grown as a specialist crop, often for people with allergies, and for pasta. Although minor, spelt is increasingly cultivated in Canada, with 825 ha reported in the 1996 Census of Agriculture, mostly in Ontario. Several thousand ha are cultivated in the US.

Triticale (×*Triticosecale* Widdmark)

Triticale is the stabilized hybrid of wheat (*Triticum*) and rye (*Secale*). Poland, Germany, China, and France account for nearly 90% of world triticale production. Globally, triticale is used primarily for livestock feed. In Mexico, which grows the crop, triticale is used mostly for whole-grain tricale breads and tortillas. In the US, triticale is harvested mostly for forage, but there is a small market for pancake mixes and crackers due to a savory, nutty flavor. Ethanol plants will pay a premium for triticale over barley since it has more starch and no hull, making alcohol production more efficient. Although wheat-rye hybrids date back to 1875, it was only in 1953 that the first North American triticale breeding program was initiated, at the University of Manitoba. Although improved cultivars have been bred, triticale has remained unimportant in Canada. However, triticale does well in regions where wheat performs poorly, notably on cold and infertile soils, extremely sandy soils, soils with high levels of boron, salty soils, acidic soils, manganese-deficient soils, and dry soils. Canada does not have large area of such soil types, but there are about 2 million ha of marginal, light mineral, low productivity land in Western Canada where triticale has the potential to displace or supplement traditional feed grain production. Winter triticale is a higher-yielding, earlier-maturing alternative to spring triticale for short season areas of the prairies. 'Pika' and 'Wintri' are the only cultivars found to be suitable for use in Western Canada. Canadian triticale is mostly used for feed and forage. Triticale production in Eastern Canada is growing, with most production in Saskatchewan, followed by Alberta and Manitoba. Forage triticale equals or outperforms barley, oats, rye, and mixed grain in areas of Western Canada, so that there is a reasonable probability that it will become more important. For a review of the triticale situation in Canada, see McKinnon (1996).

Barley (*Hordeum vulgare* L.)

Barley is basically a livestock feed, and is the major feed grain in Canada. Barley is well suited to the Canadian prairies, where most of this crop is grown, while other feed grains such as maize and sorghum are not. Barley is also a good rotation crop with wheat, tends to be higher yielding, matures earlier, and is more resistant to drought and salinity problems. It is also used in brewing beer (see below). Hulless barleys have hulls that are easily removed by threshing, as with wheat. Some hulless cultivars are produced in Canada (such as the two-rowed 'Condor', 'Phoenix', and 'CDC Dawn', and the six-rowed 'Tupper', 'Buck', and 'Falcon'), resulting in more digestible, higher-protein feed, especially for swine and poultry feeding. Pigs and chickens are monogastric (non-ruminant) animals, which are unable to digest the fibrous hull. Barley is useful for most classes of livestock, although poultry lack the enzyme to digest beta-glucans, a water-soluble fiber (this viscous polysaccharide is denatured by adding the enzyme beta-glucanase to the rations; beta-glucans from barley have been shown to reduce cholesterol in people). Although not as palatable as other cereals, some barley is consumed by humans. Barley kernels are polished to remove the inedible part of the grain. "Pearled" barley is highly polished barley; by contrast, "pot barley" is less polished, hence slightly larger than pearled barley. Pearled barley is used in breakfast cereals and infant foods. Hulless barley grains of course already lack much of the inedible portion. Various health advantages have been claimed for human consumption of barley, including benefits for regulating blood sugar levels in diabetics, and for lowering cholesterol and heart disease. A market is emerging for the fractionated components of barley kernels as pharmaceuticals (see Nutraceuticals). Because it is such a major Canadian crop (third-ranking in terms of farm receipts), breeding of Canadian cultivars is given high priority, and new cultivars are constantly emerging. For example, in Eastern Canada where there are frequent strong wind and rain storms and barley often lodges, recent cultivars (the six-rowed 'AC Alma' and the two-rowed 'AB162-9') have strong stems to keep the plants upright.

Malting Barley

About 10% of world barley production is malted, and the other 90% used as animal feed. Malting barley is simply high-quality barley with appropriate characteristics to produce good malt for making beer. Most barley cultivars can be used to make barley malt, but some are specifically bred for the purpose. Two-row malting barley represents the international industry standard outside North America and also in some South American markets. However, six-row barleys are also used. Most malting cultivars are in fact used for feed. About half of Canadian malting barley is two-row. In Canada, three-quarters of the area seeded to barley consists of malting cultivars, the other quarter being feed cultivars, which tend to have higher yields. Growing conditions in western Canada are usually cooler and drier than the US for producing superior six-row malting barley, and so the US has been Canada's major export market for this type of malting barley in recent years. The variable climate on the Prairies sometimes results in only a proportion of the malting barley crop meeting specific malting barley requirements, but as most of the crop is fed to livestock this generally does not compromise the supply for export. China is an increasing importer of Canadian 2-rowed malting barley. The creation of new two-row barley cultivars with improved malting and agronomic performance desired by the export market has been an important development in Canada in the last two decades. Hulless barley cultivars with higher energy content, discussed above, are not suitable for the malting barley process, so that hulled cultivars continue to be grown in Canada. A recent review of the malting barley situation in Canada is McKinnon (1997b).

Oats (*Avena sativa* L.)

Before 1910, the area seeded to oats often exceeded the area for wheat in Canada, in order to feed horses. Up until 1920, the area for oats was similar to wheat area in Canada, but from the early 1920s to the late 1970s, with the introduction of tractors and the replacement of horse power by machine power, the area seeded to oats decreased steadily until the 1970s. Since the 1980s, Canada has consistently captured a significant share of the world export market. Oats are still used primarily as animal feed, but human consumption is increasing, especially in North America, where oats are considered healthy, especially oat bran (see Nutraceuticals). In the US (and to a lesser extent in Canada), oats is used somewhat for pasture, silage, and haylage, and especially as a cover crop to protect soil, notably on marginal land subject to erosion, and as a nurse crop to protect newly planted forages. The world's leading oat producers are Russia, the European Union, Canada, the US, and Australia. Canada is a leading exporter, in 1997–98 accounting for almost half of all world oat exports, excluding products, 95% of this to the US. In 1997–98, about 1.9 million ha were seed to oats, an area exceeded only by wheat, barley, and canola. Over 90% of production is in Western Canada, and this represents a shift from Eastern Canada where oat cultivation has become less economical as a feedstuff. A further shift has been from the Western to the Eastern Prairies, closer to the major oat market in Minneapolis. The cool growing season on the northern Prairies where oat production is concentrated is a problem, being addressed by continuing plant breeding. Alberta is Canada's major oat producing province, and most of the crop is grown in the north in the grey woodland soil, which is quite acidic, freeing up aluminum, which reduces yield by up to 40%. There is currently research (at AAFC at Lacombe) to breed aluminum-tolerant oats to meet this problem. Oat breeding in Eastern Canada, incorporating new molecular techniques, is a specialty of AAFC at Ottawa. Oats are less likely to be traded than other grains because their bulky nature increases transport costs. Oats are about 25% hull, and offer less energy than barley and maize, limiting their use primarily to starting feedlot rations and for feeding horses. Hulless or naked oats, which lose their hull during harvest, have promise as a feed ingredient. 'AC Lotta', 'AC Percy', and very recently 'Cavena' from AAFC at Ottawa are Canadian cultivars. Hulless oats have higher protein and fat than conventional oats, as much energy as maize, and a better balance of amino acids, and have good prospects as a new Canadian crop. Another new trend is the industrial use of oats in Canada, with the establishment of a processing plant in Saskatoon that refines oat extracts used in products such as animal coat washes and diabetes screening tests. In the past 15 years, oat products have increased from virtually nothing to an estimated 200,000 tonnes for 1997–98. A recent review of trends in the Canadian oat crop is McKinnon (1998).

Maize (*Zea mays* L.)

Maize has a very long history of cultivation in Central Canada, dating back over a thousand years. With the introduction of US higher-yielding maize hybrids in the mid 1950s, commercial production expanded in the southernmost regions of Ontario. New cultivars of maize have been instrumental in Canada in lowering susceptibility to early frosts and avoiding harvest problems. With the continual development of Canadian hybrids for cooler and shorter growing seasons, commercial maize production spread beyond southern Ontario, and today maize is widely cultivated in Ontario and Quebec, with limited production in Nova Scotia, Manitoba, and Alberta. About three-quarters of Canada's maize is produced in Ontario and Quebec. Maize is primarily a feed ingredient in Canada, with Central Canada accounting for the bulk of consumption (barley is the major feed grain in Western Canada). Fodder maize, used mainly for silage, requires less heat units and has a wider growing range than grain maize. Fodder maize is generally grown for on-farm use. There is a trend for increasing food and industrial use of maize in Canada (see discussion of ethanol production, below). Canada is normally a net importer of maize, with western Canada acquiring it from the US. For a review of the maize industry in Canada, see Kurbis (1996b).

Canary Seed (*Phalaris canariensis* L.)

Canada is the world leader in the production and export of canary seed from annual canary grass, used in caged and wild bird food mixtures. Commercial production of canary seed started in the US after World War II, concentrated in Minnesota and North Dakota, and production moved to Manitoba and Saskatchewan to become commercially viable in the early 1980s. In 1996, Canada produced 90% of the world supply of canary seed, about 90% in Saskatchewan, the remainder in Manitoba and Alberta. Canary grass is extremely well adapted to the hard red spring wheat of the Prairies, although more sensitive to heat and drought. Ten to 30% of production is used domestically, the remainder, about 125,000 tonnes, is annually exported, largely to Europe, South America, and the US. Canary seed is suited to and mainly produced in the brown soil zone of Western Canada. Substitute bird seeds with the quality of canary seed are generally unavailable (there is occasional substitution with proso millet from the northern US) and, with increasing interest in birds as pets, long term growth of the industry seems assured. A new cultivar known as 'CDC Maria' was recently developed by the University of Saskatchewan's Crop Development Centre. This is expected to revolutionize the industry, eliminating problems such as itchiness and dust associated with the hairy seed coat of older cultivars. 'CDC Maria' and other "hairless" cultivars are expected to replace the traditional canary seed cultivars, which can not be used by humans for food because of the hairs. Dehulled canary seed can be processed into flour and bran, and in addition to this food potential for humans there is some potential for cosmetic purposes. A recent review of the canary seed situation in Canada is Gray (1997b).

Rye (*Secale cereale* L.)

Rye is a relatively minor cereal in Canada, which is perhaps surprising since it has the ability to withstand unfavorable growing conditions and often thrives where other cereals fail. Although rye can have a higher feed value than barley, the high soluble fiber content (pentosans) reduce feed value for poultry and swine. Although Canada is one of the world's major rye exporters and produces high-quality rye, the world market is small, and Europe grows the crop well, mostly for making bread. In Canada, rye is grown mainly for grain, but also for pasture and hay. Fall rye also provides soil cover from fall through spring. There is limited domestic use of rye in Canada for distilling and for food use, compared to the other cereals discussed above. Several new breeding lines of winter rye were recently bred at AAFC at Lethbridge.

Proso millet (*Panicum miliaceum* L.)

Proso millet has long been a staple grain in Africa, and has been grown as a forage crop. This sorghum relative is used mostly in the pet food and birdseed industries in North America, but may have some potential as a Canadian grain for human consumption. 'AC Prairie Gold', a millet line adapted to prairie growing conditions, was recently released by AAFC at Morden. While only 1000–2000 ha are currently grown in western Canada, the potential for proso millet has been estimated to be 10,000–15,0000 ha or more (Kiehn and Reimer 1992).

False Melic Grass [*Schizachne purpurascens* (Torr.) Swallen]

This widespread native grass of Canada produces large grains. It has been suggested that it could be developed into a special cereal like wild rice (Dore and McNeill 1980), although this would require considerable development.

Wild Rice (*Zizania palustris* L.)

Wild rice (not to be confused with wild forms of *Oryza sativa* L.), Canada's only native cereal, is collected from natural or planted stands, particularly by indigenous people (Aiken et al. 1988; Crop Development Centre 1991). It requires considerable development, but is well suited to Canada. Wild rice is an economically attractive crop in that the supply is limited while market demand is increasing, a premium price can be obtained, and the climate and natural aquatic habitats of portions of Canada provide competitive advantages. Semi-domesticated paddy wild rice is in commercial production in California and Minnesota, and provides competition for Canadian producers. However, a natural advantage for Canada is the availability of extensive shallow lake and river systems, which usually do not require much if any drainage control. For wild rice to expand as a crop in Canada, development of non-shattering, disease-resistant cultivars is needed. Fast-maturing strains would be an added advantage for northern regions so that seeds would mature before frost.

Buckwheat (*Fagopyrum esculentum* Moench)

Common buckwheat is grown in many major grain producing countries, especially Russia and China. Major exporters are China, Brazil, France, the US, and Canada. Japan accounts for almost all of the world's buckwheat imports. Buckwheat has been grown in Canada for many years as a special crop, and is an important cash crop in Manitoba, but production is currently low. However, this crop presents opportunities for diversification and value-added activities because the Japanese market is growing. In Japan, buckwheat flour is employed in combination with wheat flour to prepare buckwheat noodles (*soba*), a traditional dish. In some cases, Japanese noodle manufacturers add ground leaves to the buckwheat flour, producing a green noodle. Only about 10% of Canada's buckwheat production is used domestically for human consumption, but this could increase if processors develop new buckwheat products such as snack foods and flour for cr•pes. Buckwheat can be grown as a green manure crop, companion crop, cover crop, and as a source of dark buckwheat honey. The grain and straw can be used for livestock feed, but the nutritive value is lower than that of cereals. The protein in buckwheat flour is of exceptional quality, containing a high amount of lysine, which is deficient in cereals. Foods are prepared from the groats (dehulled seed) or from the flour. The low gluten content of the flour makes it ideal for crêpes, and in mixtures with wheat flour for bread, pancakes, noodles, and breakfast cereals. Groats and grits (groat granules) can be used for porridge and other breakfast cereals. Dehulled groats can be baked or steamed and eaten as a vegetable like rice, or used in appetizers, soups, salads, breads, and desserts. Development of new Canadian cultivars is occurring to counter climatic disadvantages associated with buckwheat production in Canada. The main buckwheat cultivars grown in Canada are 'Mancan' and 'Manor', developed by AAFC at Morden. 'Mancan' is employed as a quality standard by Japanese millers because of its soft white starch. 'Manisoba' is a new, higher-yielding cultivar with a larger seed that is easier to dehull, leaving behind high whole groat content. 'Manisoba' also facilitates popping the seed, like popcorn, to prepare some specialty products. Western Canadian cultivars are not well adapted to eastern Canada, and a high portion of growers in Ontario and Quebec cultivate buckwheat simply as a green manure crop or a cover crop to crowd out weeds. Research is underway to improve buckwheat cultivars in Quebec and Ontario, where lodging is a frequent problem due to excess moisture. Unlike most cereal crops, buckwheat cannot recover from lodging. There has been considerable recent governmental and grower association encouragement to increase production and marketing of buckwheat in Canada. New proposed value-added activities include dehulling, flour-making, noodle making, and roasting for snacks. Buckwheat produces rutin, which increases the elasticity of arteries and prevents their hardening, and is in demand by the pharmaceutical industry. Scientific research on buckwheat is centered at AAFC Morden. Recent achievements include the development of a self pollinating buckwheat with extremely low seed abortion and better frost tolerance. This is expected to result in a new cultivar in the next several years. A high-yielding self-pollinating experimental strain was recently bred in Manitoba (Henckes and Dietz 1997). A good review of buckwheat in Canada is Vincent and Longmuir (1996).

Quinoa (*Chenopodium quinoa* Willd.)

Quinoa originated in the highlands of Peru and Bolivia, where it became a staple crop of the Inca empire. By comparison with most cereals it is rather primitive, requiring dehulling to remove bitter seed coat saponins. Considerable quinoa is sold in Canada as a gourmet item in health food stores, in the form of whole grain, pasta, or flour. Quinoa is considered to have some promise for Canada, and there is a Canadian Quinoa Association (Anon. 1992). Currently available forms are late-maturing, therefore vulnerable to frost, and are also susceptible to insect damage. Quinoa would appear to have some possibility for development through germplasm selection in Canada, but is likely to find a more receptive area of cultivation in other countries. In the US, quinoa seems to represent one of the relatively few apparently successful introductions of a new food plant (Johnson 1990).

Amaranth (*Amaranthus hypochondriacus* L. = *A. leucocarpus* S. Watson)

Grain amaranth, a pseudo-cereal, is another ancient grain used similarly to quinoa. This dietary staple of Aztec and Mayan civilization is still grown in South and Central America, where it originated, and is used as a vegetable in India and China. The seed can be popped like popcorn and flaked like oatmeal, and is notably high in protein. Amaranth is enjoying a renaissance in popularity in North America. It is sold in health food stores, particularly when organically grown, but has achieved little market status. Amaranth has been experimentally cultivated as an annual grain at AAFC at Morden, and has been thought to have fair long-term potential in the southern Canadian prairies (Kiehn and Reimer 1992). Its future in the US has been considered debatable by some (Lehmann 1991), promising by others (see articles in previous proceedings, particularly *Advances in New Crops*, 1990).

OILSEEDS

Oilseeds tend to be higher-value crops than cereals, and are useful as alternatives in crop production and market diversification. Canola, flaxseed, and sunflower seed are particularly considered to be major cash crops for Western Canadian producers, especially when grain markets are poor. In 1996 the farm value of oilseed production in Canada was estimated at $2.883 billion. In addition, oilseed processing contributed $0.5 billion in direct value-added and over $1 billion in spinoff benefits to the Canadian economy. The meal left after oil extraction is also of considerable importance as livestock feed and, as noted below, the grain itself may be a useful animal or human food. In 1997, total vegetable oil production in Canada reached a record level of 1.6 million tonnes, with canola oil accounting for 77%, soybean oil for 17%, linseed oil for 3%, and sunflower oil for 1%. Several of the world's major edible oils, including palm oil, cottonseed oil, peanut oil, coconut oil, olive oil, and palm kernel oil, simply cannot be produced in the climate of Canada, which imports these commodities. Nevertheless, Canada has been a net exporter of vegetable oil since 1992, but this is mostly due to canola exports, especially to the US. In 1997, Canada was responsible for 43% of total world rapeseed/canola oil exports, 10% of linseed oil exports, and less than 1% of soybean and sunflower oil exports. Generally, there is strong regionalization of cultivation of Canada's oilseed species, as noted below. Attempts are underway in Canada to breed new oilseeds (most notably edible oil mustard and edible oil flax, as discussed below). There is also considerable research in Canada to develop new and improved cultivars, which may result in the major oilseeds being cultivated in regions where they are now absent or little grown.

Most of the world protein meal supply is derived from oilseed production. Oilseeds tend to produce meal that differ in their ability to meet the nutritional requirements of the different livestock categories. For example, non-ruminant livestock such as hogs and poultry need high protein feed without the high fiber content suitable for ruminant animals. Small but growing markets for protein meal include the fish feed market (aquaculture) and direct human consumption. Good dietary practice for livestock involves a complementary balance of the base grains of feed rations (such as wheat, barley, and maize), the various high-protein meal supplements, and grass and legume forage/silage crops. Canola meal, Canada's major meal, can be used up to maximum levels in feed rations of 20% for poultry, 15% for grower and finisher hogs, and 25% for dairy cattle.

Canola (*Brassica napus* L., *B. rapa* L.)

Oilseeds in Canada are currently dominated by canola (rapeseed), a high value crop cultivated by some 80,000 farms, that has become Canada's second most important crop after wheat. Canola (a trade-marked name) is primarily used in salad and cooking oils, margarine and shortening, and the mealy residue after the oil is extracted is used in livestock feeds. The 1996 census data show that canola accounts for 75% of all vegetable oils produced in Canada, 87% of salad oils, 49% of margarine oils, and 64% of shortening. The development of the canola industry is the premier example of a successful new crop for Canada. The breeding of new edible oil cultivars occurred as a focussed investment strategy that involved over 200 scientist years, costing $40,000,000, spread over 30 years (Jolliff and Snapp 1988). Canola is a relatively new Canadian crop, having begun with rapeseed cultivation in 1942 in Western Canada as a source of lubricants for the allied war effort. Today, a small area of high erucic acid rapeseed in still produced in Canada to satisfy the industrial market. Limitations of nutritional composition of available wartime cultivars restrained human consumption in Western countries. In the mid-1970s, AAFC and the University of Manitoba produced new cultivars, now known as canola, with less than 2% erucic acid and less than 30 micromoles/g of aliphatic glucosinolates in the meal (current levels have been further reduced, respectively to less than 1% and less than 20 micromoles/g). From 1976 to 1996, the total area of canola increased over five times to 3.5 million ha, representing 10% of Canada's total land in crops. In 1985, The US Food and Drug Administration granted canola GRAS (Generally Recognized as Safe) status, and in the light of its superior nutritional characteristics, canola oil sales to the US increased from virtually nil to over 400,000 tonnes annually. About two-thirds of Canada's exports of canola are to the US. Canola seed and meal sales to the US also increased along with canola oil sales. Canola oil's nutritional properties are responsible for its domination of the salad oil market: of the commercially available edible oils, canola contains the lowest levels of saturated fats (6%), the second highest level of monounsaturated fats (58%), and the highest level of the essential fatty acid, linoleic acid (10%). Globally, Canada produces about 17% of the world's rapeseed.

Given the controversy over the public acceptance of genetically-engineered foods, it is perhaps surprising to learn that close to 50% of the cultivated canola area in Canada consists of transgenic cultivars carrying selective resistance to specific herbicides. There are several new types of canola that are currently being bred and may well have a place in Canadian agriculture. "Super-high erucic acid rapeseed" is a type of genetically modified oilseed. A derivative of erucic acid, eruacmide, is used as a slip agent and plasticizer in the manufacture of plastic films. Other types of products that may be produced include cosmetics, lubricants, pharmaceuticals, plasticizers, and surfactants. "Odyssey 500" high stability oil is another product that may become useful. This is over 20 times more stable than conventional vegetable oils. It remains liquid at lower temperatures than other highly stable oils, and has no flavor or color. It may be useful as a moisture barrier, viscosity modifier, gloss enhancer, anti-duster, and band releaser. Still another new type of canola oil that offers stability, long shelf life, and fresh flavor is a high oleic oil, "Clear Valley 75." This has been praised for its desirable combination of taste and nutrition. It has the lowest level of saturated fats, no trans fatty acids from hydrogenation, and bland neutral taste that makes it ideal for cereals, popcorn, dried fruit, and crackers (Beckman 1998).

The most exciting new prospect in Canada for canola is the breeding of mustard (*Brassica juncea* Coss.) into a new canola species. To date, canola has been represented by the two *Brassica* species *B. napus* (Swede rape) and *B. rapa* (*B. campestris* L., turnip rape). For the past decade, research has been in progress in Canada toward the breeding of a drought-resistant canola-grade mustard. Canola cultivars presently available are not well suited for many of the relatively dry regions of Western Canada. By contrast, mustard cultivars have several advantages: higher-yielding in all but the short season regions of Western Canada, early maturing, more resistant to late spring frosts, more heat and drought tolerant, more resistant to seed shattering, and more resistant to blackleg disease. *Brassica juncea* is in fact used as an edible oil crop in China, India, Russia, and Eastern Europe, where an oil with higher levels of erucic acid is permitted, but this is not accepted in most Western countries. Moreover, the high glucosinolate meal has limited use for animal feed. Researchers at AAFC, Saskatoon have developed a mustard plant whose seeds contain meal and oil indistinguishable from canola (Anon. 1998a). A new cultivar may be available by 1999. Given the spectacular success of canola, this could represent an important new crop that would extend the region of the Prairies where canola-class plants can be grown. For marketing purposes, this new crop could be represented as canola, since the products are about identical. A hurdle that remains is the obtainment from the US of a GRAS designation, a necessity to remove trade restrictions. The fortunes of canola rose dramatically after it obtained GRAS status in 1985.

Soybean [*Glycine max* (L.) Merr.]

Soybean was first cultivated in Canada in 1893, but not in significant amounts until the late 1920s. Most soybeans are currently grown in Ontario (90%) and Quebec (9%). In the mid-1970s, it was almost impossible to find soybean growing in Eastern Ontario because of the inhospitable climate. 'Maple Arrow', a cultivar bred at AAFC Ottawa, provided the key adaptation for soybean to be transformed into the biggest cash crop in Ontario, where it is known as the "miracle crop." Most soybeans are used domestically in Canada, and the increase in the domestic supply has meant that imports from the US are usually equaled by exports. Soybean oil is used in a huge number of products, for example in the manufacture of edible oils, and in industrial products such as paint, varnish, resins, and plastics. Soybean meal is an important livestock feed, although half of Canada's supply is imported (unlike canola which is crushed mainly for its oil, soybeans are processed primarily for the meal). Most of Canada's soybean feed goes to the hog and chicken industries. Due to the presence of enzymes, soybeans must be roasted before being fed to livestock. Canadian research is attempting to eliminate the need for roasting, and has resulted in a reduction in the levels of the deleterious enzymes so that whole unroasted soybeans have become a significant constituent of livestock rations in Eastern Canada. Canadian cultivars have been bred with qualities required by specific soyfood markets of the Asia Pacific region. The large-seeded, white, high-protein types are prized by southeast Asian markets. Cultivars such as 'Special Quality White Hilum Beans' are exported for processing into tofu, natto, misto, and tempe in Asian markets. 'AC Onrei' is a very large-seeded high-protein cultivar suitable for top-quality nigari tofu. 'OX756' is another line produced by AAFC at Harrow designed to expand exports into the premium Asian soy food market. This is low in enzymes that cause a grassy-beany flavor that some consumers dislike. Genetically modified soybean cultivars are prevalent in the US, and are likely also to be established in Canada. As with other genetically modified crops, there is some public resistance to acceptance of human foods produced from transformed plants, especially in Europe, and this may affect the future development of export markets.

Flaxseed (*Linum usitatissimum* L.)

Flaxseed is generally known as linseed outside of North America, where the name flax refers to the fiber form of the crop used for the linen textile industry. Flaxseed was the first oilseed widely grown in Western Canada, and today the fiber form is cultivated only in very small amounts. Canada is the world's largest producer and exporter of flaxseed. Only a small proportion of Canadian flaxseed is crushed domestically. Canadian flaxseed is produced entirely in Western Canada, mostly in Saskatchewan. Flaxseed represents only 1% of the world supply of oilseeds, but as noted in the following is considered to have high potential for increased industrial use, as well as for human food and feed markets. Flaxseed (linseed) oil is a non-edible drying oil used in manufacturing paints, varnishes, linoleum, printing ink, oilcloth, putty, and plastics. The introduction of petroleum-based floor coverings and latex-based paints resulted in a worldwide decrease of the industrial use of linseed oil for paint and floor covering over the last several decades. Nevertheless, industrial use is expected to increase because of the development of new products. The biodegradability and non-allergenic characteristics of linoleum, coupled with quality improvements, have resulted in a resurgence of demand for linoleum in some parts of Europe. There has also been interest in using a linseed oil based concrete sealant. More significantly, there has been recent research into the development of edible oil-type flaxseed or "Linola" as a vegetable oil, and this market is likely to increase in Canada. Linola lines lack the high amounts of omega-3 fatty acids of conventional flaxseed lines, which makes them less nutritional, but they are more stable at high temperatures and less likely to go rancid, and so more competitive in the vegetable oil market. There has been much interest in Canada in the pharmaceutical value of edible linseed. It is well known that hardening of the arteries, heart disease, and strokes have been dietarily linked to overconsumption of saturated fats. It is much less well known that an unbalanced ratio of polyunsaturated fats has the same effects. The ratio of two polyunsaturated fats is considered particularly important—omega-6 and omega-3, recommended in an intake ratio of 3:1. Average dietary ratios in North America range between 12:1 and 20:1. Flaxseed is generally high in alpha linolenic acid, an omega-3 fatty acid, and has an omega-6/omega-3 ratio of 0.3/1, and so is extremely helpful in balancing the ratio to a healthy level. Omega-3 fatty acids lower levels of triglycerides in the blood, thereby reducing heart disease, and also show promise in the battle against inflammatory diseases such as rheumatoid arthritis. Poultry eating feed rations enriched with flaxseed produce eggs that are notably lower in saturated fat in the yolk. Full-fat (whole) flaxseed is in demand by the laying hen market. About 5% of Canadian laying hens are in fact consuming 10–20% flax in their rations, and so producing eggs that are relatively desirable in their balance of polyunsaturated fatty acids. About a dozen Canadian companies are now selling omega-3 eggs, and several US companies are following suit (Henckes 1998a). Dairy cows fed with flaxseed can produce omega-3 enriched milk and butter, and beef and chicken can be similarly enriched, although how practical this is remains to be determined. Crushing flaxseed for linseed oil produces meal/cake that serves as protein supplements in livestock rations, mainly in Western Europe. Flaxseed has been used extensively in baking in Germany and other central European countries, and there is a growing and highly profitable niche for flaxseed bakery products in North America, especially for specialty breads. Since the early 1990s, there has been some cultivation of 'Solin', a light-colored low-linolenic acid type of flaxseed that has a fatty acid profile similar to sunflower oil. New uses for flaxseed fiber are currently being developed. About $20 million of flaxseed fiber and tow were exported from western Canada to the US in 1995, but only 15–20% of available Canadian flaxseed straw is so used because of high transportation costs in moving the flaxseed straw to the processing plant, and the majority of straw is usually burned on the field. There is increasing interest in Canada in using high-quality fiber for fiberboard and similar application (see discussion below), so that a larger market for flax fiber may develop. For a review of flaxseed in Canada, see Beckman (1997).

Mustard [*Brassica juncea* (L.) Czern. & Coss., *Sinapis alba* L.]

Mustard is both a condiment and an oilseed crop, and has been grown in Canada since 1936. There are two species grown, *Brassica juncea* (brown and oriental mustard), and *Sinapis alba* (yellow or white mustard). Mustard has been an exceptional success in Canada, with an average of about 200,000 ha producing an average of 250,000 tonnes of seeds, most of which is exported. How much growth there remains for this crop remains to be seen. A small percentage of Canadian mustard is crushed locally, and some is ground to produce mustard flour, mostly for export. Canada is the world's largest supplier of mustard seed, exporting the seed to Japan, the US, Europe, and Bangladesh for use as a condiment. Nearly 40% of Canada's exports of mustard seed goes to the US, but America is increasing its seeded area. Bangladesh, Canada's second-ranking export destination, crushes mustard seed to produce a hot edible oil that is popular in the Indian sub-continent. A small shift from yellow mustards to brown and oriental mustards has been predicted in Canada (Gray 1998).

Sunflower (*Helianthus annuus* L.)

The first official government breeding program of sunflower in Canada was initiated in 1930. However, as for rapeseed, commercial cultivation began during World War II as a response to the vegetable oil shortage. Sunflower is grown in relatively small amounts, mainly in southern Manitoba and southeastern Saskatchewan, and it has become a minor "specialty" crop in the cereal areas, serving as an excellent rotation crop for wheat that reduces diseases of the latter. About half of current sunflower production is destined for the confectionery market, 40% is crushed for oil, and 10% is used for bird feed. The residual oil-cake or high-protein meal produced after oil extraction is used for animal feed. About 30% of Canadian production is exported, the US accounting for about 70% of exports, the remainder largely to Germany, Belgium, the Netherlands, and Turkey. Confectionery type seeds have striped hulls, and the largest forms are used for human food. Sunflower seeds can be roasted and salted or baked into bread products for human consumption. Oil-type Canadian sunflower seed cultivars (which can also be used for birdseed) are characterized by black hulls. In the early 1990s, sunola, a short-stemmed drought-resistant type of oilseed sunflower that can be grown as a field rather than a row crop, was introduced into the Canadian prairies, and production of this has since been expanding (Anon. 1994). However, the area of sunflower seed cultivation has been fluctuating, generally declining in Canada for the last decade. Minnesota, North Dakota, South Dakota, and Texas are presently superior sites for growing sunflower. Sunflower has not become a major source of vegetable oil in Canada because it is susceptible to diseases, has a longer growing period than desirable (120–130 days), needs specialized equipment, and is relatively expensive to produce. The latter two problems are due to the need to row crop sunflower, because of its tall height, and this requires specialized seeding and harvesting equipment, which represents additional capital costs to the producer. New types of sunflower are needed to overcome these problems. To some extent recent sunflower hybrids with earlier maturity, increased yields, and shorter stalks have generated some expansion, but Canadian production remains limited due to the high heat and moisture requirements of the plant. The sunflower situation in Canada is reviewed by Christie (1995a).

Safflower (*Carthamus tinctorius* L.)

Safflower is a crop that is deserving of attention because of its versatility. It can be grown for edible oil, meal, or whole seed for dairy cattle, birdseed, and oil for industrial uses. Safflower oil is a wholesome oil, high in polyunsaturated fatty acids, that because of its high linoleic acid content commands a premium price among edible oils, and is competitive from a health viewpoint with canola and olive oil. The cool climate of the Canadian Prairies tends to increase the level of oleic acid (e.g. to over 80%, compared to about 73% in California). Industrial uses are limited, but the drying oil produced by safflower, which is intermediate between soybean and linseed oils, can be used in non-yellowing drying paints, alkyd resins in enamels, and caulks and putties. Because it is a long season crop, safflower extracts water from the soil for a longer period than cereal crops, and the long taproot can draw moisture from deep in the subsoil. These properties can help prevent the spread of dryland salinity, using up surplus water from recharge areas that otherwise would contribute to the development or expansion of saline seeps.

Commercial cultivation of safflower began in Alberta in 1943 when wartime new crop adaptation research was in progress, and currently is concentrated in Alberta and southern Saskatchewan.

Production on the Prairies was sporadic from the 1950s through to the 1970s, but in the early 1980s contracts were obtained in southern Manitoba and southern Saskatchewan to produce safflower for processing facilities in Culbertson, Montana. The US cultivars used up to that point were too late in maturing and had severe disease susceptibility, and these problems led to a drastic reduction in cultivation in Manitoba. Most current Canadian cultivars are low in oleic acid and high in linoleic acid, and therefore more appropriate for the birdseed market, and in fact the Canadian safflower crop is currently used as birdfeed, mostly in the US. Oilseed safflower expansion depends on the development of adapted, high-oleic cultivars with high content of oil, improved seedling establishment, and active export efforts and/or a local oil processor becoming established. 'Saffire', the first Canadian safflower cultivar, is a good birdseed cultivar released in 1985, that has a total oil content of only 32%, generally too low for the oilseeed market. A more recent (1991) cultivar, 'AC Stirling', is a dual-purpose birdseed/oilseed cultivar averaging 35% oil, and is considered to have the capability of expanding the oilseed market.

Other Oilseeds

Crambe (*Crambe abyssinica* Hochst. ex R.E. Fries = *C. hispanica* L.), a cool-season annual originating from Ethiopia, has been raised in large areas in North Dakota. Meadowfoam (*Limnanthes alba* Hartw.), a winter annual, originates from and is adapted to the Pacific Northwest of the US, where it has been grown. It has also been grown on Vancouver Island. Both crops seem suitable for Canada. It is too early to judge the potential of these experimental oilseed crops, although the relatively large investments in relation to limited commercial success to date in the US and other countries are discouraging.

PULSE CROPS: DRY BEANS AND PEAS

Pulses grown in Canada as dry beans include common bean, lentil, field pea, chickpea, and faba bean. Pulses are low in fat, rich in fiber and complex carbohydrates, and good sources of vitamins, and consumption of these healthy foods has been increasing. Additionally, these legumes fix nitrogen, reducing the amount of nitrogen fertilizer required, and generally improving the yield of crops that follow in a rotation. Some pulses, most notably peas, have become an important livestock feed. Pulses have been the chief new successful crops that have served to diversify Western Canadian agriculture since the 1980s.

Common Bean (*Phaseolus vulgaris* L.)

Dry edible beans have been a commercial crop in Canada since the mid-19th century, and while not particularly new, recent bean cultivars have allowed the area seeded to expand somewhat from traditional growing areas. Demand for dry common bean has been increasing with world population. In Canada, beans are grown mostly in Ontario (which accounts for about 70%), Alberta, Manitoba, and to a lesser extent in Saskatchewan and Quebec, all areas which provide the necessary warm growing season. White and colored beans are produced in about equal amounts, but this represents a noticeable switch from white to colored bean production, primarily due to increased demand for colored cultivars for export. Indeed, colored bean production continues to increase in Canada, because of the creation of new disease-resistant cultivars, strong promotion and market development, and increasing processing capacity in Western Canada. Ontario produces most of Canada's white beans (also known as white pea beans, navy beans, and alubia chicas). Colored beans are grown mostly in Quebec, Ontario, Manitoba, and Saskatchewan, and in Alberta under irrigation. Most (75–85%) of Canada's beans are exported, about half to Europe, and about 40% to the US. Bean yields are quite variable because of the requirement for warmth and sensitivity to adverse weather, so that new cultivars better adapted to Canadian conditions are desirable. For a more detailed analysis of the bean crop in Canada, see Vincent (1995) and Gray (1997a).

Adzuki Bean [*Vigna angularis* (Willd.) Ohwi & Ohashi]

A new adzuki (azuki) bean cultivar, 'AC Gemco', was recently produced by AAFC at Harrow (Ontario), and has genetic consistency that growers have sought, as well as large seed size and high yields. This annual pulse is a major crop in Asia (second only to soybean in Japan), and a limited crop has been produced to date in North America.

Mung Bean [*Vigna radiata* (L.) R. Wilczek]

Another area of growth for beans is the sprout market, especially mung bean. Canada currently imports almost 2 million kg annually of mung beans for sprouting. The cultivar 'AC Harrowsprout' was recently produced by AAFC at Harrow to meet the demand for a domestic supply of mung beans.

Pea (*Pisum sativum* L.)

In 1997–98, Canada produced about 14% of the world's dry peas (about 13 million tonnes), and most of this was exported to Europe. Saskatchewan, Alberta, and Manitoba respectively account fr about 70, 20, and 10% of the dry pea seeded area. Field pea has become Caada's sixth most important crop. The area cultivated has been rising for the past 20 years, especially recently, due to an expanding export market, particularly in the European Economic Union, where peas are a traditional feed ingredient for hogs. In eastern Canada, where only 1,000 ha were seeded o peas in 196, the crop is used mainly for on-farm livestock feed, and the prospects for peas as a new crop in areas other than the prairies seem limited. A detailed analysis of the pea crop in Canada is Skrypetz (199).

Lentil (*Lens culinaris* Medic.)

Canada produces about 13% of the world's lentils (about 2.9 million tonnes for 199–98),and is the third largest producing country after India and Turkey. About 85% are grown in Saskatchewan, the remainder in Manitoba and Alberta. Lentil is a relatively new crop for Canada, produced on the prairies in significant quantities only since the late 1960s. Canadian cultivars ('Laird', 'Eston', 'Richlea', and others) are all green with yellow cotyledons, unlike the red-cotyledon lentils that comprise the bulk of the world's lentil production. 'CDC Redwing', a new red cultivar, is considered promising in part because of its disease resistance. Lentils have some prospect for being used as livestock feed, like peas. For additional information on the lentil crop in Canada, see Gray (1998).

Chickpea (*Cicer arietinum* L.)

Chickpeas (garbanzo beans) have a wide variety of food uses, and the lower grades can be used as livestock feed. In 1997–98 Canada produced 14,500 tonnes on 10,500 ha. This crop requires a fairly long growing season and prefers dry conditions because of susceptibility to ascochyta blight (caused by *Ascochyta rabiei*, a devastating seed-borne fungal disease) and a need for heat to set seed. Chickpea is well adapted to the brown soils of Western Canada, and its deep, extensive root system provides good drought tolerance. The Crop Development Centre of the University of Saskatchewan has been concerned with breeding shorter season and ascochyta-resistant cultivars suited to the southern Prairies. Although there is appreciable international competition, there does seem to be a good prospect that chickpea could become a more significant crop in Canada.

Faba Bean (*Vicia faba* L.)

The faba bean is a small-seeded form of broadbean, an ancient vegetable bean of Europe. A smaller-seeded type of broadbean (known as "la gourgane") is grown in commercial amounts in the St. Jean region of Quebec, mainly for soup (Munro and Small 1997). Faba bean cultivation started in western Canada in 1972, and the area under production has fluctuated widely since then. Protein content of 24–30% makes faba bean an attractive on-farm protein supplement for livestock feeding, and there is also good potential for use as silage. While faba bean is a very minor crop in Canada, it could well become more important.

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*In this paper Canadian dollar figures are reported in Canadian currency, and American dollar figures in American currency.
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part 2 of New Crops for Canadian Agriculture

Feijoa sellowiana Berg syn. *Acca sellowiana*

Myrtaceae

Feijoa, Guava, Pineapple Guava

NewCROP has Feijoa information at:

Feijoa—Julia Morton, Fruits of Warm Climates

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Magness J.R. et al. 1971. Food and feed crops of the United States.

New Horticultural Crops in New Zealand—Errol W. Hewett

Outside links:

FEIJOA "FRUIT FACTS" (Fruit Facts are a series of publications of the .California Rare Fruit Growers, Inc. that contain information on individual fruits,including botanical identification, description and culture notes based on California research, and characteristics of cultivars)

Feijoa Information from the University of California Fruit & Nut Research and Information Center

Feijoa nutritional information provided by Frieda's

Foeniculum vulgare

Apiaceae (Umbelliferae)

Fennel, *Finocchio*, Florence fennel, Meetin' seed, Roman fennel, Sweet anise, Sweet fennel, Wild fennel

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Midwest Vegetable Production Guide for Commercial Growers 1998

Fennel: A New Specialty Vegetable for the Fresh Market—Mario R. Morales, Denys J. Charles, and James E. Simon

Essential Oil Content and Chemical Composition of Finnochio Fennel—Denys J. Charles, Mario R. Morales, and James E. Simon

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Fennel: A New Specialty Vegetable

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Foeniculum vulgare Mill.Florence Fennel
Foeniculum vulgare Mill.Fennel
Foeniculum vulgare Mill. var. *piperetum* (DC.) Bail.Italian Fennel

Trigonella foenum-graecum L.

Leguminosae

Fenugreek, Foenugreek, *Methi*

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

New Crops for Canadian Agriculture—Ernest Small

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and Feed Crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

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Fescue grasses

Gramineae *Festuca* sp.

Source: Magness et al. 1971

Some 100 species of *Festuca* are known, generally found in temperate or cool climates. They vary widely in texture and growth habit. Some are annuals, others perennial. Annual kinds may be troublesome weeds, while perennial kinds are excellent for forage, pasturage and turf. The most valuable are tall fescue, meadow fescue, Idaho fescue, sheep fescue, red fescue, and Chewing's fescue

Last update February 18, 1999 by ch

Idaho fescue

Gramineae *Festuca idahoensis* Elmer

Source: Magness et al. 1971

This is a native bunchgrass found from Washington and Montana south to California and Colorado. The large bunches reach to 3 feet with numerous smooth leaves. This is a valuable range grass, palatable while green, and also curing well for fall and winter forage. It has potential for seeding on range lands.

Last update February 18, 1999 by ch

Meadow fescue

Gramineae *Festuca pratensis* Huds. (= *F. elatior* L.)

Source: Magness et al. 1971

This is a hardy perennial bunchgrass, introduced from England and adapted to cool climates. On rich soils it reaches up to 30 inches in height. Leaves are long and slender, bright green and succulent. It is now grown less than in the past for pasturage and hay because of the general superiority of tall fescue. It is not as heavy yielding nor as persistent as tall rescue.

Last update February 18, 1999 by ch

Sheep fescue

Gramineae, Poaceae *Festuca ovina* L.

Source: Magness et al. 1971

This is a bunchgrass that forms dense clumps, with numerous stiff, sharp, bluish grey leaves. It is cold and drought tolerant and is better than most grasses on sandy or gravelly soils in northern states. It is useful for grazing in early spring, but its greatest value is providing a durable turf on sandy or gravelly soils.

Last update June 28, 1996 bha

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Festuca arundinacea Schreb.

Gramineae, Poaceae

Tall fescue

We have information from several sources:

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Food and feed crops of the United States Magness, J.R., G.M. Markle, C.C. Compton. 1971

Festuca pratensis Huds.

Syn.: *Festuca elatior* L., pro partem

Meadow fescue

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update August 27, 1996 by aw

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Ficus carica L.

Moraceae

Fig, Adriatic fig, Black Mission fig, Brown Turkey fig, Calimyrna fig, Common fig, Higo, Kadotta fig, Poor-man's-food, Smyrna fig, Sycamore fig

NewCROP has fig information at:

Fig—Julia Morton, Fruits of warm climates

Magness J.R. et al. 1971. Food and feed crops of the United States.

Mediterranean Fruits—Joan Tous and Louise Ferguson

And outside links to more fig info:

Fig Information from the University of California Fruit & Nut Research and Information Center

FIG "FRUIT FACTS"(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Fig—from Mark Reiger, Dept of Horticulture, University of Georgia.

From the FAO Tropical Feeds Database.

Folk lore and other fig information from Grieve's Modern Herbal

Field pea

Leguminosae *Pisum sativum* L.

Source: Magness et al. 1971

The term **field pea** designates peas used as forage for livestock rather than for human food. The plants are annuals, adapted to cool climates. They have weak, semi-vining stems. The leaves usually consist of 3 pairs of broad, ovate leaflets and terminate in a tendril. They are borne along the whole length of the stem. Seeds are usually near round, smooth, and produced several to a pod. Field peas are grown for livestock feed in northern states from New York west to Oregon, where they are seeded in early spring. In the South they are seeded in the fall for winter pasture and green manure. For harvesting dried peas, fields are mowed, the vines windrowed to dry, then threshed with combines. The dry beans are grown on about a quarter million acres. Straw after threshing, as well as the peas, are nutritious feeds.

Last update September 27, 1997 by aw

Figwort

Scrophularia marilandica L.

Synonym.—*Scrophularia nodosa* var. *marilandica* A. Gray.

Other common names.—Maryland figwort, heal-all, pilewort, carpenter square.

Habitat and range.—This plant, often galled Maryland figwort, is found in woodlands from Maine to Kansas and south to Georgia and Tennessee.

Description.—The figwort is 3 to l0 feet high with 4-angled stems widely branched above and slender-stemmed, somewhat egg-shaped or lance-shaped sharply toothed leaves 3 to 9 inches long. The numerous small, greenish-purple flowers are produced from July to September in rather open panicles.

Part used.—The herb.

Figure 49.—Figwort (*Scrophularia marilandica*)

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Linum usitatissimum L.

Linaceae

Flax

We have information from several sources:

Flax: New Uses and Demands—Duane R. Berglund

Flax Fiber: Potential for a New Crop in the Southeast—Jonn A. Foulk, Danny E. Akin, Roy B. Dodd, and David D. McAlister III

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Flax: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Flax Council of Canada

Fortunella sp. Swingle

Rutaceae

Cumquat, Golden orange, *Kin-kan*, Kumquat, *Limau pagar*, Marumi, Meiwa, Nagami

We have information from several sources:

Kumquat—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Vitis rotundifolia Michx.

Vitaceae

Muscadine grape, Southern Fox Grape

We have information from several sources:

Temperate Berry Crops—Chad Finn

Muscadine Grape—Magness J.R. et al. 1971. Food and Feed Crops of the United States.

Outside Links:

Mucadine Grape Fruit Facts—from the California Rare Fruit Growers Association.

Grapevine—FAO/IBPGR Technical Guidelines for the Safe Movement of Grapevine Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Grapevine—Descriptors for Grapevine—Link to the publication on the International Plant Genetic Resources Institute web site

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Meadow foxtail

Gramineae *Alopecurus pratensis* L.

Source: Magness et al. 1971

This grass is native to temperate Europe and Asia, and was introduced into the United States around the middle of the last century. It is a long-lived perennial, which forms a few short rootstocks and underground branches. It produces a medium dense sod. Leaves are medium in width, dark green and numerous. Stems generally reach about 3 feet. The species is especially adapted to cool moist climates, such as west of the Cascade Mountains in Oregon and Washington; but is useful in other northern states. It is especially useful as pasture, growing throughout a long season. In combination with legumes it is made into silage in the Pacific Northwest, but is rarely harvested for hay.

Last update February 18, 1999 by ch

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Setaria italica (L.) Beauv.

Poaceae, or Graminae, Tribe Paniceae

Foxtail Millet, Italian Millet, German Millet, Hay Millet

NewCROP has Foxtail Millet information at:

Foxtail and Proso Millet. D.D. Baltensperger 1996. p.182-190. In: J. Janick (ed.), Progress in New Crops. ASHS Press, Alexandria, VA.

Progress with Proso, Pearl and Other Millets—David D. Baltensperger

Millets: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Variation in electrophoregrams of total seed protein and Wx protein in foxtail millet. Afzal, M., M. Kawase, H. Nakayama, and K. Okuno. 1996. p. 191-195. In: J. Janick (ed.), Progress in new crops. ASHS Press, Alexandria, VA.

Foxtail Millet In: Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Foxtail Millet info:

Millet Production Guide by: R. D. Baker, Extension Agronomist, New Mexico State University.

Fragaria virginiana Duchesne

Rosaceae

Strawberry, European strawberry, garden strawberry, Virginia strawberry

We have information from several sources:

The Herb Hunters Guide—Sievers, A.F. 1930.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Growing Strawberries—HO-46 Purdue University Cooperative Extension Service

Year-Round Strawberry Weed Control—HO-46 Purdue University Cooperative Extension Service

Fertilizers for Strawberries—HO-64 Purdue University Cooperative Extension Service

Outside Links:

Small Fruit—FAO/IBPGR Technical Guidelines for the Safe Movement of Small Fruit Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Strawberry—from Mark Reiger, Dept of Horticulture, University of Georgia.

Strawberry Information from the University of California Fruit & Nut Research and Information Center

White Ash

Fraxinus americana L.

White ash

Figure 114.—White ash (*Fraxinus americana*)

Synonyms.— *Fraxinus alba* Marsh.; *F. acuminata* Lam.

Other common names.—Ash, American white ash, cane ash.

Habitat and range.—The white ash is native in rich woods, from Nova Scotia to Minnesota, south to Florida and Texas, but chiefly in the Northern States and Canada

Description.—This tree usually attains a height of from 60 to 80 feet, but occasionally reaches 120 feet. The leaves, which appear late in the spring, are about 12 inches long and consist of from five to nine leaflets from 3 to 5 inches long and about half as wide. The small, whitish-green flowers which appear from April to June are arranged in loose clusters, and the fruits which follow are in the form of clustered, winged seeds each of which is from 1 to 3 inches long, narrow, flat, and 1-seeded.

Another species.—The black ash (*Fraxinus nigra* Marsh., syn. *F. sambucifolia* Lam.) is also a native, inhabiting swamps and wet woods from Canada to Virginia and Arkansas. Other names applied to it are hoop ash, swamp ash, water ash and basket ash. It reaches a maximum height of 100 feet and has leaves about 16 inches long composed of 7 to 11 leaflets 3 to 6 inches long.

Part used.—The bark of the trunk and root of both species.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Galleta grass

Gramineae, Poaceae *Hilaria jamesii* (Torr.) Benth.

Tobosa grass

***H. mutica* (Buckl.) Benth.**

Source: Magness et al. 1971

Both of these native species are slightly spreading range grasses. Galleta grass occurs from Wyoming to California and West Texas while Tobosa is in West Texas and Arizona and south into Mexico. The bases of the stems of both are rhizome like. Stems may reach to 2 feet, with small, narrow leaves. Both are found under arid conditions and are highly drought resistant. They are moderately palatable while succulent, but not when dry.

Last update June 27, 1996 bha

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Imbe

Guttiferae *Garcinia livingstonei* T. Anders.

Source: Magness et al. 1971

The Imbe is a small tree up to 20 feet, native to East Africa. Leaves are leathery, dark green, oblong, up to 6 inches in length. Fruits are up to 2 inches long, nearly as broad, and ripen in mid-summer. The skin is tender and encloses a thin, tart, watery pulp, with generally a single seed. There is no commercial production in the United States, but occasional trees may be found in tropical areas.

Last update February 18, 1999 by ch

Garcinia mangostana L.

Guttiferae

Mangosteen, King-of-fruits, *Maggistan*, Manggis, *Manggusta*, Mangostan, Men-gu

We have information from several sources:

Mangosteen—Julia Morton

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

South American Fruits Deserving Further Attention —Richard J. Campbell

Outside links:

Bibliography of *Garcinia mangostana* from Fruits for the Future.

Pisum sativum L.

Leguminosae, or Fabaceae

Pea, dry pea, Chinese pea, Chinese pea pod, Chinese snow pea, edible-podded pea, edible pod pea, podded pea, snow pea, sugar snap pea (UK, USA), Batani (Ind), Erbese (Ger), Ater (Eth), pois (Fra), Takarmany borso (Hun), Pisello (Ital), ho loan, mange-tout, papdi

We have information from several sources:

FactSHEET—contributed by F.J. Muehlbauer and Abebe Tullu

Midwest Vegetable Production Guide for Commercial Growers 2000

Dry Field Pea—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Dry Pea and Lentil as New Crops in Saskatchewan: A Case Study—A.E. Slinkard, R.S. Bhatty, B.N. Drew, and R.A.A. Morrall

Grain Yield of Oat-Pea Intercrop—Patrick M. Carr, Eric D. Eriksmoen, Glenn B. Martin, and N. Rick Olson

Food and Grain Legumes—Fredrick J. Muehlbauer

Grain Legumes—Theodore Hymowitz

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Peas and Beans—production links

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

New Crops for Canadian Agriculture—Ernest Small

Food and Feed Crops of the United States. Magness, J.R., G.M. Markle, C.C. Compton. 1971. Garden Pea

Edible-podded Pea
Field Pea

Outside links:

Pea vine report—Washington State University

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

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Gaultheria procumbens L.

Ericaceae

Wintergreen, checkerberry, teaberry

We have information from several sources:

Herbs: An Indexed Bibliography. 1971-1980—J.E. Simon, A.F. Chadwick and L.E. Craker

The Herb Hunters Guide—Sievers, A.F. 1930.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Huckleberry

Ericaceae *Gaylussacia* sp.

Source: Magness et al. 1971

In the United States, the name huckleberry is often used for blueberry, which see. While the two fruits are similar in appearance and flavor, the huckleberry which is a drupe has a 10-celled ovary, each cell (drupelet) normally containing a seed large enough to be conspicuously noticeable when the whole fruit is eaten. Blueberries, in contrast, contain many seeds so small as not to be noticeable when the fruit which is a berry is consumed. Only blueberries are a cultivated crop, but quantities of huckleberries are harvested from native plants. The huckleberry plant is a shrub, to 6 feet, with small, entire oval leaves. Fruits are borne in small clusters. Individual fruits are generally one-third inch or less in diameter, mainly blue to black in color, sweet or slightly tart when ripe. Several species, mainly in Eastern United States, produce fruits valued locally.

Genipa americana L.

Rubiaceae

Genipap, Genip, Genipe, Genipop, Jagua, Marmalade box

We have information from several sources:

Genipap—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

GERANIUM

Family: Geraniaceae, (*Pelargonium graveolens* L'Her. ex Ait.)

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Rose geranium, *Pelargonium graveolens* L'Her. ex Ait., is one of the many fragrant species of *Pelargonium* used as a source of geranium oil. The woody, perennial herb is native to South Africa and is produced in Egypt, France, the People's Republic of China, Algeria, South Africa, Morocco, and Spain. Reaching a height of one meter, the plant has pubescent, fragrant, green, deeply lobed leaves and rose-colored flowers.

The geranium flourishes in the full sun of temperate and subtropical climates. Best growth is obtained on well-drained, fertile soils and under a high relative humidity. The species are cold sensitive but tolerant of drought.

The essential oil accumulates in small glands found in the foliage and flowers. Harvesting, usually done by hand two or three times annually, begins as the plant starts flowering. The herb is cut in the morning in sunny, dry weather. Distillation begins after a few hours of field drying.

There are several types of geranium oil, the main ones being Reunion or Bourbon, Algerian, Moroccan, and French. The oils are composed chiefly of geraniol, citronellol, linalool, citronellyl formate, and several other compounds (7.5-124, 8.2-13, 8.2-33, 14.1-9). Reunion oil is very rich in citronellol and has a heavy rose and minty odor. Algerian oil has a delicate odor. Moroccan oil is similar to Algerian oil. French oil is thought to possess the finest rose-like odor. The concrete and absolute of geranium are also available commercially.

The oil of geranium, widely used in perfumery and cosmetics, is stable and blends well with other fragrances. Dried leaves are used in sachets and potpourris. Leaves of geranium are also used in herbal teas and the oil is used in baked goods and fruit desserts. The geranium of florists comes from many annual and perennial geranium species that vary in fragrance, growth habit and leaf and flower color. The scented geraniums are extensively used in flower gardens and as potted herbs.

As a medicinal plant, geranium has traditionally been considered an astringent and used as a folk remedy in the treatment of ulcers (11.1-50). A terpine hydrate synthesized from geraniol is known to be, an effective expectorant (11.1-96). Leaves are reported to have antifungal activity (7.5-124). Scented geranium and oil of geranium are reported to cause contact dermititis (8.2-79, 11.1-96). Geranium is reported to repel insects because of its citronellol content.

Several forms, varieties, and hybrids of geranium exist. Rose-scented geranium, *Pelargonium capitatum* (L.) L'Her. ex Ait.; nutmeg geranium, Pelargonium fragrans Willd.; apple geranium, *Pelareonium odoratissimum* (L.) L'Her. ex Ait. and crowfoot geranium *Pelargonium radens* H. E. Moore, represent the wide diversity of plants that contribute to the production of geranium oil. *Geranium macrorrhizum* L., an aromatic plant, and wild geranium, *Geranium maculatum*, are members of the Geraneaceae family and should not be confused with the scented geraniums. Although used in flavoring and perfumery, East Indian geranium is actually *Cymbopogon martini* Stapf., of the Poaceae family.

Pelargonium species are generally recognized as safe for human consumption as natural seasonings/flavorings and as plant extracts/essential oils (21 CFR sections 182.10, 182.20 [1982].

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Wild Geranium

Geranium maculatum L.


Figure 118.—Wild geranium (*Geranium maculatum*)

Other common names.—Crane's-bill, spotted crane's-bill, wild crane's-bill, stork's-bill, spotted geranium, alumroot, alum-bloom, chocolate-flower, crowfoot, dove's-foot, old-maid's-nightcap, shameface

Habitat and range.—Wild geranium flourishes in low grounds and open woods from Newfoundland to Manitoba and south to Georgia and Missouri.

Description.—This plant, although generally only about a foot in height will sometimes reach a height of 2 feet. It is erect, usually unbranched, and hairy. The leaves, which are 3 to 6 inches wide, are deeply parted into three or five divisions, each of which is again cleft and toothed. The rose-purple, pale or violet-purple flowers, which appear from April to June, are borne in loose clusters and are from 1 to 1 1/2 inches wide. The fruit capsule, which springs open when ripe, consists of five cells each containing one seed. The rootstock is 2 to 4 inches long, thick, with numerous branches and with sears showing the remains of stems of previous years. When dry it has a somewhat purplish color internally.

Part used.—The root, collected just before the flowering period.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Helianthus tuberosus L.

Asteraceae

Jerusalem artichoke, Girasol, Gerasole, Girsole, Sunchoke

We have information from several sources:

Jerusalem Artichoke: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Dufault, R.J., T. Phillips, and J.W. Kelly. 1990. Gerbera daisies: A potential field-produced cut flower crop for coastal South Carolina. p. 457-459. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Gerbera Daisies: A Potential Field-produced Cut Flower Crop for Coastal South Carolina

Robert J. Dufault, Tyron Phillips, and John W. Kelly

INTRODUCTION

Need for Alternative Crops

Historically, the coastal area of South Carolina has been a region of great agricultural importance in the Southeast. Dating back to the seventeenth century, many crops, once considered alternative crops or new crops were introduced and became strong industries. Rice, then indigo, and finally sea island cotton were important crops in the region for two centuries. Vegetable production supplanted cotton production by the turn of the twentieth century. During the last eighty years, crops such as beans, lettuce, carrots, cabbage, greens, and potatoes were considered major crops; however, through a variety of reasons, competition eroded these markets. Presently, fresh market tomatoes are the major vegetable produced in coastal South Carolina, but the future of this industry is threatened by strong competition from Florida's growers, who are extending their production periods.

Potential of Field Cut Flowers

The search for new crops to supplement the income from traditional crops has followed many routes. Cut flowers are one of the alternatives being considered. Presently, a few growers in South Carolina produce snapdragons, gladiola, daylilies, and statice. Most of these flowers are sold directed to retail florists. Surveys of local retail and wholesale florists in Columbia, South Carolina have indicated that there is potential for local growers to produce and sell more diverse types of cut flowers. Barberton or Transvaal daisies, or simply Gerbera daisies (*Gerbera jamesonii* Bolus) are one of the top cut flower crops in Europe and in recent years have been steadily exported to the United States from the Netherlands, France, Italy, Japan, India, Australia, and New Zealand (Tjia 1984). Gerbera daisies are produced also in South America (Colombia), but the majority of these are exported to Europe and Japan (Tjia and Rogers 1982).

Gerbera daisies are a high value cut flower crop with retail prices as high as $3.50/stem. Growers could sell Gerbera cut flowers to a wholesaler for 25 to 40 cents/stem who would, in turn, sell the same stems to a retail florist for 40 to 70 cents/stem. Demand and price paid for Gerbera cutflowers is highest from Valentine's Day to Mother's Day.

Most gerbera cut flowers are produced in some form of protected structure. In the Netherlands, Gerbera cut flowers are produced on raised beds in heated greenhouses to protect from severe winter weather. Domestically, Gerbera daisies are produced in Florida in sawtooth or saran houses (Behnke 1984). Shade cloth is needed to reduce temperatures and to enhance stem length (Auman 1980). While some production is in open fields, the majority is produced under some permanent protective structure (B. Tjia, personal communication).

The coastal area of South Carolina has many aspects about its geography and climate that can be considered favorable to the production of field gerbera cut flower production. The area is an 8 to 9 on the hardiness zone. The summers are sub-tropical with sub-temperate winters. However, to capture the early Valentine's Day market demand, some form of protection is needed. The region has ample water, warmth, and productive soils unusually high in phosphate. Gerbera daisies are a popular bedding plant in the home landscape and over-winter without plant loss. They are one of the earliest to flower in spring, are extremely heat tolerant blooming through the intense heat and humidity of the summer months, and will bloom continuously to late November. As bedding plants, they are considered "easy" to grow. Geographical benefits include close proximity to the large metropolitan areas of Charleston and Columbia, South Carolina and Atlanta and Savannah, Georgia, and within easy reach of metropolitan areas north or south along the eastern corridor. Recently, local "pick-your own," vegetable farms have diversified their product lines and sell annual cut flowers, such as zinnia, marigold, and cosmos with great success. Customers are drawn to these stands by the splashes of bright colors of cutflowers. Perennial cut flowers, such as Gerbera daisies, could be a welcome addition.

FIELD STUDIES ON GERBERA DAISY CUT FLOWER PRODUCTION

Population and Fertility Research

Potential factors working against the success of this new crop are uncertainties of the cultural practices needed to produce high quality gerbera cut flowers in open fields. The basic fertility and population considerations to produce quality cuts are unknown and awareness of pest problems needs close scrutiny The floral industry has defined the level of quality the grower needs to satisfy. Florists demand large, showy blooms preferably 7.5 cm in diameter or greater. The many different types of gerbera flower forms include singles, doubles, crested doubles, full-crested doubles, and quilled types (Clay 1983). Florists seldom use singles in arrangements, preferring the fancier flower types. Stems should be sturdy and at least 30 cm, but preferably 60 cm in length. Blooms must be insect- and disease-free. Work was initiated in 1987 at Clemson's Coastal Research Center in Charleston to determine the appropriate cultural practices to produce quality cut flowers in unprotected culture in the open field (Fig. 1).

A two-year study evaluated the influence of nitrogen (N) and potassium (K) fertility and plant populations on quality cutflower production. Three levels of N (55, 110, and 220 kg/ha) and plant populations of 24,000, 36,000, and 72,000 plants/ha were factorially combined to produce 27 unique cultural systems. In the first year of production, we found that populations of 72,000 plants/ha can be used to produce cut flowers without loss of flower size and quality. At least 110 kg N/ha, was needed to enhance high yields (Table 1). Increasing the N rate to 220 kg/ha increased cull production with negligible increases in marketable yields. Nitrogen rate did not affect flower size or quality. At least 220 kg K/ha is needed to increase marketable yield, individual flower fresh weight and vase life and to decrease cull flower production.

Marketable and cull yield also increased with N rate applied in the second year (Table 1). In contrast to the first year's work, production was highest with 220 kg N/ha while K had no effect on yield. High populations of 72,000 plants/ha increased marketable yields. Levels of N, K or plant populations had no effect on flower diameter, stem length, flower fresh weight or overall quality. To obtain high yields of marketable quality, fertility regimes of 220 kg N/ha with at least 55 kg K/ha are needed. High plant populations of 72,000 plants/ha win maximize flower yields without adverse effect on flower quality and production.

Research To Improve Stem Length and Earliness

Short stem length was a persistent problem in the fertility/population experiments. Stem lengths averages about 31 cm and 34 cm in 1987, and 34 cm in 1988. Fertility and plant spacing did not affect stem length. Research is ongoing to study the utility of shade cloth of 30, 47, 63 or 80% light exclusion to induce greater stem length. Portable shade cloth houses are placed over the beds during the growing season. The benefits to production and economics of utilizing shade cloth remain to be determined.

Normally in Charleston, gerberas bloom in early April. The use of row covers could increase early production to mid-February, and are currently being investigated. Although all row cover materials tested resulted in earlier production in January, 1989, the lengthening stems were abraded by the row cover materials and seriously damaged. Better designs combining row covers with higher clearance tunnels are needed.

POTENTIAL OF GERBERA AS AN ALTERNATIVE CROP

Thrip-induced petal striations and streaks are the major hindrance to quality flower production in coastal South Carolina. Various systemic and non-systemic insecticides evaluated were ineffective in controlling thrips and these compounds are not yet labeled for use with these crops. Before this new crop can be grown commercially, entomological studies are needed to learn how to control thrips.

The success of this crop in the market place will depend ultimately on the aggressiveness of the grower to pursue retail and wholesale floral markets. Quality must be demonstrated and price set to undersell the competition. Only a limited number of Gerbera daisies can be absorbed by local market outlets. Retailing through "pick-your-own" farmstands and farmers markets may be the best ways for the small grower to become familiar with growing the crop, developing a quality product, and establishing a good reputation in the market.

Floral trade experts expect that the boom in flower use by Americans will continue to increase. Americans spent about $21 per capita in 1986 for cut flowers (Levin 1987). Although our use of flowers still lags behind the Europeans, the trend of buying flowers for the home is moving the country closer to the European tradition. We expect that field-production of cut flowers will increase significantly in the coming years.

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Table 1. Effect of fertility and plant populations on gerbera cut flower yield.

	Cut flower yield (1000's/ha)	
	Marketable	Cull

Variable	1987	1988	1987	1988
N (kg/ha)				
55	76.7b[z]	187.9c	146.1c	122.0c
110	92.9a	259.7b	168.9b	145.0b
220	96.2a	305.1a	197.2a	190.2a
K (kg/ha)				
55	79.4b	224.0a	180.1a	231.1a
110	91.4a	278.8a	175.6a	228.6a
220	95.0a	249.6a	156.6b	223.4a
Plants/ha				
72,000	131.4a	289.0a	227.1a	146.7b
36,000	78.5b	228.2b	161.8b	166.2a
24,000	55.9c	235.5b	123.4c	144.4b

[z]Means within columns separated by LSD .05 level.

Fig. 1. Field production of gerbera in South Carolina.

Last update September 5, 1997 by aw

Prosopis cineraria (L.) Druce

Syn.: *Prosopis spicigera* L.
Mimosaceae
Ghaf (Arabic), Jand (Punjab), Jandi (Pakistan), Shum (India)

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

According to Burkart (1976) *Prosopis cineraria* is not used commercially. During India's Rajputana famine (1868–69), many lives were spared, using the sweetish bark as a food. It was ground into flour and made into cakes. Wood used for boat frames, houses, posts, and tool handles; the poor form of unimproved trees limits use as timber. Containing 31% soluble potassium salts, the wood ash may serve as a potash source. Pods and lopping provide valuable fodder during the dry season. According to the NAS (1980a), it "does not compete for moisture with crop plants, which may be grown close to its trunk." Pakistanis and Indians believe, quite properly, that it increases fertility under its canopy. Bark and leaf galls used for tanning. The gum exuding from the trunk is suggestive of gum arabic.

Folk Medicine

Reported to be astringent, demulcent, and pectoral, ghaf is a folk remedy for various ailments. In India, the flowers are mixed with sugar and administered to prevent miscarriage. In Las Bela, India, the ashes are rubbed over the skin to remove hair (perhaps *Leucaena* ashes should be tried as well). The bark, considered anthelmintic, refrigerant, and tonic, is used for asthma, bronchitis, dysentery, leucoderma, leprosy, muscle tremors, piles, and wandering of the mind. Smoke from the leaves is suggested for eye troubles, but the fruit is said to be indigestible, inducing biliousness, and destroying nails and hair. Punjabis consider the pod astringent. Central Province Indians use bark for rheumatism. Although recommended for scorpion sting and snakebite, the plant has not proved out (Kirtikar and Basu, 1975).

Chemistry

The heartwood, contains sugars, five flavonones, fatty acids, and tannins (Burkart, 1976). Fresh leaves (ZMB) contain 15.3% CP, 17.5% CF, 10.0% ash, 3.2% EE, 54.0% NFE, 2.65% Ca, and 0.24% P (Gohl, 1981). Wealth of India reports that leaves contain 2.9% N, 0.4% P_2O_5, 1.4% K_2O, and 2.8% CaO. The flavone glycoside patulitrin has been isolated from the flowers (C.S.I.R., 1948–1976). A novel variant on the piperidine-3-ol alkaloid recently reported is spicigerine (Jewers et al., 1976).

Description

Tree to 6.5 m high; cortex cinereous; prickles internodal, scattered, straight, somewhat acroscopic, conical with broad bases. Taproot to more than 3 m long. Leaves 1–3-jugate, glabrous or puberulous; petiole and rachis 0.5–4 cm long, the pinnae 2–7 cm long; leaflets 7–14-jugate, ovate, straight to subfalcate, without nerves (or 2–4-nerved at base, the midrib excentric), mucronate, 4–15 mm long x 2–4.5 mm broad, grayish when dry; stipules foliaceous, deciduous. Racemes spiciform, 5–13 cm long, several together, subpaniculate; peduncle with amplexicaul bract (or 2 bracts united), this caducous and leaving an oblique scar, 1.5–2 mm long; bractlets ovate, sessile, 0.5–0.8 mm long, caducous; pedicels 0.5 mm, to 1.5 mm long when mature; flowers yellow, glabrous; calyx truncate, 0.8–1.2 mm long; corolla 3.5 mm long, glabrous, the petals rolled back in age; anthers 0.8–1 mm long; pistil glabrous. Fruit slender, elongate, 8–19 cm long (including the stipe 0.8–2 cm), subcylindric-torulose, 4–7 mm in diameter, glabrous; pericarp thin, brittle; endocarp segments thin, longitudinal, little developed; seeds distant, longitudinal, ovate, 6 mm long, the tegument with open horse-shoe fissural line on faces (Burkart, 1976), 10–15 in a pod, brown (C.S.I.R., 1948–1976).

Germplasm

Reported from the Hindustani Center of Diversity, ghaf, or cvs thereof, is reported to tolerate alkalinity, drought, grazing, heat, high pH, poor soil, sand, and salt. Young seedlings are sensitive to frost (C.S.I.R., 1948–1976).

Distribution

In dry and arid regions of northwestern India in Punjab, West Rajasthan, Gujarat, Uttar Pradesh, in dry parts of central and southern India, extending into Pakistan, Afghanistan, Iran, and Arabia. Usually at low elevations. Introduced in Abu Dhabi, where plantings totaling 2,000 ha have been made on flat, silty, gravelly plains and in shifting sand dunes (NAS, 1980a).

Ecology

Withstands slight frost (-6°C minimum) and high temperatures (40–50°C maximum shade). Sometimes gregarious but scattered in open dry forest. Seems to require light. Our computer entries for *Prosopis* spp. are unreliable, partly due to past taxonomic confusions. I estimate this species to range from Tropical Thorn to Moist through Subtropical Thorn to Moist Forest Life Zones. I estimate it tolerates annual precipitation of 1 to 20 dm and pH of 6.5–9.8. The chief Indian tree species in the Punjab, where rainfall is less than 750 mm.

Cultivation

Reproduces freely by root suckers and establishes well from seed, which remain viable for decades. Seeds, which should be soaked for 24 hours, may be processed and planted like *P. alba*. They retain their viability for at least one year. An initial spacing of 2 x 2 m is recommended. Should be weeded until well established.

Harvesting

Tree coppices readily.

Yields and Economics

Standing crops yield 7–70 m^3 fuel/ha, averaging 21 m^3 stacked. Annual yields of stacked firewood approach 3 m^3/ha. The heartwood is very hard and heavy (769–945 kg cu m).

Energy

In the Punjab, its rather scanty, purplish brown heartwood is preferred to other kinds for firewood (Burkart, 1976). It is an excellent fuel, also giving high-quality charcoal (5,000 kcal/kg). According to the Wealth of India, the calorific value of the sapwood is 5,003 kcal (9007 BTU) (C.S.I.R., 1948–1976).

Biotic Factors

NAS (1980a) reports that "one fungus and five insect species are known to attack the tree." Species of Chrysobothris and Sinoxylon bore into the dead wood, causing wood rot. Felker et al. (1981) review the pest infestations of their *Prosopis* plantings with suggestions for their control. Browne (1968) lists the following: Angiospermae—*Cuscuta reflexs;* Coleoptera—*Caryedon gonagra, celosterna scabrator*; Hemiptra—*Drosicha stebbingi, Laccifer lacca, Oxyrhachia tarandus, Perisopneumon tamarinda;* and Orthoptera— *Schistocerca gregaria.*

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Complete list of references for Duke, Handbook of Energy Crops

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Last update January 8, 1998 by aw

Zingiber officinale Roscoe

Zingiberaceae

Ginger, Gingerroot, Jamaica ginger

NewCROP has information from the following sources:

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links to Ginger info:

Illustration of *Zingiber officinale* Roscoe Zingiberaceae from Hermann A. Köhler's 3-part tomes *Medizinal Pflanzen* (1887) plates.

Ginkgo biloba L.

Ginkgoaceae

Ginkgo, Maidenhair tree

We have information from several sources:

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Herbs Affecting the Central Nervous System—Varro E. Tyler

Panax spp.

Araliaceae

Ginseng, American ginseng, Dwarf ginseng

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Ginseng: Old Crop, New Directions—John T.A. Proctor

Commercial Production of Ginseng and Goldenseal—L.P. Stoltz

Ginseng: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Immune Stimulants and Antiviral Botanicals: Echinacea and Ginseng—Dennis V.C. Awang

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Outside links:

Woods-Grown Ginseng West Virginia University Extension Service

"Wild-Simulated" Forest Farming for Ginseng Production

Canadian ginseng

Salsola kali L.

Chenopodiaceae
Russian thistle, Prickly saltwort, Tumbleweed, Glasswort

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Young plants serve as useful fodder, as long as they are not too high in nitrites or oxalic acids. As a low-water-use plant, germinating quickly on minimally disturbed soils, and relatively free of diseases and parasites, this has been suggested as a fuel source for arid lands (Foster et al., 1980). This is one of several plants burned to make soap, even in Biblical times, at least so we read in WSSA. Soap made in this fashion is still traded at Joppa and other Mediterranean ports [WSSA Newsletter 9(4): 12. 1981]. On account of its high alkali content, the plant has also been used in making glass (Watt and Breyer-Brandwijk, 1962). Salsolin has been used to regulate the blood pressure, said to resemble papaverine in its effect on vasoconstriction, hydrastine in its effect on the smooth muscles of the uterus (List and Horhammer, 1969–1979).

Folk Medicine

According to Hartwell (1967–1971), the plants are used in folk remedies for that cancerous condition he terms superfluous flesh. Reported to be cathartic, diuretic, emmenagogue, poisonous, stimulant, and vermifuge, Russian thistle is a folk remedy for dropsy and excrescences (Duke and Wain, 1981). Navaho used a decoction of the ashes, both internally and externally for influenza and smallpox (Duke, 1983c).

Chemistry

Of 21 samples, the average DM content was 39.4% (20.0–80.2). On a Zero Moisture Basis (ZMB), CP, ran 4.9–25.0% (mean of 31 = 12.3), EE 0.6–3.8 (mean of 23 = 1.8), CF 20.2–43.1% (mean of 21 = 31.7), ash, 5.4–22.8% (mean of 30 = 15.2), and the NFE averaged 39.0%. Ca ranged from 1.6–4.14 (mean of 48 = 2.47%), P from 0.04–0.27 (mean of 48 = 0.17%), K from 4.63–6.83% (mean of 6 = 6.46%), Mg from 0.60–0.93 (mean of 17 = 0.81%), with ca 19 mg/kg Cu, 33 mg/kg Mn, 0–8 mg/kg carotene (Miller, 1958). Seeds contain 40.5% protein, 27.0% fat, on a ZMB (Duke and Atchley, 1983). Fruiting plants may contain 0.2% alkaloids, among them salsolidine and salsoline. Hager's Handbuch reports the fatty oils from the plant contain linolenic-, oleic-, arachidic-, palmitic-, and stearic-acids, along with glucose, arabinose, fructose, and rhamnose, with eicosanol and β-sitosterol. The ash contains ca 20% K, 18% Ca, 3% Mg, 1.5% Al, 1.5% Fe, 6% phosphate, 6% sulfate, 40% carbonate, and 2% chloride (List and Horhammer, 1969–1979).

Toxicity

The plant can contain as much as 5% oxalic acid. This oxalic acid, or excess of KNO_3 may lie behind reports of toxicity to grazing animals.

Description

Annual herb with spreading taproot; stems bushy, much-branched, 1.5–12 dm tall, 3–15 dm in diameter, rigid, spiny, spherical, often reddish in age, young stems and leaves green and succulent; leaves alternate, the first-formed fleshy, cylindrical or awl-shaped, 0.5 mm broad, 1.2–6.5 cm long, apically pointed, the latter-formed shorter, stiff, dilated and thickened at the base, ending in a hard sharp spine. Flowers small, greenish, mostly solitary in the axils; petals none; sepals 5, papery and persistent; stamens 5; pistil 1, bracts at the base of each flower 2, rigid, spine-tipped; fruit surrounded by the 5 enlarged sepals, each developing a fan-shaped, strongly veined wing on its back, 3–9 mm broad. Seeds numerous (to one million per plant), top-shaped, ca 2 mm broad, with a yellowish coiled embryo, visible through the thin gray wall (Reed, 1970).

Germplasm

Reported from several arid Mediterranean Centers of Diversity, Russian thistle, or cvs thereof, is reported to tolerate drought, grazing, heat, and poor soils. I predict it will also tolerate salinity and high pH, as do so many desert xerophytes. ($2n = 36$)

Distribution

Disturbed areas, roadsides, ditchbanks, fallow abandoned grain-fields, overgrazed ranges, and pastures. Common to abundant in Western and parts of the Central States of the US, occasional along the eastern and southern coasts, where it is spreading rapidly (Reed, 1970). Treated as a serious weed in Afghanistan and Argentina, a principal weed in Canada and Hungary, a common weed in Iran, Italy, Morocco, South Africa, and the United States. Listed also as weed in Australia, Chile, China, Egypt, Greece, Hawaii, Indonesia, Iran, Japan, Lebanon, Mexico, Norway, New Zealand, Pakistan, Poland, Turkey, and the USSR (Holm et al., 1977).

Ecology

Estimated to range from Cool Temperate Desert to Steppe to Subtropical Very Dry to Thorn Forest Life Zones, Russian thistle is reported to tolerate annual precipitation of 2.6 to 9.7 dm (mean of 4 cases = 4.9), annual temperature of 9.2 to 23.8°C (mean of 4 cases = 15.3), and pH of 7.0 to 7.9 (mean of 2 cases = 7.4) (Duke, 1978, 1979).

Cultivation

A self seeding annual, producing up to a million seed a plant, the Russian thistle doesn't really need to be cultivated, except perhaps as a desert fuel candidate.

Harvesting

Spread of the weed is encouraged by the long-viable seed. Harvesting of the tumbleweed and processing it for fuel is treated in various papers by Karpiscak and/or Foster.

Yields and Economics

Productivity of natural stands in Avra Valley, ca 32 km northwest of Tucson, averages more than 3 MT/ha. Hence this weed has been suggested as desert fuel crop for 240,000 ha of arid or fallow land retired as the cost of irrigation increases (Foster, Rawles, and Karpiscak, 1980). With its C4 photophysiology, it has a high water use efficiency. Currently, this is an economic negative. Tumbleweeds block irrigation canals. They are a traffic hazard which cost the California transportation department hundreds of thousands of dollars to eliminate (Anon., 1982a). It costs about $250 a hectare to haul away the brush, while application of an herbicide (e.g. Brominal) costs closer to $100.

Energy

According to the phytomass files (Duke, 1981b), annual productivity ranges around 3 MT/ha but yields of ca 6–10 MT/ha forage are reported for *Salsola orientalis* (with Eurotia and Kochia) in Kazakhstan (USSR) (Pryanishikov and Alimaev, 1977. Proc. 13th Internat. Grassland Cong. Leipzig) [CAB V81(10)]. In dry regimes, *Salsola kali* has higher biomass in mixed than in monoculture (Allen, 1982). Karpiscak et al (1980) report on the feasibility of agricultural production as a source of burnable biomass. Foster et al. (1980) discuss the processing into artificial fireplace logs whose economic potential is substantial. Energy content in field-dried tumbleweed ranges from 6,500–6,800 Btu/lb cf 5,580–7,920 for lignite. Wild stands yield 3–10 MT/ha; irrigated plots up to 15 MT/ha. The value of the fireplace logs made from compressed tumbleweed is $14 to $20 per million Btu. It costs $4.33–6.40 to prepare the product (Foster et al, 1983). The most common means of eradication is by burning, which only perpetuates the problem by releasing up to 1,000,000 fire-resistant seeds per plant (Anon., 1982a).

Biotic Factors

Agriculture Handbook No. 165 lists the following as affecting this species: *Melanospora townei* (on stems), *Phymatotrichum omnivorum* (root rot), *Pleospora lecanora* (on stems), *Puccinia aristidae* (rust), *Pyrenophora salsolae* (on stems), *Pythium deparyanum* (root rot), and curly top virus *Ruga verrucosans*. Golden (p.c. 1984) lists the "false root-knot" nematode, *Nacobbus aberrans*.

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Gleditsia triacanthos L.

Caesalpiniaceae
Honeylocust

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Widely introduced as a fast-growing tree for fuel and fodder and fence posts, for ornament, shade and soil reclamation. The wood is said to be coarse-grained, durable, hard, and resistant to soil decay. Hence it is used for fence posts, railroad ties and tubs for wheels. South Africans sometimes plant orchards of the tree for fodder. The gum from the seeds has been suggested as an emulsifying substitute for acacia and tragacanth. Flowers very attractive to bees. The pulp has always attracted the sweet tooth of animal and man alike, when better sweets were not available. A potable or energy alcohol can be made by fermenting the pulp. Seeds have been roasted and used as a coffee substitute. Wood is hard, coarse grained, reddish-brown and takes a high polish; the wood resists decay and makes good fence posts. Lumber is used for various purposes, but the chief use is as an ornamental. The pods are readily eaten by cattle, goats, deer, squirrel, rabbits, quail, and starlings (Brown and Brown, 1972).

Folk Medicine

Sokoloff et al. (1964) note that recently, Soviet investigators have been studying the biological factors present in the fruit and leaves of *Gleditsia triacanthos.* The alcoholic extract of the fruits of the Kirgis honey locust, after elimination of tannin, considerably retarded the growth, up to 63% of Ehrlich mouse carcinoma. However, the cytotoxicity of the extract was quite high and the animals, besides losing weight, showed dystrophic changes in their liver and spleen. The alcoholic extract of the fruit exerted moderate oncostatic activity against sarcoma 180 and Ehrlich carcinoma at the total dose 350 mg/kg/body weight/mouse. Weight loss was considerable. Epicatechol-3-D-glucoside dihydride, isolated from the flowers, exhibited no oncostatic or cytotoxic activity. The Pigment tentatively identified as dihydroxy-4-methoxyisoflavone, isolated from the fruit, exerted considerable oncostatic activity (and cytotoxicity). Triacanthine from the leaves was highly toxic (LD_{50} ca 35 mg/kg) and of questionable oncostatic activity (Sokoloff et al., 1964). In Lesotho, fruit pulp is used for catarrh of of the lung. Powdered seed used as a snuff for head cold. Some people, probably having seen the erroneous report of cocaine in the leaves, state that "ingestion of a suitable preparation of the leaf increases the capacity for muscular work and delays the onset of fatigue." Reported to be anodyne, mydriatic, narcotic, and experimentally oxytocic (Duke and Wain, 1981), honeylocust pods are a folk remedy for dyspepsia and measles among the Cherokee. The bark tea is used for whooping cough. Delaware Indians used the bark for blood disorders and coughs, the Fox for colds, fevers, measles, and smallpox. Chinese probed tumors and abscesses with the thorns of *Gleditsia sinensis*, considering them counterirritant.

Chemistry

Per 100 g, the fruit is reported to contain (ZMB): 23.1 g protein, 4.6 g fat, 66.9 g total carbohydrate, 12.7 fiber, 5.4 g ash. The seed is said to contain 10.6 g protein, 0.8 g fat, 84.7 g total carbohydrate, 21.1 g fiber, 3.9 g ash, 280 mg Ca and 320 mg P. Scanlon (1980), interested in the potential of honeylocust for alcohol production, presents the following analytical data. Differences in sugar content are possible in trees of the same clone grown in different locations. 'Millwood' pods from trees grown in Beltsville, Maryland, contained 21.07% total sugars, while 'Millwood' at Auburn, Alabama, contained 36.8%. Small differences in sugars were found in pods from the same clonal trees collected in different years.

Constituents of 'Millwood'	Whole pods	Pods without seeds	Seeds only
Ash	3.75	3.82	10.23
Crude fat (ether extract)	0.81	0.52	3.06
Crude protein (%N x 6.25)	10.15	8.21	28.74
Crude fiber	14.19	13.81	11.02

Nitrogen-free extract	71.10	73.64	46.95
Reducing sugars (glucose)	2.86	3.32	
Nonreducing sugars (sucrose)	29.12	32.22	
Total sugars	31.98	35.54	

Air-dried leaf yields 0.5% of an alkaloid triacanthine $C_8H_{10}N_4$ which in intravenous doses of 0.1 mg/kg, depresses the action of the cat heart, the intensity apparently depending on the intensity of effect on the vasomotor centre (145). Heart-wood contains 4–4.8% tannin and also fustin and fisetin (Watt and Breyer-Brandwijk, 1962). The alkaloid gleditschine is said to produce stupor and loss of reflex activity in a frog. Stenocarpine has been used for local anesthesia (Grieve 1931). "It also contains cocaine" (Grieve 1931). To the best of my knowledge it does not contain cocaine!

Description

Tree 20–30 m tall with trunk 3–6 dm in diameter, occasionally reaching a maximum of 50 m tall, diameter to 1.5 m; bark with many large plates, loose at edges, grayish-brown. Twigs brown, glabrous; buds small, glabrous, superposed, the upper one producing a thorn or an inflorescence. Thorns axillary, lustrous, reddish-brown, ca 5–8 cm long, with 2 short branches near base, those on trunk often longer and more branched, with new ones produced for many years. Leaves 1.6–2 dm long; if bipinnate, composed of 4–7 pairs of pinnae, each pinna 18–28 leaflets, or the ultimate sections of the leaf pinnate. Leaflets oval to ovate-oblong, 1.5–3 cm long, 1.25 cm wide, dark green and glossy above, yellowish-green and essentially glabrous beneath; margins nearly entire, obtuse at both ends. Racemes 5–12 cm long, flowers about 5 mm broad, greenish. Pod dark brown 2–4 dm long, 2.5–3.5 cm wide, about 1 cm thick, smooth and shining. Space between the seeds filled with sweet edible pulp.

Germplasm

Reported from the North American Center of Diversity, honeylocust or cvs thereof is reported to tolerate drought, frost, pests, poor soil and slope. Germplasm is covered rather thoroughly in the SERI symposium on Tree Crops for Energy Co-production on Farms, especially the papers by McDaniel (1980) and Scanlon (1980). 'Moraine' and 'sunburst' locusts are nursery selections of the unarmed types.

Distribution

Native to the central United States, now naturalized east of the Appalachian Mountains from South Carolina to New England. Also introduced, established and possibly spreading, sometimes as a weed tree in India, New Zealand and South Africa.

Ecology

Ranging from Warm Temperate Dry to Moist through Cool Temperate Dry to Moist Forest Life Zones, honeylocust is speculated to tolerate annual precipitation of 6 to 15 dm, annual temperature of 10 to 21°C, and pH of 6 to 8.

Cultivation

Pretreated seeds (hot water or sulfuric acid) are drilled in rows 15–25 cm apart and covered with 1–2 cm soil with 30–40 seed per linear meter. Seedlings reach suitable size for outplanting in one year. Clonal reproduction of select germplasm is often recommended. ($2n = 28$)

Harvesting

There is a trend toward biennial production in the cultivars, a hectare of Millwood yielding ca 8000 kg/ha in 1946, but only 550 kg/ha in 1947. Harvesting of pods is rather difficult, especially in thorny cvs.

Yields and Economics

'Calhoun' 3 yrs old yielded ca 0.5 kg/tree, 4-yr-olds ca 2 kg/tree, and 5-yr-olds ca 12 kg. 'Millwood 3-yr-olds yielded ca 0.6 kg/tree, 4-yr-olds ca 2 kg/tree, and 5-yr-olds ca 27 kg/ha. With such low yields (Scanlon, 1980) it is difficult to see how we could get 50 barrels of ethanol per ha. Older 'Millwoods' averaged 33 kg which would give only 3,300 kg/ha if spaced at 100 trees/ha. In Alabama, nearly 6.5 MT *Lespedeza sericea* hay was produced annually in the shade of honeylocust spaced at ca 85 trees/ha.

Energy

Freedman (1980) cited figures suggesting yields of only 3 MT/ha which would yield only ca 5 barrels ethanol. The wood has been described as good fuel wood (C.S.I.R., 1948–1976). Williams (1980) ranks this as a highly feasible (high yield, low maintenance) woody perennial for ethanol production in Applachia, along with blackberry, blueberry, cranberry, elderberry, hawthorn, mulberry, persimmon, raspberry and serviceberry. He estimated yields at ca 10–58 barrels alcohol per ha, much higher than is consonant with fruit dry weights of 3.3 MT/ha/yr, which is closer to the lower barrel figure (Scanlon, 1980; Williams, 1980). Avgerinos and Wang (1980) were more pessimistic about honeylocust than mesquite pods for alcohol production.

Biotic Factors

Allen and Allen (1981) report the invasion of honeylocust root hairs by rhizobia from *Erythrina, Glycine, Leucaena, Lupinus, Pisum,* and *Vigna* species. The infection threads did not penetrate beyond the epidermal wall. Disk assay tests using aqueous root extracts showed the presence of antirhizobial substances that were suggestive of flavones in other tests. Nodulation was not inhibited or diminished on diverse species of other leguminous genera grown in association with honeylocust. It was concluded that the nodule-inhibitory principle was root-contained, or nonfunctional, if exuded into the rhizosphere (Allen and Allen 1981). In the middle Atlantic states, the mimosa webworm is beginning to cause problems. Grazing animals may damage young plants, while other animals and birds may eat the pods. Agriculture Handbook 165 lists quite a few diseases: *Aglaospora anomia, Agrobacterium rhizogenes, B. ribis, Cercospora condensata, C. olivacea, Curcurbitaria elongata, C. recuperata, Cytospora gleditschiae, Daelalea ambigua, D. elegans, Dothiorella gleditschiae, Eutypella fraxinicola, Fomes* spp., *F. applanatus, F. connatus, F. igiarius* var. *laevigatus, F. marmoratus, F. meliae, Ganoderma curtisii, G. lucidum, Glomerella cingulata, Haplosporella gleditschiae, H. gleditschiicola, Hendersonia* sp., *Libertella gleditschiae, Linospora gleditsiae, Macrophoma mamillaris, Melasmia hypophila, Microsphaera alni, M. ravenelii, Mycosphaerella* sp., *Nectria cinnabarina, Parodiella perisporioides, Phoradendron flavescens Phymatotrichum omnivorum Physalospora obtusa, P. rhodina Phytophthora citrophthora, Polyporus* spp., *P. adustus, P. Albus, P. arcularius, P. hydnoides, P. pargamenus, P. pulchellus, P. sulphureus, P. supinus, P. tulipiferus, P. versicolor, Poria ambigua, Ravenelia opaca, Schizophyllum commune, Septobasidium curtisii, Sphaeropsis gleditschiae, S. gleditschiicola, Sphaeropsis mamillaris, S. triacanthi, Thyronectria austro-americana, Xylaria mali* and *Chlorogenus robiniae.* Nematodes of the genus Meloidogyne may be present.

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Last update Wednesday, January 7, 1998 by aw

Gliricidia sepium (Jacq.) Steud.

Fabaceae
Madre de cacao

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

According to the National Academy of Sciences (1980a), the leaves contain over 20% crude protein and are nutritious for cattle though TOXIC to most other animals including horses. The tree is widely planted as shade for chocolate, coffee, tea, and vanilla. There are few "living fence" species that strike root from cuttings more readily, also widely planted as a hedge and/or windbreak. Tilth and fertility of the soil beneath the trees are greatly improved from the leaf- and flower-fall. The timber is said to finish smoothly and be used for furniture, agricultural instruments, posts, railroad ties, and heavy construction. Flowers are a good source of forage for bees. Flowers are consumed by Mexican rural inhabitants who use the pods for rat poison. In the Philippines, the foetid leaves are crushed and rubbed onto cattle. In Indonesia, the tree is planted as a firebreak. This and other fast-growing leguminous trees have the vigor to outgrow or compete with the Imperata grass. In the shade of *Gliricida*, the grass finally dies, leaving nothing that can sustain a grass fire (NAS, 1980a).

Folk Medicine

Reported to be expectorant, insecticidal, rodenticidal, sedative, suppurative, Madre de Cacao is a folk remedy for alopecia, boils, bruises, burns, colds, cough, debility, eruptions, erysipelas, fever, fractures, gangrene, head-ache, itch, prickly heat, rheumatism, skin, sore, tumors, ulcers, urticaria, and wounds (Duke and Wain, 1981).

Chemistry

According to Roskoski et al. (1980), studying Mexican material, the seeds contain 11.93% humidity, 1.90% ash, 33.00% CP, 16.50% CF EE, 9.07% CF, 27.60% carbohydrates with a 52.42% in vitro digestibility. The foliage contains 11.96% humidity, 12.09% ash, 19.92% CP, 2.34% crude fat, 11.04% CF, 42.65% carbohydrates, and 69.69% in vitro digestibility. Low levels of alkaloids were found in the seed and saponins in the foliage, but the plant is still used for forage. Allen and Allen (1981) cite data suggesting that fallen leaves emit the new-mown-hay odor, because of the occurrence of coumarin compounds.

Description

Smooth deciduous tree to 10 m tall, 20–30 cm DBH. Leaves alternate, pinnately compound, 15–30 cm long, the 9–13 leaflets 3–6 cm long, opposite, oblong-ovate, bluntly pointed at the tip, rounded at the base, entire. Flowers on numerous lateral racemes, often on leafless branches, the clusters 5–125 cm long; flowers pinkish, ca 2 cm long; stamens 10, 9 united in a tube, one separate, white. Pods yellow-green when immature, turning blackish 10–14 cm long, 1–2 cm broad, with 3–8 elliptic, flat, shiny, blackish seed (ca 4,400/kg).

Germplasm

Reported from the American Center of Diversity, Madre de Cacao, or cvs thereof, is reported to tolerate drought, limestone, slope, and weeds. ($2n = 20$)

Distribution

Native from Mexico to Colombia, Venezuela, and the Guianas, widely introduced and naturalized throughout the tropics.

Ecology

Ranging from Subtropical Thorn to Wet through Tropical Thorn to Wet Forest Life Zones, Madre de Cacao is reported to tolerate annual precipitation of 4.8 to 41.0 dm (mean of 79 cases = 16.2), annual temperature of 21.3 to 28.5°C (mean of 61 cases = 25.3), and pH of 4.3 to 5.0 (mean of 2 cases = 4.6) (Duke, 1978, 1979).

Cultivation

Soak seeds 24 hours in lukewarm water and sow directly in potting soil in prepared pots (10 x 15 mm) wrapped in polyethylene. Move to shade for three weeks after germination, watering as needed. Use insecticide/fungicide once a month or as needed. Hardened 2–3 month old seedlings may be outplanted, avoiding midday heat, at the beginning of the rainy season (Fabian, 1981). Roskoski et al. (1980) note that the tree is easily propagated from seeds (which require no special treatment) or cuttings. Cuttings are used to make living fences throughout the tropics.

Harvesting

Living fences may be lopped for fuel or fodder as needed.

Yields and Economics

In Sri Lankan tea plantations, an average tree gave 64 kg green loppings per year (Allen and Allen, 1981). Studying Mexican material, Roskoski et al (1980) concluded that there were 44.1 (± 14.9) moles N_2 fixed per gram of nodule per hour in one assay, 11.7 ± 2.6 in another. One stand was fixing N at the rate of 13 kg/ha/yr.

Energy

Wood coppiced from living fences of *Gliricidia sepium* is burned for fuel by the rural population of Veracruz, Mexico. Annual productivity has not yet been determined here. The calorific value of the wood is 4,900 kcal/kg.

Biotic Factors

In Puerto Rico, the foliage is often attacked by aphids that secrete a sweet honeydew which attracts ants, causing the leaves to fall. On the other hand, the wood is said to be highly resistant to termites and decay.

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Glory Lily or Kalihari (*Gloriosa superba* L.)

Contributor: Pankaj Oudhia

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Common (Indian) Names:
Hindi: Kalihari, Kathari, Kulhari, Languli
Gujerati: Dudhio Vacchonag
Canarase: Akkitang hall, Huliyuguru, Nangulika, Sivasaktibalb
Marathi: Indai, Karianag, Khadyanag
Sanskrit: Agnimukhi, Garbhapatani, Kalikari

Family: Liliaceae

Habitat: Common in forests. Under cultivation in fairly large areas of India.

Botany: Herbaceous, tall, stout climbing herb. Root-stock of arched, solid, fleshy-white cylindric tubers. Leaves sessile. Ovate lanceolate, tip ending in a tendril-like spiral. Flowers large solitary, axillary, changing colors from greenish yellow, orange, scarlet and crimson from blooming to fading. Fruits cupsule. Flowering time July in October to Indian conditions.

Related Species: Six tuberous-rooted species in tropical Africa and Asia have been reported. Difference between two major varieties *G. superba* and *G. rothschildiana* are given in Table 1.

Table 1. Comparison of *Gloriosa superba* and *G. rothschildiana*

Particulars	*Gloriosa superba*	*Gloriasa rothschildiana*
Height	Climbing 1.5 m or more	Tall climbing
Leaves	Long-lanceolate to narrowly ovate-lanceolate	Broad lanceolate to broadly ovate lanceolate
Leaf length	10.2-12.7 cm	12.7–17.8 cm
Leaf width	1.3–2.5 cm	3.8–5.1 cm
Flowers	linear to narrow lanceolate	oblong-lanceolate to ovate-lanceolate
Flower length	5.1–7.6 cm	5.1–7.6 cm
Flower color	Yellow changing to red	Whitish and yellow at the base, crimson and more or less margined above
Origin	Tropical Africa and Asia	Tropical Africa

Useful Parts: Tubers, leaves, and flowers.

Medicinal Properties and Uses: In Ayurveda and Yunani systems of medicine it is a reputed medicine. According to Ayurveda, tuber is pungent, bitter, acrid, heating, anthemirtic, laxative, alexiteric, abortifacient, and useful in ulcers, leprosy, piles, iflommations, abdominal pains, itching and thirst.

Chemical Constituents: Seed contain high level of colchicines. Cornigerine, 3-demethyl-N-formyl-N-deacetyl-β-lumicolchicine, 3-demethyl-γ-lumicolchicine, 3-demethyl colchicines have been isolated from plant. β-sitosterol, its glucoside, a long chain fatty acid, β and γ-lumiccolchicines from fresh tubers and luteolin, colchicines, N-formyldeacetylcolchicines and glucosides of 3-demethylcolchicine have been isolated from flowers.

Cultivation: Kalihari is under cultivation in many states of India particularly in South India.

Propagation: From its 'V' shaped tubers.

Spacing: 60 × 45 cm.

Season: Kharif (June-July in Indian conditions)

Manures and Fertilizers: In general, it is raised under organic farming. Initially before sowing 15–20 tonnes of farm yard manure is applied.

Insects & Diseases: No insect or disease have been reported in Indian conditions.

Maturity: 170–180 days after sowing.

Yield: 200 kg seed and 150 kg pericarp.

Resource Person:
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Phone: 91-771-253243
Mobile: 91-98271-15642
Fax: 91-771-536312

Glycycrhiza glabra L.

Fabaceae (Leguminosae)

American licorice, Licorice, Licorice root, Wild licorice

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Gmelina arborea Roxb

Verbenaceae
Gmelina, White teak

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The wood is one of the best timbers of the tropics, useful for particle board, plywood core stock, pit props, matches, and saw timber for light construction, furniture, general carpentry, and packing. Also used in carriages, carvings, musical instruments, and ornamental work. Graveyard tests indicate that the untreated timber may last 15 years in contact with the soil. With pulping properties superior to most hardwood pulps, gmelina has been planted by the millions, e.g. in the Rio Jari region of Brazil to feed a 750 MT/day kraft pulp mill. In Gambia there are dual purpose plantings, for firewood and for honey. It is often planted as an ornamental avenue shade tree. The wood makes a fairly good charcoal. According to Little (1983), the leaves are harvested for fodder for animals and silkworms; the bittersweet fruits were once consumed by humans.

Folk Medicine

According to Hartwell (1967–1971), the root decoction is used in folk remedies for abdominal tumors in India. Reported to be anodyne, demulcent, lactagogue, refrigerant, stomachic, and tonic, gmelina is a folk remedy for anasarca, anthrax, bilious disorder, bites, blood disorders, cholera, colic, convulsions, delirium, diarrhea, dropsy, dyspepsia, epilepsy, fever, gout, ,gravel, headache, hemorrhage, intoxication, madness, phthisis, ratbites, rheumatism, rinderpest, septicemia, smallpox, snakebite, sores, sorethroat, splenitis, stomachic, swelling, and urticaria (Duke and Wain, 1981). Deeming the fruits alterative, aphrodisiac, astringent, diuretic, and tonic, Ayurvedics prescribe them for alopecia, anemia, consumption, leprosy, strangury, thirst, and vaginal discharges; the flowers for blood disorders and leprosy; the root, deemed anthelmintic, apertif, laxative, and stomachic, for abdominal pains, burning sensations, fever, hallucinations, piles, thirst and urinary discharges (Duke, 1984 in ed.).

Chemistry

The drupes are reported to contain butyric acid traces of tartaric acid and resinous and saccharine matter, the latter two also in the roots, which contain traces of benzoic acid.

Description

Deciduous tree 12–30 m high and 60–100 cm in diameter. Bark light gray or gray-yellow, smooth, thin, somewhat corking, becoming brown and rough; twigs stout, often slightly 4-angled. Leaves opposite, broadly ovate, 10–20 cm long, 7–13 cm wide; base with 2–4 glands beneath, acuminate, entire, with 3 or 5 main veins from near base and 2–5 pairs of side veins, underneath velvety with yellow-brown hairs. Petiole 5–12 cm long, hairy. Cymes paniculate at ends of twigs, 15–30 cm long, branched, densely hairy. Flowers many, short-stalked, nodding, 4 cm long, densely hairy. Calyx bell-shaped, 5 mm long, 5-toothed; corolla bright orange-yellow or brownish-yellow, with short narrow tube, 2-lipped; stamens 4 in 2 pairs inserted near base of tube. Pistil with elliptical 4-celled ovary having 1 ovule in each cell. Stigma often slightly 2–4-forked. Drupes ovate or pyriform, 2–2.5 cm long, smooth, becoming orange-yellow, pulpy, with large egg-shaped stone, having 1–4 cells. Seeds 1–4 (Little, 1983).

Germplasm

Reported to tolerate disease, drought, fire, heat, laterite, light frosts, and slope. Although casting a dense shade itself, it is intolerant of shade as a seedling (Little, 1983).($2n = 36, 38$)

Distribution

Native to tropical moist forest from India, Burma, and Sri Lanka to southern China, Gmelina is widely introduced, e.g. in Brazil, Gambia, Honduras, Ivory Coast, Malaysia, Malawi, Nigeria, Panama, Philippines, and Sierra Leone.

Ecology

Estimated to range from Tropical Very Dry to Wet through Subtropical Very Dry to Wet Forest Life Zones, gmelina is reported or estimated to tolerate annual precipitation of 7 to 45 dm (NAS, 1980a), annual temperature of 20 to 26°C, and pH of 6 to 8. It can tolerate a 6–7-month dry season. Grows on many soils, acidic laterites to calcareous loams, doing poorly on thin or poor soils with hardpan, dry sands, or heavily leached acidic soils, well-drained basic alluviums.

Cultivation

Seeds, retaining their viability for only about 12 months, will benefit from soaking if rain or irrigation is not expected. Direct seeding is cheap but tubed seedlings are also outplanted, sometimes intercropped with beans, cashew, corn, peanuts, and tobacco. For fuelwood, spacing at 2 x 2 m is recommended, wider spacings for timber plantations. For the first year or so, weeding is necessary, but the canopy is soon dense, like the litter layer, quickly arresting the weed growth.

Harvesting

Trees coppice well, with 5-year coppice rotations for fuel, longer rotations for timber.

Yields and Economics

The NAS (1980a) reports annual increments; >30 m^3/ha, on fertile sites. Rotations of 5–8 years may produce 20–35 m^3. Occasionally trees may start dying out at only 10 years age.

Energy

Destructive distillation of the wood yields 31.8% charcoal, 47.1% total distillate, 37.1% pyroligneous acid, 10.0% tar, 2.4% pitch, and losses, 4.47% acids, 3.42% esters, 2.38% acetone, and 1.28% methanol on a dry weight basis. The non-condensable gases (1.88 ft^3/lb) contain 59% CO_2, 31.75% CO, 4.5% methane, 4.15% H, and 0.6% unsaturated hydrocarbons. Many of these have energetic potential (C.S.I.R., 1948–1976). Reynolds and Lawson (1978) concluded that the heating value of Gmelina wood was less than that from the local eucalypts. Although the calorific values of the samples studied were almost identical (4.53 mcal/kg and 4.54 respectively), the DM contents were 45 and 56%. The fresh weight of Gmelina firewood brought in cubic-meter lots was significantly correlated with butt size. The NAS (1980a) suggests 4.8 mcal/kg for the sapwood, spec. grav. 0.42–0.64. The charcoal burns well, without smoke, leaving a lot of ash. The Wealth of India (C.S.I.R., 1948–1976) puts the calorific value at 4.763 mcal (8,547 BTU) with silica free ash of 1.54%. In a 10-year-old Philippine stand, the aboveground biomass was 127 MT/ha, leaf biomass was 1.4 MT, leaf litter ca 5.2 MT, constituting ca 62% of the total litter. Annual productivity was 18 MT/ha. Annual stem increment was about 10 MT/ha or 30 M^3/ha, little influenced by the age of the stand over the first 15 years (Kawahara et al., 1981). Akachuku's data (1981) show annual yields of 20–50 m^3/ha/yr but he cites other studies on poor sandy soil yielding only 7, on laterites only 18; on the best of savanna sites 25, on rainforest sites 31–36, on Malaysia sites 28–38, and on Philippine sites 36 m^3. MAI in 7-year trees was 32 m^3 (15 MT) to 47 m^3 (23 MT)/ha (Akachuku, 1981).

Biotic Factors

Cattle may eat the foliage and bark; seeds and foliage are consumed avidly by rabbits and deer. In Latin America, the leaves are gathered by the leaf-cutter ants. In India, other insects may defoliate the plant. Calopepla may defoliate, while the borers, Dihamnus and Alicide, may damage the trees. The "machete disease", *Ceratocystis fimbriata,* is sometimes severe in moister climates. *Poria rhizomorpha* may cause stem and root diseases in wet situations with heavy soils. Browne (1968) lists the following as affecting *Gmelina arborea:* (Fungi) *Armillaria mellea, Cercospora ranjita, Fomes roseus, Polyporus baudni, Poria rhizomorpha, Sclerotinia rolfsii, Trametes straminea.* (Angiospermae) *Tapinanthus* sp. (Mollusca) *Limicolaria aurora.* (Myriapoda) *Odontopyge* sp. (Coleoptera) *Alcidodes ludificator, Apion angulicolle, A. armipes, Apophyllia chloroptera, A. sulcata, Calopepla leayana, Dihammus cervinus, Empecamenta calabarica, Lagria villosa, Lixus camerunus, L. spinimanus, Macrocoma candens, podagrica dilecta, Prioptera punctipennis, Xyleborus fornicatus.* (Hemiptera) *Agaeus pavimentatus, Anoplocnemis tristator, Chunrocerus niveosparsus, Dysdercus superstitiosus, Tingis beesoni, Trioza fletcheri.* (Isoptera) *Coptotermes curvignathus, C. niger, Macrotermes goliath.* (Lepidoptera) *Acrocercops telestis, Endoclita undulifer, Eupterote geminata, E. undata, Evergestis aureolalis, Gonodontis clelia, Indarbela quadrinotata, Metanastria hyrtaca, Phostria caniusalis, Psilogramma menephron, Sahyadrassus malabaricus, Selepa celtis, Xyleutes ceramica.* (Orthoptera) *Heteropternis thoracica, Kraussaria angulifera, Phaneroptera nana, Phymateus viridipes, Zonocerus elegans.* (Mammalia) *Axis axis, Strepsiceros strepsiceros, Sylvicarpa grimmia, Thryonomys swinderianus, Tragelaphus scriptus.*

References

- Akachuku, A.E. 1981. Estimation of volume and weight growth in *Gmelina arborea* with X-ray densitometer. p. 105–113. In: Kyoto biomass studies. Univ. of Maine at Orono. Maine.
- Browne, F.G. 1968. Pests and diseases of forest plantations trees. Clarendon Press, Oxford.
- C.S.I.R. (Council of Scientific and Industrial Research). 1948–1976. The wealth of India. 11 vols. New Delhi.
- Duke, J.A. 1984. in ed. An herb a day ... Ayurvedic. Typescript.
- Duke, J.A. and Wain, K.K. 1981. Medicinal plants of the world. Computer index with more than 85,000 entries. 3 vols.
- Hartwell, J.L. 1967–1971. Plants used against cancer. A survey. Lloydia 30–34.
- Kawahara, T., Kanazawa, Y., and Sakura, S. 1981. Biomass and net production of

man-made forests in the Philippines. J. Jap. For. Soc. 63(9):320–327.

- Little, E.L. Jr. 1983. Common fuelwood crops: a handbook for their identification. McClain Printing Co., Parsons, WV.
- N.A.S. 1980a. Firewood crops. Shrub and tree species for energy production. National Academy of Sciences, Washington, DC.
- Reynolds, L. and Lawson, E.C. 1978. A comparison of the fuelwood value of *Gmelina arborea* and *Eucalyptus* spp. from the Bunda Forest. Res. Bul. Bunda Coll.of Agr. Uni. of Malawi, 9:71–75.

Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Sweet Cudweed

Gnaphalium obtusifolium L.

Synonym.—*Gnaphalium polycephalum* Michx.

Sweet cudweed

Figure 103.—Sweet cudweed (*Gnaphalium obtusifolium*)

Other common names.—Fragrant life everSievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Lasting, sweet balsam, white balsam, feather-weed, rabbit-tobacco.

Habitat and range.—This plant grows in dry, mostly open places from Nova Scotia to Manitoba and south to Florida, Kansas, and Texas.

Description.—Sweet cudweed, which is better known in the drug market as life everSievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Lasting, is a fragrant herb 1 to 3 feet high, white-woolly nearly throughout, with an erect stem, simple or branched above. The leaves are narrow, one-sixth to one-third of an inch wide, and 1 to 3 inches long dark green above and densely white-woolly underneath. The flowers, produce] about August to September, are borne in numerous barely crowded heads consisting of one to five individual flowers.

Part used.—The herb.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Simmondsia chinensis L.

Simmondsiaceae, (also sometimes listed within the Buxaceae)

Jojoba, Goatnut

We have information from several sources:

Jojoba FactSHEET contributed by: Aliza Benzioni

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Jojoba: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Jojoba: A Unique Liquid Wax Producer from the American Desert—Himayat H. Naqvi and Irwin P. Ting

Variation and Broad Sense Heritability of Branching Frequency of Jojoba—Damian A. Ravetta and David A. Palzkill

Irrigation Effects on Growth, Cold Tolerance of Flower Buds and Seed Yield of Jojoba—J.M. Nelson and D.A. Palzkill

New Industrial Crops: Northwestern Argentina Regional Project—Ricardo Ayerza (h) and Wayne Coates

Food Intake Inhibitory Activity of Simmondsin and Defatted Jojoba Meal: Dose-Response Curves in Rats—Marnix M. Cokelaere, Gerda Flo, Paul Daenens, Eddy Decuypere, Maurits Van Boven, and Sabien Vermaut

Chemistry of New Oilseed Industrial Crops—Robert Kleiman

Arid-land Industrial Crops—Anson E. Thompson

New Crops Research and Development: A Federal Perspective—L.H. Princen

Producing Wax Esters in Transgenic Plants by Expression of Genes Derived from Jojoba—Michael W. Lassner, Kathryn Lardizabal, and James G. Metz

And NewCROP has outside links to other Jojoba info sources:

Photographs of Jojoba.

The History and Promise of Jojoba By Gary Tremper

Jojoba Growers and Processors, Inc.
2267 S. Coconino Dr.
Apache Junction, Arizona USA

Golden Groundsel

Senecio aureus L.

Other common names.—Life root, golden ragwort, swamp squawweed, coughweed, grundy-swallow.

Golden groundsel

Figure 55.—Golden groundsel (*Senecio aureus*)

Habitat and range.—Golden groundsel is found in swamps and meadows from Newfoundland to Ontario, and Missouri, Florida, and Texas.

Description.—This plant is a smooth herb with rather slender, solitary or tufted stems one-half to 2 1/2 feet high. The basal leaves, which are 1 to 6 inches long, are heart-shaped or kidney-shaped with long stems and often purplish beneath. The lower stem leaves are lance-shaped and deeply out and the upper most small and clasping. The flower heads, from two-thirds of an inch to about 1 inch broad, consisting of disk and deep yellow ray flowers, are borne several in a flat-topped open cluster during the early summer.

Part used.—The herb and the root.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Solidago odora Schoepf.

Asteraceae (Compositae)

Goldenrod, Blue mountain tea, Sweet goldenrod

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

New Flower Crops—Abraham H. Halevy

Hydrastis canadensis L.

Ranunculaceae

Goldenseal

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Commercial Production of Ginseng and Goldenseal—L.P. Stoltz

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Monday, April 20, 1998 by aw

Gourds

Sing kwa, Luffa, Dishcloth gourd, Strainer vine, Chinese okra, Vegetable sponge, California okra

Cucurbitaceae *Luffa acutangula* (L.) Roxb., *L. cylindrica* (L.) Roem, *Lagenaria* sp.

Source: Magness et al. 1971

Plants are running vines, similar to cucumber and melon. Leaves are rounded. Fruits are strongly ribbed, elongated, pyriform or cylindrical in shape, 1 foot or more in length, gourd-like. Sometimes young fruits are consumed as cooked vegetables. When ripe shell is hard and interior is fibrous, sponge-like, and inedible.

Season, seeding to harvest as vegetable: 3 or 4 months.

Production in U.S.: No data. Very limited.

Use: Immature fruits as cooked vegetable.

Part of plant consumed: All of young fruits.

Last update February 18, 1999 by ch

Lycium chinense Mill.

Solanaceae

Gow kee, go qi zi, wolfberry, martimony vine

We have information from several sources:

Chinese Medicinal Herbs: Opportunities for Domestic Production—Lyle E. Craker and Jean Giblette

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Punica granatum L.

Punicaceae

Chinese apple, Dalima, Granada, Grenade, Grenadine, Melograno, Pomegranate

NewCROP has Pomegranate information at:

Pomegranate—Julia Morton, Fruits of Warm Climates

Mediterranean Fruits—Joan Tous and Louise Ferguson

Magness J.R. et al. 1971. Food and feed crops of the United States.

Outside links:

POMEGRANATE "FRUIT FACTS" (Fruit Facts are a series of publications of the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Pomegranate—from Mark Reiger, Dept of Horticulture, University of Georgia.

Pomegranate Information from the University of California Fruit & Nut Research and Information Center

Nutritional information on Pomegranate from Freida's Inc.

Passiflora species - Passifloraceae

There are over 60 true species with edible fruits - promising interspecific hybrids also exist.

(Those listed with green type have cultivated varieties)

- *Passiflora adenopoda* Granadilla de monte
- *P. alata* Fragrant Granadilla, Maracuja grande
- *P. ambigua* Granadilla de monte
- *P. ampullacea* White-flowered Tacso
- *P. antioquiensis* Banana passionfruit
- *P. caerulea* Blue-crown passionflower
- *P. coccinea* Red Granadilla
- *P. cumbalensis* Red Banana Passionfruit
- *P. edulus* Sims Purple passionfruit, Purple granadilla
- *P. edulis* f. *flavicarpa* Deg. Yellow passionfruit, Yellow granadilla
- *P. exoniensis*
- *P. herbertiana* Austrailian passionfruit
- *P. incarnata* Maypop
- *P. laurifolia* Yellow Granadilla, Jamaica honeysuckle
- *P. ligularis* Sweet Granadilla, Sweet Passionfruit
- *P. maliformus* Sweet Calabash, Chulupa
- *P. manicata*
- *P. mixta* Curuba de Indio
- *P. mollissima* Bananapassionfruit, Tacso
- *P. platyloba* Acid granadilla
- *P. quadrangularis* L. Giantgranadilla
- *P. rubra* Pomme de liane zombie
- *P. seemannii* Guate-guate
- *P. serrato-digitata* Tagua-tagua

- *P. suberosa* Cork-stem Passionfruit
- *P. trifoliata*
- *P. tripartita* Tacso
- *P. trisecta*
- *P. vitifolia* Grape-leaf passionfruit
- *P. warmingii* Maracuja mirim

NewCROP has Passion Fruit information at:

Passionfruit— Julia Morton, Fruits of Warm Climates

Golden Berry, Passionfruit, and White Sapote: Potential Fruits for Cool Subtropical Areas—Richard McCain

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Maypop—Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness J.R. et al. 1971. Food and feed crops of the United States.

Herbs Affecting the Central Nervous System—Varro E. Tyler

Outside links:

Passionfruit can be found in Lost Crops of the Incas from National Academy Press
Curuba *Passiflora mollissima*
Sweet Grandilla *Passiflora ligularis*
Columbian Passionfruit *Passiflora antioquiensis*
Curubejo *Passiflora popenovii*
Galupa *Passiflora pinnatistipula*
Chulupa *Passiflora maliformis*
Rosy Passionfruit *Passiflora cumbalensis*
Passiflora schlimiana
Passiflora ampullacea
Passiflora tripartita
Passiflora mixta
Passiflora ambigua
Passiflora mandonii

Passion Fruit "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Ethnobotanical and phytochemical information on Passiflora spp.

The Passiflora Discussion Group:

Send an email message to BIHOREL@cris.com, put the word PASSIF in the subject line, in the message portion of the letter, put the word SUBSCRIBE your name.

Grape, American

Slip skin grape

Vitaceae *Vitis* sp., mostly *V. labrusca* L.

Source: Magness et al. 1971

These are grape varieties developed in whole or in part from species indigenous in this country. They are hardier and more disease resistant than the Old World grape, and are grown at least in home gardens in all mainland states except Alaska. Plants are perennial and long-lived vines, in commerce supported on trellises. Fruit is produced in bunches. Individual berries, from 0.5 inch to near 1 inch diameter, vary in shape from oval to slightly oblate and in color from green to red or black. Skin is thin and waxy, and separates readily from pulp, hence the name "slip skin." Fruits generally contain contain 2 to 4 seeds.

Season, bloom to harvest: 3 to 5 months.

Production in U.S.: About 300,000 tons commercially; extensively grown in home plantings.

Use: Fresh, juice, wine, jelly and jam.

Part of fruit consumed: Generally pulp only, but skin included by some people when eating fresh, or is separated from the pulp in the mouth.

Last update February 18, 1999 by ch

Grape seed oil

Vitaceae *Vitis* sp.

Source: Magness et al. 1971

Large quantities of grape seeds are available from grapes processed for wine, seeded raisins and grape juice. The seeds, up to 0.5 inch long, are enclosed near the center of the fleshy pulp. They contain about 12 percent of a drying oil. The oil is obtained by expression or with solvents. The oil, after refining, is used mainly for edible purposes. Oil from raisin grape seed is used for coating the raisins to improve appearance and keep them pliable. Grape seed oil is also used in industry.

Last update February 18, 1999 by ch

Lathyrus sativus L.

Leguminosae

Grasspea, Chickling pea, Indian vetch (UK and N. America), Almorta (Spain), khesari or Batura (India), Alverjas (Venezuela), Gilban (Sudan), Guaya (Ethiopia), Matri (Pakistan), Gesette (France), Pisello bretonne (Italy).

We have information from several sources:

FactSHEET—contributed by F.J. Muehlbauer and Abebe Tullu

Food and Grain Legumes—Fredrick J. Muehlbauer

New Crops for Canadian Agriculture—Ernest Small

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside Links

Grass pea—by Clayton G. Campbell—Link to the publication on the International Plant Genetic Resources Institute web site

Garlic, Great-headed

Elephant garlic

Amaryllidaceae *Allium ampeloprasum* L. (Great-headed garlic group)

Source: Magness et al. 1971

Plants have appearance of very robust garlic plants. Great-headed garlic forms large flower heads which usually lack bulblets. It may produce a cluster of several cloves similar to garlic, or a single massive bulb, with small bulblets around its main bulb. The bulb flavor is intermediate between onion and garlic. Cultural practices are similar to those for garlic. The bulbs are developed entirely underground. Great-headed garlic is grown in many home gardens, but rarely as a commercial crop.

Season, setting to harvest: About 8 months.

Production in U.S.: No data separate from garlic. Mainly in home gardens.

Use: Culinary, and as part of stews and soups.

Part of plant consumed: Bulb only. Last update February 18, 1999 by ch

Green needlegrass

Feather bunchgrass

Gramineae *Stipa viridula* Trin.

Source: Magness et al. 1971

This native bunchgrass is most abundant on the upland prairie and ranges of the Northern Plains. It frequently invades abandoned cropland. It grows on most soil types but thrives best on sandy soils. It grows up to 3 feet. Leaves are mostly basal, up to 12 inches long and 0.5 inch wide. Seed spikes have bent awns about an inch long but are less troublesome to livestock than those of Needle-and-thread grass. Growth starts early in the spring and continues through summer when moisture is available. The grass is palatable and nutritious and makes excellent hay. It also cures well on the ground so is useful for winter grazing. It is useful for revegetation as seedlings are vigorous and drought resistant. Seed of some improved varieties is available.

Last update February 18, 1999 by ch

Index | Search | Home

Grewia asiatica L.

Tiliaceae

Phalsa, Pharsa

We have information from several sources:

Phalsa—Julia Morton, Fruits of warm climates

Phalsa: A Potential New Small Fruit for Georgia—Anand K. Yadav

Grindelia camporum

Asteraceae

Gumweed

We have information from several sources:

FactSHEET contributed by: Steven P. McLaughlin

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Arid-land Industrial Crops—Anson E. Thompson

Preliminary Agronomic Evaluation of New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

last update October 23, 1997

Gum Plant

Grindelia robusta Nutt.; (2) *G. squarrosa* (Pursh) Dunal.

Other common names.—(2) Broad-leafed gum plant, scaly grindelia.

Figure 59.—Broad-leafed gum plant (*Grindelia squarrosa*)

Habitat and range.—The gum plant (*Grindelia robusta*) grows in California, while the broad-leafed gum plant (*G. squarrosa*) is more widely distributed, being of common occurrence on the plains and prairies from Saskatchewan to Minnesota and south to Texas and Mexico.

Description.—The name " gum plant " is applied especially to Grindelia robusta on account of the fact that the entire plant is covered with a resinous substance, giving it a gummy, varnished appearance. It is an erect herb with a round, smooth stem about 1 1/2 feet in height. The leaves, about 1 inch in length, are green, leathery, rather rigid, and covered with resin. The plant branches freely near the top, each branch terminating in a yellow flower about three-fourths of an inch in diameter.

The broad-leafed gum plant, *Grindelia squarrosa*, is similar to *G. robusta*, except that it is smaller and less gummy in appearance. The leaves are much smaller and thinner and less rigid.

Part used.—The leaves and flowering tops of both species, collected when the plants are in full bloom.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Physalis ixocarpa Brot.

Solanaceae

Tomatillo, Chinese lantern, fresadilla, green tomato, husk tomato, jamberry, Mexican green tomato, husk tomato, jamberry, Mexican green tomato, Mexican husk tomato, miltomate, tomate de bolsa, tomate de cascara, tomatillo enteros, tomatillo ground cherry, tomatitos verdes, tomatl, tomatoe verde

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We have information from several sources:

Tomatillo: A Potential Vegetable Crop for Louisiana—D.N. Moriconi, M.C. Rush, and H. Flores

Tomatillo Julia Morton, Fruits of warm climates

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971

Tomatillo production links (see bottom of page)

Ground-Ivy

Nepeta hederacea (L.) Trev.

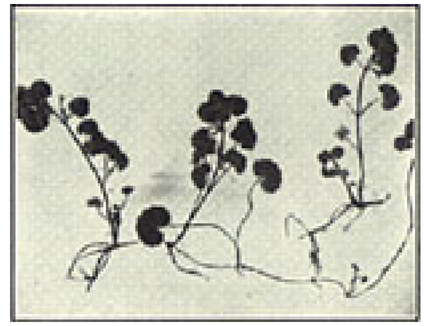

Figure 58.—Ground-ivy (*Nepeta hederacea*)

Synonym.—*Nepeta glechoma* Benth.; *Glecoma hederacea* L.

Other common names.—Field balm, gill-over-the-ground, gill, creeping Charlie, robin-runs-away, cat's-foot.

Habitat and range.—Ground-ivy is found in dams and shady places, especially in thickets, from Newfoundland and Ontario to Georgia, Tennessee, Kansas, and Colorado.

Description.—This small herb has numerous creeping, leafy, hairy stems sometimes 18 inches long, commonly branching at the base. The opposite leaves are round kidney-shaped, bluntly toothed, green on both sides, and one-half to 1 1/2 inches in diameter. The stems of the lower leaves are commonly longer than the leaves. The blue and white tube-shaped flowers are borne, few in a cluster, in the axils of the leaves from March to May.

Part used.—The herb.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Inga spp.

Fabaceae

We have information from several sources:

James A. Duke. 1983. Handbook of Energy Crops. unpublished.
Inga edulis
Inga vera

Outside links:

Pacay (Ice-Cream Beans) can be found in Lost Crops of the Incas from National Academy Press

Last update Friday, February 19, 1999 by ch

Pithecellobium dulce (Roxb.) Benth.

Mimosaceae
Guamachil, Manila tamarind

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Often planted for living fence or thorny hedge, eventually nearly impenetrable, guamachil furnishes food, forage, and firewood, while fixing a little nitrogen. The pods, harvested in Mexico, Cuba, and Thailand, and customarily sold on roadside stands, contain a thick sweetish, but also acidic pulp, eaten raw or made into a drink similar to lemonade. Pods are devoured by livestock of all kinds; the leaves are browsed by horses, cattle, goats, and sheep; and hedge clippings are often gathered for animal feed. The plants withstand heavy browsing. The seeds contain a greenish oil (20%), which, after refining and bleaching, can be used for food or in making soap. The presscake, rich in protein (30%), may be used as stockfeed. Bark used as a fish poison in the Philippines (Perry, 1980). Known in the Philippines as "Kamachil", the wood, malodorous when cut, is used for boxes, crates, fuel, and wagon wheels. The gum exuding from the trunk can be used for mucilage, the tannin for tanning. The bark is harvested for tanning in Mexico. Tree seems promising for the cultivation of the lac insect. Flowers make good honey.

Folk Medicine

Reported to be abortifacient, anodyne, astringent, larvicidal, guamachil is a folk remedy for convulsions, dysentery, dyspepsia, earache, leprosy, peptic ulcers, sores, toothache, and venereal disease (Duke and Wain, 1981). The bark of *P. avaremotem*, the "avaremo-temo" from Brazil, is a folk cancer elixir (Hartwell, 1967–1971).

Chemistry

The fruit, more probably the aril, is reported to contain, per 100 g, 78 calories, 77.8% water, 3.0% protein, 0.4% fat, 18.2% total carbohydrate, 1.2% fiber, 0.6% ash, 13 mg Ca, 42 mg P, 0.5 mg Fe, 19 mg Na, 222 mg K, 15 mg β-carotene equivalent, 0.24 mg thiamine, 0.10 mg riboflavin, 0.60 mg niacin, and 133 mg ascorbic acid. The essential amino acids in the aril are 143 mg/100 g valine, 178 lysine, 41 phenylalanine, and 26 tryptophan. An Indian aril (60% of the pod) contained 21.0 mg Ca/100 g, 40.0 Mg, 58.0 P, 1.1 Fe, 3.7 Na, 377 K, 0.6 Cu, and 109 S. As calcium pectate, pectin occurs as 0.96% of the sugars (mostly glucose) analysis of the aril (C.S.I.R., 1948–1976). The whole fruit, with husk and seeds (58% refuse) contains 33 calories, 32.7% moisture, 1.3 g protein, 0.2 g fat, 7.6 g total carbohydrate, 0.5 g fiber, 0.2 g ash, 5 mg Ca, 18 mg P, 0.2 mg Fe, 8 mg Na, 93 mg K, 5 mcg β-carotene equivalent, 0.10 mg thiamine, 0.4 mg riboflavin, 0.2 mg niacin, and 56 mg ascorbic acid (Leung et al, 1972). Per 100 g, the seed is reported to contain 13.5 g H_2O, 17.7 g protein, 17.1 g fat, 41.4 g starch, 7.8 g fiber, 2.6 g ash. On alcoholic extraction, the seeds yield a saponin, a sterol glucoside, a flavone, and lecithin. The fatty acid composition of the seed is 24.3% saturated acids, 51.1% oleic, and 24.0% linoleic. Hager's Handbook (List and Horhammer, 1969–1979) reports 0.3% caprylic, 0.3% caprinic, 0.3% lauric, 0.8% myristic, 12.1% palmitic, 6.9% stearic, 3.1% arachidic, 13.1% behenic, 4.9% lignoceric, 32.2% oleic, and 26.0% linoleic acids in the fatty acids. Further listed is a saponin containing oleanolic- and echinocytic acids, with the sugar sequence xylose, arabinose, and glucose; also pithogenin, ($C_{28}H_{44}O_4$), hederagenin and sodium nimbinate (which latter two are said to be antiarthritic and antiedemic in rats). Wax, hexacosanol, L-proline, L-leucine, L-valine, and asparagine, are also reported from the fruit, leucoro-binetinidin, leucofisetinidin, and melacacidin from the wood. After extraction of ca 20% edible oil, the seed cake, with 29.7% protein, can be used as animal feed. Bark contains up to 37% of a catechol type tannin. Bark also yields a yellow dye and 1.5% pectin. It is said to cause dermititis and eye inflammation. According to Roskoski et al (1980), studying Mexican material, the seeds contain 14.00% humidity, 2.66% ash, 25.69% CP, 8.12% EE, 22.16% CF, 26.97% carbohydrates with a 80.84% in vitro digestibility. The foliage contains 6.46% humidity, 15.34% ash, 17.17% CP, 6.83% EE, 30–95% CF, 23.25% carbohydrates, and 71.46% in vitro digestibility. For comparison, the Wealth of India reports (ZMB): 29.0% CP, 4.4% EE, 17.5% fiber, 43.6% NFE, 5.6% ash, 1.14% Ca, and 0.35% P. The manurial value of dry leaves is 4.91% N, 0.78% P2O5, 1.04% CaO, and 2.67% K_2O. The antitumor compound, β-sitosterol (perhaps ubiquitous), and campesterol, stigmasterol, and α-spinasterol occur in the heartwood (C.S.I.R., 1948–1976).

Description

A large, nearly evergreen tree that grows up to 20 m or more in height, Manila tamarind has a broad crown (to 30 m across) and a short bole (to 1 m thick). At the base of each leaf is normally found a pair of short, sharp spines, though some specimens are spineless. (NAS, 1980a).

Germplasm

Reported from the American Center of Diversity, guamachil, or cvs thereof is reported to tolerate drought, heat, poor soil, salt, sand, and shade. ($2n = 26$).

Distribution

Native to Mexico through Central America to Colombia and Venezuela. Introduced in southern Florida, Cuba, Jamaica, Puerto Rico, and St. Croix. Widely planted and naturalized in tropical regions, including the Old World (Little and Wadsworth, 1964). Listed as a common weed in Hawaii.

Ecology

Ranging from Tropical Desert (along water courses) to Moist through Subtropical Desert to Moist Forest Life Zones, guamachil is reported to tolerate annual precipitation of 1.4 to 22.0 dm (mean of 43 cases = 14.7), annual temperature of 18.0 to 27.9°C (mean of 37 cases = 25.4), and pH up to 8.3 (Duke, 1978, 1979). Occurs up to 1,800 m in Mexico and 1,500 m in Burundi. Suitable for most dry regions, it is drought resistant, in low rainfall areas developing an extensive root system. In Burundi it grows well at 800 m elevation and 600 mm, spread evenly year-round. In southern Florida rainfall averages 1,650 mm or more. It has great adaptability and grows on most soil types, including clay, oolitic limestone, and rather barren sands. It can also be found in wet sands that have a brackish water table (NAS, 1980a).

Cultivation

Reproduces easily by seeds or cuttings. For hedges, seeds may be sown in site, spaced 15 cm apart in two rows 30 cm apart.

Harvesting

Cut as needed for fuel, the tree has a fast rate of growth, coppices vigorously and can withstand "any amount of pruning, lopping, or browsing by animals." (C.S.I.R., 1948–1976).

Yields and Economics

In favorable soils and climates, the Manila tamarind may reach a height of 10 m in 5 or 6 years (NAS, 1980a). With no specific data available, I project that well established trees would produce forage somewhere between 6–20 MT/ha/yr, the 6 projected for *Prosopis tamarugo* and the 20 for *Leucaena*, by Felker (1981). Pod yields, according to my visual estimation, should approach those of *Prosopis juliflora*, a rather productive legume.

Energy

The reddish-brown wood is usually hard, heavy, and strong, though it is also brittle and rather difficult to cut. It is used (in India, Africa, and America) as a fuel, but smokes condiserably and is not best quality. Calorific value, 5,200–5,600 kcal per kg. In parts of India it is used as fuel for brick kilns (NAS, 1980a).

Biotic Factors

Normally pest damage is insignificant; can become affected by leaf spot diseases, *Phyllosticta inga-dulcis* and *Colletotrichum* sp., and a number of defoliating and boring insect pests. It is a favorite host of the thornbug. (NAS, 1980a). The nematode *Meloidogyne* is reported as a pest in Florida, the twig blight *Phomopsis* sp., the leaf spot *Phyllosticta pithecolubis* in Texas and Puerto Rico, *Physalospora fusca* and *Physalospora rhodina* in Florida, the wood rot *Polyporus gilvus* in Hawaii. Since several rhizobial cultures from guamachil failed to nodulate on several other taxa, this species was considered highly selective. Other tests with Baptisia, Crotalaria, and Dalea incurred nodulation (Allen and Allen, 1981). Browne (1968) lists: Fungi. *Corticum salmonicolor, Phyllosticta ingae-dulcis.* Coleoptera. *Celosterna scabrator, Sternocera sternicornis*. Hemiptera. *Kerria lacca, Nipaecoccus vastator.* Lepidoptera. *Cryptophlebia illepida, Eucosma stereoma, Euproctis scintillans, Hypanartia hecabe, Macroplectra nararia*.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Paullinia cupana H.B.K.

Sapindaceae

Guarana

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

New Crops from Brazil—David Arkcoll

Psidium guajava L.

Myrtaceae

Guava, Brazilian guava, Common guava Goyave, *Guayaba*, Guinea guava, Guyaba, Lemon guava, Montain guava, Purple guava, *Waiawi-'ula'ula*

NewCROP has Guava information at:

Guava—Julia Morton, Fruits of Warm Climates

Guava Production in Georgia under Cold-protection Structure—Umedi L. Yadava

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Guava info:

GUAVA "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Commodity Sheet FVSU-003 Guava from Fort Valley State University

NewCROP also has information on a related *Psidium* species:
Psidium angulatum, Araca-Pera

Parthenium argentatum Gray

Asteraceae, or Compositae

Guayule

NewCROP has Guayule information at:

Arid-land Industrial Crops—Anson E. Thompson

Germplasm Use in Arid Lands Industrial Crops—Dennis T. Ray and David A. Dierig

Interspecific Hybridization Between *Parthenium argentatum* Gray and *Parthenium lozanianum*—Alfonso López Benitez, F. Ramirez, S. Kuruvadi, and F. Borrego

Facultative Apomixis in Guayule as a Source of Genetic Diversity—Dennis T. Ray, David A. Dierig, and Anson E. Thompson

Improved Guayule Germplasm for Domestic Production of Natural Rubber—A. Estilai and J.G. Waines

Guayule: A Source of Natural Rubber—Dennis T. Ray

Hypoallergenic Guayule Latex: Research to Commercialization—Katrina Cornish and Deborah J. Siler

Engineering New Sources of Domestic Natural Rubber—Katrina Cornish, Zhiqang Pan, and Ralph A. Backhaus

Purification of Hypoallergenic Latex from Guayule—Katrina Cornish and Jenny L. Brichta

Relationship Between Guayule Biomass Production, Rubber Synthesis, and Climatic Conditions—José Luis Angulo-Sánchez, Diana Jasso de Rodríguez, and Raúl Rodriguez-García

Guayule Production: Rubber and Biomass Response to Irrigation—Raúl Rodríguez-García, Diana Jasso de Rodríguez, and José Luis Angulo-Sánchez

Identification of Guayule Regions in Northern Mexico, Based on Rubber Yield and Coproducts Quality—Diana Jasso Cantú, José Luis Angulo Sánchez, and Raúl Rodriguez García

Evaluation of Rubber and Resin Content in Lines of Guayule Collected from Nuevo Leon Province in Mexico—Sathyanarayanaiah Kuruvadi, Alfonso López Benitez, and F. Borrego

Rubber and Resin Content in the Bark and Wood Portions of the Root Stem and Branches in Guayule—Sathyanarayanaiah Kuruvadi and Diana Jasso de Rodriguez

Interspecific Hybridization Between *Parthenium argentatum* Gray and *Parthenium lozanianum*—Alfonso López Benitez, F. Ramirez, S. Kuruvadi, and F. Borrego

Salt Tolerance in Relation to Ploidy Level in Guayule—Ali Estilai and Michael C. Shannon

Growth of Direct Seeded and Transplanted Guayule Seedlings—James L. Fowler and Robert Tinguely

Impact of Seeding Rate and Planting Date on Guayule Stand Establishment by Direct Seeding in West Texas—Michael Foster, Greg Kleine, and Jaroy Moore

In Vitro Characterization of Apomictic Reproduction in Guayule—Roy N. Keys, Dennis T. Ray, and David A. Dierig

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark

New Industrial Crops: Northwestern Argentina Regional Project—Ricardo Ayerza (h) and Wayne Coates

Commercializing Promising Technologies—Paul F. O'Connell

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Perspective from an Independent Industrial Consulting Company—R. Martin O'Shea

And outside links to more Guayule info:

Guayule from the USDA Agriculture Research Service

Domestic Production of Natural Rubber WRRC Discovery Center

Gudmar or Merasingi (Gymnema sylvestre R. Br.)

Contributor: Pankaj Oudhia

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Gudmar or Merasingi (Gymnema sylvestre R. Br.)

Contributor: Pankaj Oudhia

English Name: Periploca of the woods, Small Indian ipecacuanha

Common (Indian) Name:
Hindi: Gudmar, Merasingi
Canarese: Sanngera, Sannagerse
Gujrati: Mardashingi
Marathi: Bediki, Kavali, Vakundi
Sanskrit: Mehashingi, Meshavalli, Vishani

Family: Asclepiadaceae

Botany: Much branched large woody climber, young stems are densely pubescent. Leaves - Opposite, Ovate, elliptic, base rounded or cordate . Flower - in Cymes; C. - Companulate; yellow, corona of 5 processes; Fruits - Follicle, lanceolate, usually single; Seeds - with thin marginal wing; flowering time in Indian conditions - April - May.

Habitat: In India naturally occur in monsoon forests.

Useful parts: Whole plant

Medicinal Properties: According to Ayurveda, it is bitter, acrid, cooling, tonic, alterative, anthelmintic, alexeritic. It cures eye complaints, burning sensation, biliousness, bronchitis, ulcers, asthma etc. The plant has been used to treat diabetes in India for 2,000 years by traditional medicinal practioners, but interest in its properties waned during the British colonial period when western rather than traditional therapy was official patronized by the government, as well as diminished with the advent of insulin. Leaves possess special feature. The leaves when chewed, have remarkable property of paralysing the taste glands for few hours against sweet and bitter taste.

Chemical Constituents: The leaves contain pentriacontane, hentriacontane, phytin, a and b chlorophylls, resin, tartaric acid, formic acid, butyric acid, mucilage, inositol, gymnemic acid and antheraquinone. The plant is reported to content alkaloids, betain, choline and trimethylamine in the leaves

Cultivation: Gymnema is under cultivation as medicinal crop in fairly large areas, in different parts of India. Standard cultivation practices for commercial cultivation has yet not been developed.

Resource Person:

Pankaj Oudhia
Society for Parthenium Management, (SOPAM)
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E-mail: pankajoudhia@usa.net
Homepage: www.celestine-india.com/pankajoudhia
Phone: 91-771-253243
Mobile: 91-98271-15642
Fax: 91-771-536312

Pachira aquatica syn. *Bombax glabra*

Bombaceae

Malabar Chestnut, Guiana Chestnut, Saba Nut

NewCROP has links to Malabar Chestnut information at:

MALABAR CHESTNUT "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Image of fruit & flower of Malabar Chestnut (from University of Hawaii - http://www.botany.hawaii.edu/faculty/carr/bombac.htm)

last update June 10, 1997

Panicum maximum L.

Poaceae

Guineagrass, Hamilgrass

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Guizotia abyssinica (L.f.) Cass.

Asteraceae

Niger

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Nigerseed: Specialty Grain Opportunity for Midwestern US—J. Quinn and R.L. Myers

Outside Links:

Niger—*Guizotia abyssinica* (L.f.) Cass.—Link to the publication on the International Plant Genetic Resources Institute web site

Witch-Hazel

Hamamelis virginiana L.

Witch-hazel

Figure 122.—Witch-hazel (*Hamamelis virginiana*)

Other common names.—Snapping hazel, winterbloom, wych-hazel, striped alder, spotted alder, tobacco wood.

Habitat and range.—The home of this native shrub is in low damp woods from New Brunswick to Minnesota and south to Florida and Texas

Description.—Witch-hazel, while it may grow to 25 feet in height, more frequently reaches a height of only 8 to 15 feet. It has a crooked stem and long forking branches with smooth, brown bark. The leaves are from 3 to 5 inches long, thick, and borne on short stalks. A peculiar feature of the plant is the lateness of the threadlike, yellow flowers, which do not appear until late in autumn or in early winter after the leaves have fallen. The seed capsule does not mature until the following season, when it bursts open, scattering the shining black, hard seeds with great force and to a considerable distance.

Part used.—The leaves, twigs, and bark, collected in autumn. These contain a volatile oil the distillation of which for the production of witch-hazel extract b; a well-developed industry in southern New England.*

*Information on the extraction of volatile oils from plants is contained in the following publication: Sievers, A.F. Methods of extracting volatile oils from plant material and the production of such oils in the United States. U.S. Dept. Agr. Tech. Bul. 16, 36 p. illus. 1928.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

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Pittosporum resiniferum Hemsl.

Pittosporaceae
Petroleum nut (English) Hanga (Philippine)

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Called petroleum nut because of the fancied resemblance of the odor of the fruit's oil to that of petroleum, the fruits, even green ones, burn brilliantly when ignited. Hence they are used like torch nuts or candlenuts for illumination in the bush. Dihydroterpene ($C_{10}H_{18}$) is used in perfumes and medicines. Heptane (C_7H_{16}) is a component of gasoline, and has been suggested as a possible component of paint and varnish (Anonymous, 1981c).

Folk Medicine

Fruit is used as a panacea by Philippine traditionalists, especially, however, for abdominal pain. The oleoresin is used to treat muscular pains and skin diseases (Perry, 1980). The nut decoction is used for colds. Crushed nuts are mixed with coconut oil as a relief for myalgia. Altschul (1973) quotes from a 1947 Sulit herbarium specimen, "Petroleum gas extracted from the fruit is medicinal for stomachache and cicitrizant."

Chemistry

The volatile oil of the fruit is reported to contain "dihydroterpene and heptane, which is a cardiac glycoside." (Perry, 1980). The Horticultural and Special Crops Laboratory at Peoria analyzed an accession of fruit, and identified, from its "squeezings", constituents passing through a gas chromatographic column, heptane (about 45% of the elutents) nonane, α-pinene or β-ocimene, β-pinene, myrcene, and unidentified materials. According to Nemethy and Calvin (1982) the essential oil (8-10% of fruit weight) contains myrcene (40%) and α-pinene (38%) in ± equal quantities (*P. undulatum's* contains mostly limonene). The two components n-heptane (5%) and n-nonane (7%) are minor components.

Description

Aromatic tree to 30 m tall, but probably smaller in its elfin forest habitat (perhaps even epiphytic); fruiting when only 6–12 m tall. Leaves aromatic, coriaceous, entire (possibly evergreen), thickest above the middle, pinnately nerved, with a short acumen at the tip. Flowers fragrant, white, clustered on the stems. Fruits average 25 mm in diameter (12–43). Each fruit has 5–72 seeds (average 31), the seeds ranging from 1–40 mm, averaging 3 mm. The seeds are about as close to hexahedral and prismatic as any I have seen, being quite angular, black to blackish gold, often still surrounded by a gummy or resinous endocarp.

Germplasm

The FORI Director in the Philippines is actively collecting superior germplasm in the high mountains of Bontoc and Benguet where they abound, especially in elfin forests.($2n = 24$)

Distribution

In the Philippines, petroleum nut is locally known in Benguet as apisang, abkol, abkel, and langis; in the Mountain Province, dael and dingo, and in Abra, sagaga. It abounds in Mt. Pulis, Ifugao, and is reported from the headwaters of the Agno and Chico River Basins. Also in the Bicol Provinces, Palawan, Hindoro, Nueva Ecija, and Laguna Provinces. It is being cultivated at FORI's Conifer Research Center, Baguio City.

Ecology

Petroleum nut is reported to range from 600–2,400 m elevation, usually in elfin or Benguet Pine Forest. Average of 7 climatic data sites where the *Pittosporum* grows, was close to 1,000 m, the range from ca 550 to 2,000 m. Whether or not it can stand frost, dry heat, and drought is questionable. Frequently, species of elfin forests have very narrow ecological amplitudes and do not thrive in other vegetation types. Results of transplants and trials are unavailable to me now. Reportedly seed were introduced once, at least to Hawaii. Thanks to Professors Ludivina S. de Padua, S.C. Hales, and Juan V. Pancho of the Philippines, we now have a fairly good idea of the ecosystematic amplitudes of the Pittosporum, an energy plant that has captured the imagination of many. Professor de Padua checked off all the climatic data points (from our climatic data base) at which *Pittosporum resiniferum* was growing, prior to its widespread introduction for potential energy studies elsewhere in the Philippines. Ranging from Tropical Dry to Moist through Subtropical Forest Life Zones, the petroleum nut grows where the annual precipitation ranges from 15 to more than 50 dm (mean of 36 cases = 27 dm), annual temperature from 18–28°C (mean of 17 cases = 26°C). Of 17 cases where both temperature and rainfall data were available to us, 13 would suggest Tropical Moist Forest Life Zone, three would suggest Tropical Dry, and one would suggest Subtropical Rain Forest Life Zones.

Cultivation

Seeds and cutting can be used to propagate the tree. Seeds may lose their vitality rather rapidly. According to Juan V. Pancho (personal communication, 1982), "from my experience, the seed lost its viability after one month storage."

Harvesting

Currently, seeds are harvested from the wild.

Yields and Economics

A single fruit yields 0.1–3.3 ml, averaging about 1.3 ml. In general, the bigger the fruit, the larger the seed, and the greater the oil content (Veracion and Costales, 1981). It is reported (Anonymous, 1981) that a single tree from Mount Mariveles, Bataan, yielded 15 kg green fruits, which yielded 80 cm^3 of oil. The residue, ground up and distilled with steam, yielded 73 cm^3 more. Another report gave 68 g per kg fresh nuts, suggesting about 1 kg oil per tree yielding 15 kg (Anonymous, 1981c). Currently seed are being sold at $2.00 per gram in 5-gram lots (ca 40 seed per g) by the FORI Seed Officer, Forest Research Institute, College, Laguna, Philippines.

Energy

The plant was discovered as a hydrocarbon source just after 1900, but based on the previous paragraph, it seems it would take 1,000 trees per ha to get one MT oil per hectare from the fruits. Perhaps the resin in the leaves, twigs, etc. would equal or exceed this; figures are not yet available. The oil derived from the fruits is quite sticky and rapidly turns resinous when laid thin. In an open dish, it burns strongly, although with a sooty flame (Anonymous, 1981). C.A. Arroyo (1981) notes that for home use as fuel, "the husk of African oil palm nuts could be much better than the petroleum nut that emits sooty smoke and strong smell." Recently, I heard rumors that President Marcos was encouraging each Philippine farmer to plant five trees in the hopes that they could obtain 300 liters of oil therefrom, per year. I saw nothing about this at the Philippine exhibit at the World's Fair in June 1982. However, if yields of 60 liters of oil per tree are possible, the tree should certainly be examined! In the January 1981 issue of Canopy, Generalao (1981) lists petroleum nut at the top of a long list of potential oil seeds including *Pongamia pinnata*, *Sterculia foetida, Terminalia catappa, Sindora supa, Calophyllum inophyllum, Canarium luzonicum*, *Aleurites moluccana*, *Aleurites trisperma, Mallotus philippensis*, *Barringtonia asiatica*, *Sindora inermis, Pithecellobium dulce, Tamarindus indica, Chisocheton cumingianus, Jatropha curcas*, and *Euphorbia philippensis* to help the Philippines solve their energy problem (importing 85%). Presidential Decree 1068 declares the imperative acceleration of research on energy alternatives. Speaking in that same issue of Canopy, an editorial notes that in 1978 FORI concluded the flammable element in petroleum nut is volatile, evaporating quickly like acetone. Some chemists believe admixing another element will stabilize the compound. One seed catalog (Anonymous, ca 1983) has very optimistic notes about the plant. "The Gasoline Tree produces masses of apricot-sized orange fruits which when cut and touched with a match leap into flame and burn steadily. The fruits contain 46% of gasoline type components (heptane,dihydroterpene, etc.), which are found in extensive networks of large resin canals. If planted the estimated yield would be about 45 tons of fruit or 2500 gallons of 'gasoline' per acre per year."

Biotic Factors

No data available.

References

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- Arroyo, C.A. 1981. Fuel for home use. Canopy International. 7(7):15.
- Generalao, M.L. 1981. Those seemingly insignificant plants. Canopy International 7(1):6.
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- Veracion, V.P. and Costales, E.F. 1981, The bigger, the more. Canopy Int. 7(6):1981.

[Complete list of references for Duke, Handbook of Energy Crops]

Last update Wednesday, January 7, 1998 by aw

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Hardinggrass

Gramineae *Phalaris stenoptera* Hack.

Source: Magness et al. 1971

This is a cool-season grass, native to Africa, but brought to the United States from Australia in 1914. It is a long-lived bunchgrass with short, stout rhizomes. It is adapted to mild climates with winter rainfall and thrives best on heavy soils. It is the most widely adapted range grass in California but is grown only sparingly in other areas of the Southwest. Where adapted, forage yields are high and quality is good.

Last update February 18, 1999 by ch

Helianthus annuus L.

Asteraceae, or Compositae

Sunflower, common sunflower, giant sunflower, prairie sunflower, single-headed sunflower

We have information from several sources:

NuSun Sunflower Oil: Redirection of an Industry—Larry W. Kleingartner

Grain Yield and Fatty Acid Composition of Sunflower Seed for Cultivars Developed Under Dry Land Conditions—Diana Jasso de Rodríguez, Bliss S. Phillips, Raúl Rodríguez-García, and José Luis Angulo-Sánchez

Characterization of Proteins from Sunflower Leaves and Seeds: Relationship of Biomass and Seed Yield—Diana Jasso de Rodríguez, Jorge Romero-García, Raúl Rodríguez-García, and José Luis Angulo Sánchez

Potential Source of Reduced Palmitic and Stearic Fatty Acids in Sunflower Oil From a Population of Wild *Helianthus annuus*—G.J. Seiler

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

New Crops for Canadian Agriculture—Ernest Small

Sunflower: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Sunflower In: Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and Feed Crops of the United States.

Outside links:

Sunflower: An American Native University of Missouri Agricultural publication G4290

Photographs from University of Minnesota Center for Alternative Plant & Animal Products.

Hemlock

Tsuga canadensis (L.) Carr.

Synonym.—*Abies canadensis* Michx.

Other common names.—Hemlock spruce, weeping spruce, spruce pine, tanbark

Habitat and range. The hemlock tree is found in forests from Ontario south to Virginia and Alabama and west to Michigan and Wisconsin.

Description.—This tall forest tree, which at times attains a height of 110 feet and a trunk diameter of 4 feet, is well known throughout its range as a source of tanbark. Its lower branches are somewhat drooping, and the dense, rather delicate foliage is deep green above and silvery beneath. The flat, narrow leaves are from one-half to three-fourths of an inch long and less than one-twelfth of an inch wide. The hanging cones are as long as or slightly longer than the leaves.

Part used.—The bark.

Figure 61.—Hemlock (*Tsuga canadensis*)

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

HENNA

Family: Lythraceae, (*Lawsonia inermis* L.)

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Henna, *Lawsonia inermis* L., a perennial shrub native to northern Africa, Asia, and Australia, is naturalized and cultivated in the tropics of America, Egypt, India, and parts of the Middle East. Also known as El-Henna, Egyptian priest, and mignonette tree, the species is sometimes classified as *Lawsonia alba* Lam. or *Lawsonia ruba*. Reaching a height of up to 6 meters, the plant has fragrant white or rose-red flowers.

The reported life zone of henna is 19 to 27 degrees centigrade with an annual precipitation of 0.2 to 4.2 meters and a soil pH of 4.3 to 8.0 (4.1-31). Henna is planted today primarily as an ornamental hedge, but is probably best known for the dried, ground leaves (called henna) traditionally used to produce colorfast orange, red, and brown dyes. Dried, powdered leaves of henna contain about 0.5 to 1.5 percent lawsone, the chief constituent responsible for the dyeing properties of the plant (1.1-273, 14.1-35). Henna also contains mannite, tannic acid, mucilage, gallic acid, and napthaquinone (7.6-192).

The leaves of henna have been used in Asia since antiquity as a hair, nail, and skin dye. In the West and the Middle East, henna is used in hair shampoos, dyes, conditioners, and rinses. Henna dye products are mixed with indigo or other plant material to obtain a greater color range. Extracts of henna are also used to stain wood and to dye fabrics and textiles.

As a medicinal plant, henna has been used for astringent, antihemorrhagic, intestinal antineoplastic, cardio-inhibitory, hypotensive, and sedative effects (7.6-192, 11.1-154). It has also been used as a folk remedy against amoebiasis, headache, jaundice, and leprosy (11.1-154). Henna extracts show antibacterial, antifungal, and ultraviolet light screening activity (1.8-169, 7.2-21,14.1-21, 14.1-35). Henna has exhibited antifertility activity in animals and may induce menstruation (7.5-76, 11.1-154).

The dried leaf and petiole of henna are generally recognized as safe when used as a color additive for hair (21 CFR section 73.2190[1982]).

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Liverleaf

(1) *Hepatica americana* Ker.; (2) *H. acutiloba* DC.

Other common names.—(1) Round-leaved hepatica, common liverleaf kidney liverleaf, liverwort (incorrect), noble liverwort, heart liverwort, three-leaved liverwort, liverweed, herb trinity, golden trefoil, ivy flower, mouse-ears, squirrel cup; (2) heart liverleaf, acute-lobed liverleaf, sharplobe liverleaf, sharplobe hepatica.

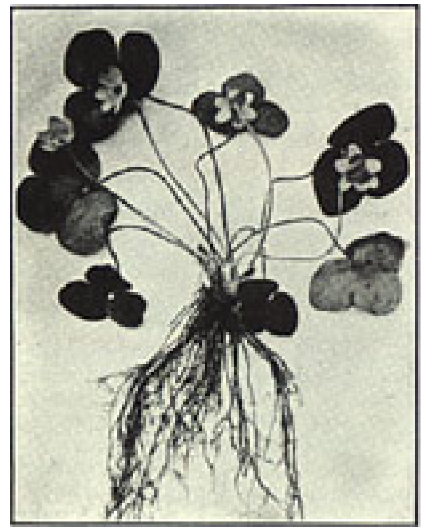

Figure 73.—Liverleaf (*Hepatica americana*)

Habitat and range.—The common liverleaf is found in woods from Nova Scotia to northern Florida and west to Iowa and Missouri, while the heart liverleaf occurs from Quebec to Ontario, south to Georgia (but rare near the coast), and west to Missouri and Minnesota.

Description.—The hepaticas are among the earliest of our spring flowers, blossoming about March and frequently sooner. They grow only about 4 to 6 inches in height, with leaves produced from the rootstocks on soft, hairy stalks spreading on the ground. The thick and leathery evergreen leaves are roundish or kidney-shaped. The bluish to purple or white flowers are about half an inch in diameter and are borne singly on slender, hairy stalks arising from the root.

The heart liverleaf is very similar to the common liverleaf, but has sharp leaf lobes while those of the common species are very blunt.

Part used.—The leaves of both species, collected in April.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Phleum pratense L.

Syn.: *Phleum nodosum* L.

Poaceae

Timothy, Herdgrass

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Hesperaloe sp.

Agavaceae

We have information from several sources:

FactSHEET contributed by: Steven P. McLaughlin

Development of *Hesperaloe* Species (Agavaceae) as New Fiber Crops—Steven P.McLaughlin

Domestication of *Hesperaloe*: Progress, Problems, and Prospects—Steven P. McLaughlin

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

New Arid Land Ornamentals: Recent Introductions for Desert Landscapes—Janet H. Rademacher

Hevea brasiliensis Muell. Arg.

Euphorbiaceae

Rubber

We have information from several sources:

Surfactant Treatment Reduces Both Allergen Content and Cure Efficiency of Hevea Latex—W.W. Schloman, Jr.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Hibiscus sabdariffa L.

Malvaceae

Indian sorrel, Jamaican sorrel, Java jute, Red sorrel, Roselle, Rozelle, Sorrel

We have information from several sources:

Roselle—Julia Morton, Fruits of warm climates

Effect of Nitrogen Nutrition on Roselle—E.G. Rhoden, P. David, and T. Small

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Hibiscus spp.

Malvaceae

Hibiscus

We have information from several sources:

Hippophae rhamnoides L.

Elaeagnaceae

Sea buckthorn

We have information from several sources:

Sea Buckthorn: New Crop Opportunity—Thomas S.C. Li

DNA Analysis as a Tool in Sea Buckthorn Breeding—N. Jeppsson, I.V. Bartish, and H.A. Persson

Product Development of Sea Buckthorn—Thomas S.C. Li

Heavy Metal Accumulation in Sea Buckthorn Cultivars in Siberia—Wudeneh Letchamo, Roman Klevakin, and Irina I. Lobatcheva

Evaluation of Siberian Sea Buckthorn Cultivars in Washington State—I.I. Lobatcheva, W. Letchamo, L. Huszar, S.A. Muchortov, N.N. Malkova, E.I. Panteleeva

Temperate Berry Crops—Chad Finn

Outside links:

Sea-Buckthorn: A Promising Multi-Purpose Crop for Saskatchewan

Sea Buckthorn Production in Manitoba

Shelterbelt Varieties for Alberta - Sea Buckthorn

Okanagan Sea Buckthorn

Marrubium vulgare L.

Lamiaceae (Labiatae)

Horehound, Hoarhound

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Panicum miliaceum L.

Poaceae, or Graminae, Tribe Paniceae

Proso Millet

NewCROP has Proso Millet information at:

Foxtail and Proso Millet—D.D. Baltensperger

Millets: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Proso Millet info:

Panic grasses from Lost Crops of Africa: Volume I: Grains

Ecofarming: No-till Ecofallow Proso Millet in Winter Wheat Stubble. From the University of Nebraska.

Millet Production Guide by: R. D. Baker, Extension Agronomist, New Mexico State University.

Tyfon, or Holland Greens

Brassica rapa 'Tyfon'

Brassicaceae or Cruciferae

Source: *Cornucopia, a Source Book of Edible Plants,* by Stephen Facciola, 2nd ed., Kampong Publications, Vista, California. 1992.

Tyfon, or Holland greens is a hybrid between Chinese Cabbage (*Brassica rapa* Pekeninensis Group) and stubble turnip (*Brassica rapa* Rapifera Group). Tyfon is rapid growing and vigorous...extremely cold-hardy and also slow to bolt. Several foliage harvests can be made by repeated cuttings. Mild in flavor, Tyfon can be eaten fresh as a salad green, or as a cooked pot-herb, just as collard or mustard greens.

Amaranth, Chinese

Hon-toi-moi, Tampala, Chinese spinach

Amaranthaceae *Amaranthus tricolor* L.

Source: Magness et al. 1971

Several species of Amaranthus are cultivated in Southwest Asia and to a limited extent by Chinese gardeners in the U.S. Plants are annuals, grown from seed, and leaves and young stems are used as pot herbs. Mature plants are 1 to 3 feet tall, with leaves 6 inches long. For use as pot herbs, young plants may be pulled at 3 to 4 weeks; or the tops may be cut off at that stage, and a second crop will be produced from lateral growth. Plant growth and parts used are similar to spinach.

Season, seeding to harvest: 3 to 6 weeks. A second crop may be reduced.

Production in U.S.: No data. Mainly by Oriental gardeners for Chinese users.

Use: Cooked as a pot herb.

Part of plant consumed: Young stems and leaves.

Last update February 18, 1999 by ch

Prosopis spp.

Fabaceae

Algarroba, Fremont screwbean, Honey locust, Mesquite, Screwbean, Screwbean mesquite, Screwpod mesquite, Tornillo, Velvet mesquite, Western honey mesquite

We have information from several sources:

Commercializing Mesquite, Leucaena, and Cactus in Texas—Peter Felker

James A. Duke. 1983. Handbook of Energy Crops. unpublished.
Prosopis alba
Prosopis chilensis
Prosopis cineraria
Prosopis glandulosa
Prosopis juliflora
Prosopis pallida
Prosopis tamarugo

Hophornbeam

Ostrya virginiana (Mill.) K. Koch.

Figure 64.—Hophornbeam (*Ostrya virginiana*)

Other common names.—Ironwood, deerwood, leverwood, black hazel, Indian cedar

Habitat and range.—The ironwood is common in rich woods in Canada and the eastern United States, and westward to Minnesota and Texas.

Description.—This slender tree sometimes attains a height of 50 feet in the western portion of its range, but farther eastward it usually grows only 15 to 20 feet high. The bark is finely furrowed in short lines lengthwise, and the wood is very hard and heavy. The leaves are from 2 1/2 to 4 inches long and about an inch or more wide, resembling the leaves of the sweet birch except that they are rough to the touch instead of smooth and shining. The green inconspicuous male and female flowers are produced from April to May. The male flowers are borne in cylindrical catkins from l 1/2 to 3 inches long and the female flowers in short catkins which mature in July and August into large fruiting cones which very much resemble hops.

Part used.—The bark and inner wood.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Humulus lupulus L.

Cannabinaceae

Hops, Common hops, Hop plant

We have information from several sources:

Hop: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Herbs Affecting the Central Nervous System—Varro E. Tyler

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside sources and links:

Humulus Accessions available through the National Germplasm Repository, Corvallis, Oregon.

Hoptree

Ptelea trifoliata L.

Figure 65.—Hoptree (*Ptelea trifoliata*)

Other common names.—Waferash, ptelea, wingseed, shrubby trefoil, swamp dogwood, three-leaved hoptree, ague bark, prairie-grub, quinine tree, stinking ash, stinking prairie-bush, sang-tree, pickaway-anise.

Habitat and range.—This native shrub is found in shady woods from New York to Florida and west to Minnesota and Texas, occurring in greatest abundance west of the Alleghenies.

Description.—The hoptree is a shrub usually from 6 to 8 feet, sometimes 20 feet, in height, with leaves consisting of three dark green, shining leaflets 2 to 6 inches long. The leaves are glandular dotted and are borne on long stems, but the leaflets are stemless. The greenish-white flowers, produced in June, are borne in compound clusters at the end of the stems. Both leaves and flowers have an unpleasant odor. The flowers are followed by large clusters of winged, flat, roundish fruits each containing two seeds. They have a bitter taste.

Part used.—The bark of the root.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Barley

Gramineae Hordeum sp.

Source: Magness et al. 1971

Barley is the fourth most important grain crop in the United States. Acreage planted in 1966 and 1967 averaged about 10.6 million, with an average yield for the two years of 381.7 million bushels.

Barley is one of the most ancient of cultivated grains. Grains found in pits and pyramids in Egypt indicate that barley was cultivated there more than 5000 years ago. The most ancient glyph or pictograph found for barley is dated about 3000 B.C. Numerous references to barley and beer are found in the earliest Egyptian and Sumerian writings.

The origin of barley is still not known. There are differing views among researchers as to whether the original wild forms were indigenous to Eastern Asia, particulariy Tibet, or to the Near East or Eastern Mediterranean Area, or both. Possibly in a crop so long cultivated this can never be resolved with certainty. J. R. Harlan, in U.S.D.A. Handbook 338, Barley: Origin, Botany, Culture, Winterhardiness, Genetics, Utilization, Pests, summarizes the evidence for different viewpoints.

Species and Characteristics of Barley

Three species of *Hordeum* constitute the barleys under cultivation.

They are derived species, not known as such in nature. All have 14 cbromosomes in the diploid stage and inter-cross readily. They are characterized as follows:

Hordeum vulgare L. These are 6-rowed barleys with a tough rachis or spike stem. All florets are fertile and develop normal kernels. Within the species are two groups: (1) The typical group in which lateral kernels are only slightly smaller than the central one. (2) The intermediate group in which lateral kernels are distinctly smaller than central ones. This group may contain kinds with sterile or near sterile lateral spikelets. The two groups may overlap and are not fully distinct.

Hordeum distichon L. This species is the 2-rowed barleys with a tough rachis. The central spikelets all contain a fertile flower, while flowers in the lateral spikelets are either male or sexless. Two groups of varieties occur: (1) The typical 2-row group, with lateral flowers containing lemma, palea and reduced sexual parts. (2) The deficiens group, with lateral flowers containing no sexual parts.

Hordeum irregulare E. Aberg and Wiebe. This is an irregular barley with a tough rachis, but with lateral flowers reduced in some instances to a stem piece only; and others fertile, sterile or sexless. Central spikelets contain fertile flowers and set seeds.

A number of species of *Hordeum* are native in various parts of the world. Hitchcock (Manual of

Grasses of the United States, Ed. 2, U.S.D.A. Misc. Pub. 200, 1951) lists 11 species of barley grasses as occurring in the United States. None of the native species is in cultivation.

Barley plants are annual grasses which may be either winter annuals or spring annuals. Winter annuals require a period of exposure to cold in order to produce flowers and set seeds, thus are planted in the fall. They form a rosette type of growth in fall and winter, developing elongated stems and flower heads in early summer. If seeded in the spring they fail to produce seed heads. Winter varieties form branch stems or tillers at the base so several stems rise from a single plant. The winter varieties of barlev are more hardy than winter oats, but somewhat less hardy than winter wheat. Around a fourth of the barley grown in the United States is of winter varieties. Spring varieties do not require exposure to cold in order to devlop seed heads. Also, they do not have a typical rosette stage and so develop fewer tillers than winter varieties. They are the only kind adapted to areas with very cold winters. For best production they should be seeded as early as land can be worked in the spring.

The stems of both winter and spring varieties may vary in length from 1 to 4 feet, depending on variety and growing conditions. Stems are round, hollow between nodes, and develop 5 to 7 nodes below the head. At each node a clasping leaf develops. In most varieties the leaves are coated with a waxy chalklike deposit. The density of this varies, and in some varieties no waxiness is present and leaves are glossy. Shape and size of leaves varies with varietv, growing conditions, and position on the plant.

The spike, which contains the flowers and later the mature seeds, consists of spikelets attached to the central stem or rachis. Stem intervals between spikelets are 2 mm. or less in dense headed varieties and up to 4 to 5 mm. in lax or open headed kinds. Three spikelets develop at each node on the rachis. Barley varieties are classed as 2-row or 6-row. In 2-row varieties only the central spikelet develops a fertile flower and seed. In 6-row varieties all three of the spikelets at each node develop a seed.

Each spikelet has two glumes rising from near the base. These are linear to lanceolate and flat and terminate in an awn. The glumes minus the awn are about half the length of the kernel in most varieties, but this varies from less than half to equal to the kernel in length. Glumes may be covered with hairs, weakly haired or hairless. The awns on the glumes may be shorter than the giume, equal in length or longer. The glumes are removed in threshing.

The barley kernel consists of the caryopsis, or internal seed, the lemma and palea. In most barley varieties the lema and palea adhere to the caryopsis and are a part of the grain following threshing. However, naked or hutless varieties also occur. In these the caryopsis is free of the lemma and palea and threshes out free as in wheat. This type is grown mainly where barley is used for human food and is rarely found in the United States.

The lemmas in barley are usually awned. Awns vary from very short up to as much as 12 inches in length. Edges of awns may be rough or "barbed" (bearded) or nearly smooth. Awnless varieties are also known. In 6-row barley awns are usually more developed on the central spikelets than on the lateral ones.

The barley kernel is generally spindle shaped. In commercial varieties grown in the United States length ranges from 7 to 12 mm. Kernels from 2-rowed varieties are symmetrical. In 6-rowed varieties the third of the kernels from the central spikelets are symmetrical, but the two-thirds from lateral spikelets are twisted. The twist is most apparent at the attachment end, less conspicuous at the terminal. The dorsal surface of kernels is smooth, the ventral surface grooved.

The period from flowering until barley is ready for harvest may vary from 40 days to as long as 55 days, varying with varieties and climatic conditions.

Cultivated Variety Groups

Some 150 varieties of barley are cultivated in the United States, many on a minor scale. Varieties are constantly changing as new ones are devloped and tested while others pass out of cultivation. These varieties fall into four general groups, as follows:

Manchuria - OAC 21 - Aderbrucker Group- These are 6-rowed, awned, spring-type varieties with medium sized kernels. The type is believed to have come originally from Manchuria. Plants are tall with open or lax, nodding heads. They tend to shatter badly in dry climates. These are grown mainly in the upper Mississippi Valley and are extensively used for malting.

Coast Group. These varieties trace to North African ancestry and are grown in California and Arizona, also in the Inter-Mountain Region. They are 6-rowed, awned, with large kernels, and short to medium length stems. Spikes are medium to short, dense and generally held erect to semierect. They mature early and are not prone to shatter. They have a spring growth habit but may be fall or winter seeded in California and Arizona where winters are mild.

Tennessee Winter Group. Varieties of this group trace to the Balkan-Caucasus Region or Korea. They are 6-rowed, avrned, with mid-long lax spikes which tend to nod. Plants are medium tall, of winter habit. These varieties are fall seeded and are grown in the southeastern quarter of the United States.

Two-rowed Group. This group includes types tracing to Europe and Turkey--the Turkish type being adapted to areas with marginal rainfall. Varieties in this group are grown principally in the Pacific and InterMountain States and to some extent in the Northern Great Plains. Varieties are mainly spring type though 2-rowed winter varieties are known. Some varieties are used mainly for malting, others for feed.

Uses of Barley

Half or more of the barley grown in the United States is used for livestock feed. As feed it is nearly equal in nutritive value to kernel corn. It is especially valuable as hog feed, giving desirable portions of firm fat and lean meat. The entire kernel is used in feed, generally after grinding or steam rolling. Malt sprouts from malting as well as brewers grain--byproducts of brewing--are also valuable livestock feeds.

Around 25 percent of the barley crop is used for malting in the United States. Of the malted barley some 80 percent is used for beer, around 14 percent for distilled alcohol products, and 6 percent for malt syrup, malted milk and breakfast foods. For malting, the barley is steeped in aerated water in large tanks for 45 to 65 hours, then transferred to germinating tanks or compartments where it is held with intermittent stirring for 5 to 7 days at temperatures of 60-70°F. During this treatment root sprouts emerge, but not the stems. This "green" malt is then dried in hot air kilns. For making beer the dried malt is crushed between rollers, mixed in proper proportions with slightly warm water, and held under rigidly controlled temperatures. The starch is converted by enzymatic reaction into maltose and dextrins. Proteins are also broken down by enzyme action. Upon completion of this process the solids settle out, the extract is filtered, then boiled with hops to add flavor, then cooled. Yeast is added to ferment the sugars into alcohol and carbon dioxide. The hop residue and proteins are then removed and the product (beer) is aged, chilled, filtered, pasteurized and bottled. Keg beer is similar but is not pasteurized or bottled. The solids from this process (brewer's grain) are a valuable livestock feed.

Barley for human food is made into pearl barley by using abrasive disks to grind the hulls and bran off the kernels. Alter three successive "Pearlings" or grinding operations all the bull and most of the bran is removed. At this stage the remaining kernel part is known as pot barley. Two or three additional pearlings produce pearl barley, in which most of the embryo is removed. These later pearlings also produce barley flour. Pot and pearl barley are used in soups and dressings. The flour is used in baby foods and breakfast cereals, or mixed with wheat flour in baking.

Barley is also grown as a hay crop in some areas. For hay, only smooth-awned varieties or awnless are used. Winter barley also may be pastured moderately before the stems start to elongate. It furnishes nutritive pasturage, and grain yields are not seriously reduced.

Last update February 18, 1999 by ch

Horse Nettle

Solanum carolinense L.

Figure 67.—Horse nettle (*Solanum carolinense*)

Other common names.—Sand brier, bull nettle, radical-weed, tread-softly, apple of Sodom.

Habitat and range.—The horse nettle is found in dry, sandy soil from Ontario to Illinois and Massachusetts, Florida, and Texas.

Description.—This plant is easily recognized in late summer and fall by its round, smooth, orange-yellow berries about one-half to three-fourths of an inch in diameter which are borne in small drooping clusters. It is an herb 1 to 4 feet high with an erect, branched stem and covered with fine hair. The branches, also the petioles and midveins of the leaves, are armed with straight yellow prickles. The leaves are 2 to 6 inches long with rather deep triangular lobes. From May to September the plant produces violet or white flowers about 1 to 1 1/4 inches broad.

Part used.—The ripe berries, carefully dried.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 19, 1998 by aw

Smooth Hydrangea

Hydrangea arborescens L.

Other common names.—Wild hydrangea, sevenbark.

Figure 97.—Smooth hydrangea (*Hydrangea arborescens*)

Habitat and range.—Hydrangea frequents rocky river banks and ravines from the southern part of New York to Florida and westward to Iowa and Missouri being especially abundant in the valley of the Delaware and southward.

Description.—Hydrangea is a shrub 5 to 6 feet high with weak twigs, slender leaf stems, and thin leaves, the latter 3 to 6 inches long, oval or heart-shaped, and sharply toothed. The flowers, which are small and greenish white, are produced from June to July in loose, broad clusters. Sometimes the plant will flower a second time early in the fall. The stem has a peculiar tendency to peel off in several successive layers of thin, different-colored bark, hence the name "sevenbark." The root is roughly branched and when fresh is very juicy, but when dry it is very hard and tough.

Part used.—The root, collected in autumn. On account of its toughness when dry the root should be cut in short pieces while fresh and then dried.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

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Hylocereus sp.

Cactaceae

Pitaya

We have information from several sources:

Pitayas (Genus *Hylocereus*): New Fruit Crop for the Negev Desert of Israel—Eran Raveh, Julia Weiss, Avinoam Nerd, and Yosef Mizrahi

New Crops as a Possible Solution for the Troubled Israeli Export Market—Y. Mizrahi and A. Nerd

Climbing and Columnar Cacti: New Arid Land Fruit Crops—Yosef Mizrahi and Avinoam Nerd

New Fruits for Arid Climates—Yosef Mizrahi, Avinoam Nerd, and Yaron Sitrit

Hypericum perforatum L. Per.

Hypericaceae

St. John's Wort, Great Saint-John's-wort

We have information from several sources:

Biochemical and Eco-physiological Studies on *Hypericum* spp.—T.B. Kireeva, U.L. Sharanov, and W. Letchamo

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Herbs Affecting the Central Nervous System—Varro E. Tyler

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Hyssopus officinalis L.

Lamiaceae (Labiatae)

Hyssop

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update December 31, 1997 by aw

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 245-252.

Maté

(*Ilex paraguariensis*)

The author of this chapter is G.C. Giberti (Centre of Pharmacological and Botanical Studies, Buenos Aires, Argentina).

Botanical name: *Ilex paraguariensis* A. St-Hil. var. *paraguariensis*

Family: Aquifoliaceae

Common names. English: maté, Brazilian tea, Paraguay tea: Guarani: ka'a; Kaingangue: kongóñ: Spanish: yerba maté, té de los jesuitas: Portuguese: congonha, erva maté

Maté, with a very restricted distribution outside America, is a tree that produces a raw material for industrialization and consumption as a stimulating infusion. So far, this has been the main use of this somewhat overlooked crop.

Although no archaeological remains have been found that show that it was used in pre-Columbian times. it is assumed that it was the Guarani Indians who taught the Spanish how to use it. However, what seems to be an indirect consequence of the discovery is the fact that the first people to have cultivated this species were the Jesuit missionaries who, around 1670, already had artificial maté plantations. In time, the settlements of Guarani Indians converted to Christianity were to become economically dependent on maté production.

The expulsion of the Jesuits from the Spanish dominions (1767) was a step backwards in the history of maté. There was a return to the forest exploitation method which utilized the natural maté plantations exclusively and inadequately. It may be said that this type of laborious and uneconomical forest management extended up to the first decades of the twentieth century, in spite of maté planting having been renewed in Nueva Germania, Paraguay and in Santa Ana, Argentina, in 1897.

Although very much reduced, maté production did not disappear with the Jesuit plantations. During the remainder of the colonial period, the use of this herb, which had spread extensively, persisted even in the region of the Viceroyalty of Peru, where there was another methyl xanthine stimulant of the same genus: *Ilex guayusa* Loes. emend. Shemluck, also marketed by the Jesuits from that region in Quito.

It has been established that trade in maté was not interrupted and that it was commonly used in what is now Peru and Ecuador. However, following the independence of the Spanish colonies and the adoption of free trade, English tea began to be introduced into those countries and so maté gradually lost the markets of those Andean countries.

The decline and complete disappearance of the maté plantations in the settlements of Christianized Indians (which ended around 1820 after a series of wars waged in the region between the Spanish and Portuguese Crowns, followed by the struggles for independence) and the policy of isolation and control of international trade maintained by the first governor of independent Paraguay meant that, in the 1820s, Brazil began commercial exploitation of its natural maté plantations.

The most accessible plantations were situated in the vicinity of Curitiba, Paraná, and as they were slowly exhausted they were gradually replaced by the others located towards the west. The Brazilian product, which then began to spread on the markets as "Paranagua maté", was considered to be of inferior quality to that from Paraguay. However, in the course of time it replaced the Paraguayan product, a development which became more marked after the war of the Triple Alliance (1870).

At the end of the nineteenth century, the limitations of the exhaustive exploitation of this forestry resource stimulated efforts to produce large plantations of *I. paraguariensis* once again. Eventually. these efforts were successful, especially in Argentina.

At the same time as the increase in Argentinian maté production, the extraordinary expansion of the agricultural frontiers in traditional maté-growing states of southern Brazil (Paraná, Santa Catarina. Rio Grande do Sul, Mato Grosso do Sul) took place. Regrettably, the disappearance of enormous areas of natural forests in those states jeopardized the conservation of maté's genetic richness.

The complicated economic history of this crop (barely sketched out here) which is characterized by periods of scarcity alternating with periods of excessive demand, the sporadic but real existence of periods during which it was adulterated with other plants and the most common method of preparation—maté sucked through a small tube—considered by many to be unhygienic, had a bearing on the limited spread of maté outside southern South America.

Its main use is in infusions prepared as tea with leaves and dried stems which have been industrially shredded. Generally speaking, it is drunk by tilling small gourds (maté gourds or *cuias*) with maté. to which boiling water is gradually added, the liquid being sucked up through a metal tube (the *bombilla*). Infusions of *cimarrón,* or bitter maté, are usually modified with sugar (sweet maté), milk or aromatic herbs. Other methods of consumption are boiled maté, *tereré* (maté prepared with cold water, common in Paraguay and northeastern Argentina), liqueurs prepared with maté, ice-creams, desserts, etc. The industry also produces compound maté (which contains aromatic and/or medicinal herbs), soluble maté and maté teabags.

The aqueous infusion of maté owes its stimulant properties to the caffeine content (between 1 and 2 percent) so that, 60 minutes after consuming maté, an average of 80 to 120 mg of this pseudoalkaloid is consumed. Its nutritional qualities are due to its content of vitamins A, C and B complex and the existence of minerals (P, Ca and Fe).

Argentina, the main producer and consumer, grows around 130000 ha of maté in the northeast of the country (Misiones and Corrientes), which produce about 140000 tonnes per year. Brazil is the world's second producer, followed by Paraguay. For the Argentinan province of Misiones, maté cultivation represents an important part of the country's GDP.

Botanical description

The maté is a dioecious evergreen tree which grows up to 18 m in height. The leaves are alternate, coriaceous and obovate with a serrate margin and obtuse apex. The inflorescences are in corymboid fascicles, the male ones in a dichasium with three to 11 flowers, the female ones with one or three flowers. The flowers are small, and simple, number four or five and have a whitish corolla. The fruit is in a nucule; there are four or five single seed pyrenes (propagules).

Maté flowers in the spring (from October to November), has entomophilous pollination (diptera, hymenoptera) and fruits from March to June; dissemination is endozoic (birds). There is a rudimentary embryo in many externally ripe seeds which causes a long period of germination From the time of sowing.

Figure 29. A) Maté (*Ilex paraguariensis*); A1) inflorescence; A2) flower; A3) fruit; A4) gourd and tube for consuming the infusion

Ecology and phytogeography

Prominent among the ecological requirements of this subtropical species are climatic conditions, especially mean annual precipitation and an even distribution of rainfall throughout the year. This must not be less than 1200 mm annually and, during the driest quarter—which in the region is winter—the minimum must be 250 mm. *I. paraguariensis'* wild distribution area is always unaffected by water shortages. The mean annual temperature of the area is approximately 21 to 22°C. The absolute minimum temperature that this species is able to tolerate is -6°C, even though winter snows are frequent on the plateaus and mountain regions to the south of Brazil and east of Misiones.

It requires lateritic, acid (pH between 5.8 and 6.8) soils that are of medium to fine texture.

Figure 30 shows the natural distribution of *I. paraguariensis*. The area of economic cultivation of maté coincides approximately with the main dispersion area of the var. *paraguariensis*.

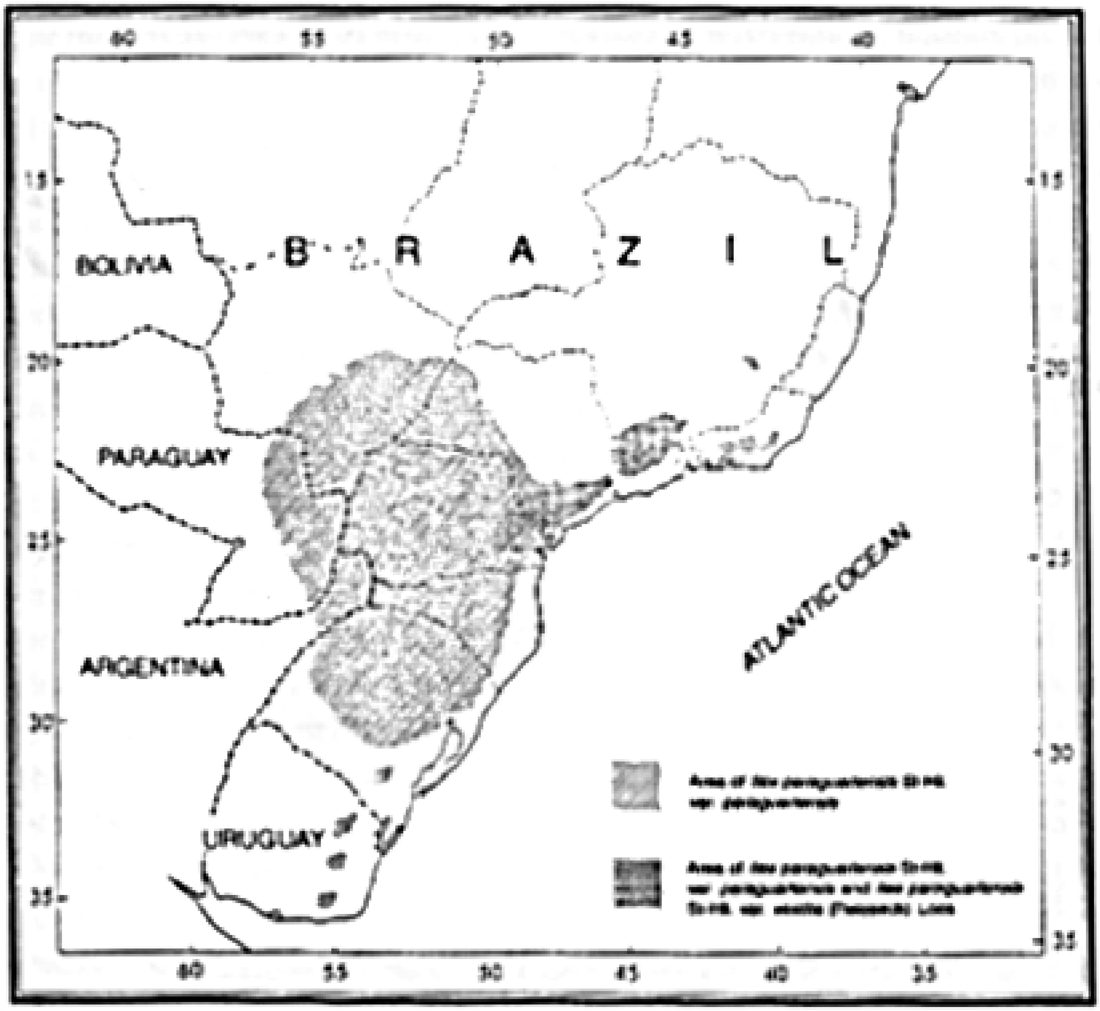

Figure 30. Distribution area of *Ilex paraguariensis* var. *paraguariensis* and var. *vestita*

Genetic diversity

There is still no exhaustive modern picture that explains in biological terms the infraspecific variability of this species, which is widely dispersed geographically in South America. Up to the present, taking as a basis the morphological characteristics alone, at least two varieties are recognized: *I. paraguariensis* A. St-Hill var. *paraguariensis* (cultivated maté, almost completely glabrous) and *I. paraguariensis* var. *vestita* (Reisseck) Loes. (not acceptable for industrialization, of dense pubescence). Both varieties coexist in limited areas of Brazil.

The wild species closest to *I. paraguariensis* belong to the subgenus *euilex* Loes., subsection *repandae* Loes. Only *I. cognata* Reisseck lives in the distribution area of maté. *I. cognata* is very little known; its vernacular name is chá do mato and it is used to adulterate maté.

A number of wild species of *Ilex* are sympatric with genuine maté and have been, or are, used to manufacture the product although, up to the present and according to the legislation in force, they are to be considered adulterations. Of those most frequently referred to, the following deserve mention: *Ilex affinis* Gardner (the ca' a chirí or congonha of Goyaz, a species abundant in central Brazil and northeastern Paraguay); *I. dumosa* Reisseck var. *guaranina* Loes. (*yerba señorita, aperea ka'a, cauna, caá chiri*), native to Paraguay, Argentina and Brazil, the producer of a bitter-tasting maté and supposedly cultivated in Misiones by the Jesuits to produce their famous "caá miní" maté; *I. theezans*, C. Martius ex Reisseck (cauna de folhas largas, ca'a na, congonha), a good substitute for *I. paraguariensis*, found in Paraguay, Argentina and Brazil. *I. brevicuspis* Reisseck, known as cauna or voadeira, like the previous species, is a faithful companion of *I. paraguariensis* in plant communities characteristic of the region—where *Araucaria* is also prominent—but the product obtained from its experimental industrialization is of low quality.

Outside the natural area of distribution and production of maté, in northwestern Argentina and southeastern Bolivia, *Ilex argentina* Lillo, a related species that is known not to accumulate caffeine but theobromine, has been used to prepare maté. It is a tree characteristic of the area of transition between the forests of Myrtaceae and alder (*Alnus* spp.) of the phytogeographical province of the yungas.

Known cultivars of *I. paraguariensis*. The infraspecific classification of *I. paraguariensis* is still under study. Consequently, the correspondence between the biological varieties and the horticultural varieties of genuine maté is not clear. Following is a list of some of the varieties recognized as such by growers in the three countries: Erva de talo roxo, Erva de talo branco, Erva piriquita (Brazil); Caá verá, Caá manduví, Caá panambi, Caá cuatí, Caá ñú, Caá eté, Caá mi, Caá chacra, Caá-je-he-ni (Paraguay); Yerba colorada, Yerba señorita, Caá miní (Argentina).

INTA in Argentina recently began to distribute seeds of clones and selected clonal progeny which, following comparative trials, demonstrated their superiority.

In wild South American *Ilex* species and in the maté-growing region, the risks of genetic erosion are high because the natural forest is gradually giving way to agroforestry and livestock production, a process accentuated by the relatively low germinating capacity of many species (especially that of maté). As no suitable method has yet been discovered for maintaining the germinating capacity of *I. paraguariensis* for prolonged periods, there are no seed banks of the species. Nevertheless, at the Cerro Azul de Misiones experimental agricultural station in Argentina, a maté clonal garden began to be developed in 1976, complemented by the nursery started in 1986 with *I. paraguariensis* of various origins and with other species of *Ilex*.

Cultivation practices

In the wide and varied economic production area of maté, the practices for the cultivation or exploitation of natural maté vary considerably in their technical aspects, resulting in different yields per hectare.

Three methods of production can be distinguished which are arranged here in increasing order of importance reflecting the use of techniques and their yields:

Extractive exploitation of the natural forest. Here the richness of natural maté plantations is utilized. Harvesting is not mechanized and the pruning system is generally incorrect. This form of production is diffused mainly in Brazil.

Mixed system or system for the enrichment of the natural forest. This consists of increasing the number of natural plantations and reconstituting those that have been lost. In Brazil, where this method is most commonly practiced, it is called densifying the maté plantation. Since, generally speaking, this technique is accompanied by others that increase the yield, such as cultivation care and improved pruning methods, the higher production cost is compensated for.

Cultivated maté plantations. This is undoubtedly the best system, and came into general use in Argentina around 1915. In spite of higher costs, the yield per hectare greatly increases. Complemented by measures such as improvement in the layout of plantations (which have evolved from trees planted in quincunxes, with spaced out plants used by Jesuits, to cultivation following contour lines, with a high density per hectare and use of the *corte mesa* pruning and plant management system), with well-timed pruning, cultivation work and harvesting, this system enabled Argentinian production to exceed that of Brazil, in spite of the former being carried out in a very reduced area and even outside the environments most suited for maté. For example, rising from a density of 1000 to 1500 plants per hectare (still fairly widespread) to a density of 2500 or 4000 plants per hectare, production can increase from around 1000 to 1800 kg to 2100 to 3300 kg per hectare.

The *corte mesa* system not only increases the yield but is also better suited to mechanical harvesting.

Yields are improved by: planting following contours; the use of natural or introduced cover (rape, legumes, etc.); fertilization (NPK); weed control (mechanical and/or using herbicides); suitable phytosanitary treatments; and rational harvesting. The relevant experiments have been going on for some years but, regrettably, their results have not become generalized. The introduction into cultivation of improved cultivars is much less widespread.

Conventional propagation techniques. *Sexual propagation* ("seeds" = pyrenes). This is the most common reproduction technique. In the case of maté, the advantage of sexual propagation lies in the fact that the variability in descendants may give rise to individuals better suited to different environments (which on other occasions may not be desired).

The seeds are harvested in the region (from February to April). They must be stratified or sown immediately, otherwise they quickly lose their viability.

Stored at 5°C, they maintain a very reduced germinating capacity (1.7 to 6.6 percent) for a further 11 months. The relatively short period of viability together with the low germination rate (immature embryos, phytosanitary problems) have undoubtedly been the cause of the difficulties in its cultivation spreading to other continents in the past.

Agamic reproduction. Grafting, propagation by cuttings and layering are not very widespread. It is relatively difficult to obtain rooted cuttings and this is generally achieved by using young branches from the stools, irrespective of whether plant hormone treatment is used. Additional experiments are necessary if the intention is to increase the rooting percentage.

In vitro cultivation of *I. paraguariensis* is being tried out in Brazil and Argentina by various research groups, with varying results which still do not clearly indicate which are the economically viable techniques for the clonal reproduction of selected individuals.

According to the Under-Secretariat for Agriculture and Livestock, in Argentina in 1988, the average yield of semi-processed maté was 1220 kg per hectare.

Prospects for improvement

The limitations of cultivation are due to the fact that there is no demand for the product on a macroeconomic scale. The recurrent cycles of surplus supply, low prices, disinvestment in plantations, scarcity of raw materials, high prices—very often linked with international trading terms between producer countries, which result in a greater distortion—have historically acted against a stable supply of the product in terms of quality and quantity. Even worse, they have discouraged the continuation of basic and/or applied research, which cultivation and processing require. The partial or total absence of knowledge concerning maté biology, plant chemistry, dietetics, agronomics and industrialization have made it difficult to adopt international standards which would lay down norms for the quality of the product and improve and guarantee it over time, depending on its distribution to the major international markets for the production of methyl xanthine infusions.

Potential areas for the introduction of this crop are subtropical regions with acid soils and a water supply similar to those of the species' natural area of dispersal.

It has recently been suggested that *Ilex verticillata,* a North American species, could be a source of biodegradable detergents because of its high saponin content. Since research regarding similar subjects is being continued on *I. paraguariensis* and, furthermore, since other related species are studied even less than maté from the chemical point of view, it would be advantageous to go into these aspects more deeply.

Ilex argentina is also a possible caffeine-free maté and is, moreover, remarkable for its richness in liver-protecting phenolics similar to those in artichokes (*Cynara scolymus*).

There are also reports of a range of non-traditional uses for *I. paraguariensis*, for instance as a source of edible oils, furfural and cosmetics.

Finally, the importance of the wild *Ilex* species in genetic improvement of the crop should be mentioned.

Lines of research

- **Botanical:** Infraspecific variability of *I. paraguariensis* and how it is related to other species of the genus; an updated chorology; crossing systems of *I. paraguariensis* and other species of *Ilex;* inheritance of sex.
- Physiology of the seed and micropropagation methods.
- **Plant chemistry:** Cycle of the xanthines in the species and its relatives; toxic and undesirable compounds of allied species; analytical determination of the infusion's flavour

components.

- Updating, from the food point of view and with relation to allied species.
- Architecture of the individual of *I. paraguariensis* and of allied species; phenology and adaptation of these trees to mechanical harvesting.
- **Industrialization:** Improvements in the drying and accelerated seasoning systems without organoleptic losses; alternative industries with cultivation by-products.
- New ways of consuming and presenting the product.

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last update Friday, June 12, 1998 by aw

Common Winterberry

Ilex verticillata (L.) A. Gray.

Synonym.—*Prinos verticillata* L.

Other common names.—Prinos, winterberry, Virginia winterberry, black alder, false alder, white alder, feverbush.

Habitat and range.—This native shrub is found in swamps, moist woods, and along banks of streams in Canada and the eastern United States, and westward to Wisconsin and Missouri.

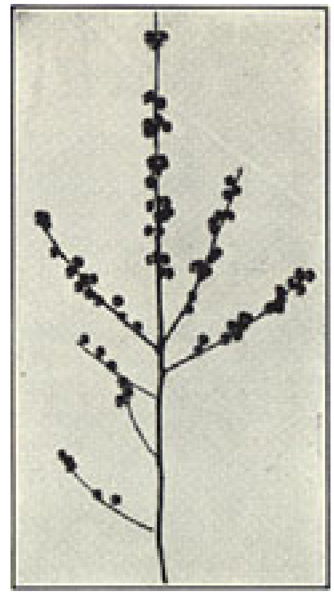

Figure 44.—Common winterberry (*Ilex verticillata*)

Description.—Common winterberry is a shrub usually from 6 to 8 feet high (sometimes much higher) with grayish bark and smooth twigs. The leaves are from 2 to 3 inches long and about an inch wide. They are usually rather thick and sharply toothed. In autumn the leaves turn black. The flowers which appear from May to July, are small and white, the male clusters consisting of 2 to 10 flowers and the female clusters of only 1 to 3. The bright-red, shining fruits about the size of a pea and each containing about six seeds, are clustered around the stem. Branches and twigs of this plant with their bright-red berries are a familiar sight during the Christmas season when they are much used for decorative purposes.

Part used.—The bark, and to a less extent the berries, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update March 18, 1998 by aw

Spondias tuberosa Arruda.

Anacardiaceae

Umbú

We have information from several sources:

South American Fruits Deserving Further Attention—Richard J. Campbell

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Imbu—Julia Morton, Fruits of warm climates

last update March 3, 1999 by ch

Indian ricegrass

Gramineae *Oryzopsis hymenoides* (Roem. and Schult.) Ricker

Source: Magness et al. 1971

This is a native bunchgrass distributed from the Dakotas south to Texas and west to the Pacific Ocean. It is drought-resistant, adapted to dry, sandy soils. The plant grows in dense clumps, up to 2 feet tall. The leaves are slender and nearly as long as the stems. It is highly palatable to livestock, both while green in summer and dried in winter. Natural stands in many areas have been greatly depleted by over grazing. This is an important species for reseeding range lands. Seeds were formerly used by Indians for grinding into meal and making bread.

Last update February 18, 1999 by ch

Indiangrass

Gramineae *Sorghastrum nutans* (L.) Nash ex Small

Source: Magness et al. 1971

This is a native bunchgrass with short rhizomes, widely distributed east of the Rocky Mountains from Canada south to the Gulf of Mexico and into Mexico. Under the best conditions stems may reach to 10 feet. Leaves are smooth and flat, near a half inch wide, elongated, narrow at the base. Indiangrass thrives best on fertile bottom soils but also occurs on sandy soils and dry slopes. It is palatable while succulent but only fairly so when dry. It is most useful in the Central and Southern Great Plains. Some selected varieties are in commerce.

Last update February 18, 1999 by ch

INDIGO

Family: Fabaceae (Leguminosae), *Indigofera* species

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Indigo refers to several species of *Indigofera*, famous for the natural blue colors obtained from leaflets and branches of this herb. Of primary importance are French indigo, *Indigofera tinctoria* L., and Guatemalan indigo, *Indigofera suffruticosa* Mill., which was formerly classified as *Indigofera anil* L. These plants are perennial shrubs with an erect stem reaching a height of 1 to 2 meters. The French and Guatemalan indigo differ in size and shape of the leaflets and pods (14.1-3). Prior to the development of synthetic aniline and indigo dyes, the indigo species were grown commercially in the East Indies, India, and parts of North, South, and Central America for export and domestic use. Popularity and economic value of the plant reached a peak during the Middle Ages, when indigo was the most important dye plant for blue color in the western portion of the world (9.1-5).

The reported life zone of *Indigofera tinctoria* is 16 to 27 degrees centigrade with an annual precipitation of 0.7 to 4.2 meters and a soil pH of 5.0 to 7.3 (4.1-31). Indigo is generally grown as a perennial shrub, although in Morocco it grows as a biennial herbaceous plant (13.1-76).

The blue dyestuff is produced during fermentation of the leaves, commonly with caustic soda or sodium hydrosulfite. A paste that exudes from fermenting plant material is processed into cakes and finely ground. The blue color develops as the material is exposed to air (13.1-76). The indigo dye is a derivative of indican, a natural constituent of several of the *Indigofera* species (14.1-19). Indican is enzymatically converted to blue indigotin (14.1-35). The colorfast dye is mixed with different mordants and other plant materials to produce a wide range of colorants. The species name *tinctoria* refers to tinctorius, meaning "of dyes" or "belonging to dyes" (14.1-3). Today almost all indigo for dyeing cotton and wool is synthesized commercially.

As a medicinal plant, indigo has been used as an emetic. The Chinese use *Indigofera tinctoria* L. to clean the liver, detoxify the blood, reduce inflammation, alleviate pain, and reduce fever (11.1-10). The powdered root of *Indigofera* cf. *patens* is used in South Africa to alleviate toothache (11.1-96). *Indigofera spirata* is known as a plant teratogen because of the presence of indospicine (11.1-96). *Indigofera endecaphylla* plant, creeping indigo, is poisonous and has been responsible for livestock death (11.1-96). *Indigofera arrecta* Hochst. ex A. Rich and *Indigofera caroliniana* Mill. are used as dye plants (9.1-5).

False, wild, and bastard indigo are names for *Baptisia tinctoria* L., a native North-American member of the Leguminosae family, whose leaves, pods, and bark are used to make a blue color. Medicinally, it is employed as an astringent, emetic, stimulant, and antiseptic. Fake indigo and *Baptisia leucantha* are reported to have caused poisonings, diarrhea, vomiting, and loss of appetite (11.1-96, 11.1-136). *Strobilanthes flaccidifolis* and *Dalea emoryi* L., known as indigo bush, have been used as indigo dye plants.

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Ipomoea aquatic Forsk

Syn.: *Ipomoea reptans* Poir.

Convolvulaceae

Sweetpotato, Camote

We have information from several sources:

Asian Vegetables—Mas Yamaguchi

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

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Ipomoea batatas (L.) Lam.

Syn.: *Ipomoea fastigiata* Choisy

Convolvulaceae

Sweetpotato, camote, batata, batata dulce, common potato, kumara, wild sweet potato

We have information from several sources:

FactSHEET—contributed by: Wanda W. Collins

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Tropical Root and Tuber Crops—Stephen K. O'Hair

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

Evaluation of Tropical Leaf Vegetables in the Virgin Islands—Manuel C. Palada and Stafford M.A. Crossman

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Midwest Vegetable Production Guide for Commercial Growers 2000

Sweetpotato—production links

The Sweet Potato—HO-136 Purdue University cooperative Extension Service

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside Links

Sweet Potato—FAO/IPGRI Technical Guidelines for the Safe Movement of Sweet Potato Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Italian ryegrass

Gramineae *Lolium multiflorum* Lam.

Source: Magness et al. 1971

This is an annual grass from Europe, grown for hay in Oregon and Washington west of the Cascade Mountains. In the Southern States it is grown as a winter annual for pasture, hay, silage and as a cover crop. The plant develops rapidly from seed, making a quick cover suitable for early grazing. It is nutritious and palatable. Many seed sources contain both Italian and perennial seed. See perennial ryegrass.

Last update February 18, 1999 by ch

Index | Search | Home

Myrciaria cauliflora Berg.

Myrtaceae

Jaboticaba, Brazilian grape, Brazilian grape tree

NewCROP has Jaboticaba information at:

Jaboticabas—Julia Morton, Fruits of Warm Climates

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Jaboticaba info:

JABOTICABA "FRUIT FACTS"(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits,including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Mungesa or Jangli Moong (*Phaseolus trilobatus* (L.) Schreb Syn. *P. trilobus* Ait)

Contributor: Pankaj Oudhia

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Common Indian Names:
Hindi: Mugani, Mudagparni, Mungawana, Trianguli, Mungesa, Jangli Moong.
Gujrati: Adabanmagi, Adavada, Magavala
Canarese: Kohesaru
Marathi: Ranmath , Ranwum
Saskrit: Koshila, Kurangika, Shimbi parni, Vanmudga
English Name: Wild gram

Family: Leguminosae

Botany: It is a trailing, straggling and suberect annual herb. Leaves are trifoliate, petioles 3–12 cm long, stipules peltate, ovate-oblong ciliate, leaflet, palmately trilobed, middle lobe larged and broadly spathulate, lateral oblong or more or less spathulate. Flowers are in sub-capitate, few flowered racemes, peduncles 10–23 cm long and yellow. Pod up to 5 cm long slightly curved. Seeds 6–12. Flowering time in India is Oct–Nov.

Distribution: In India it is found as wasteland and crop fields. Found in all most every part.

Useful parts: Leaves and fruit

Medicinal properties and uses: According to Ayurveda fruit is cooling, dry, bitter, aphrodisiac, astringent, styptic, anthelmintic and good for the eyes. Cures constipation, inflammations, fever, burning sensation, thirst, piles, dysentry, cough, gout, biliousness etc. Mungesa is one of the popular folk remedies in India. In many parts of India, the leaves and its decoction are used in case of fever and cough. It is also used in eye-diseases.

Besides medicinal uses, Mungesa is also a popular fodder. The paddy workers use the ripe fruit as breakfast during their field work. Stimulatory allelopathic effects of this weed on many agricultural crops viz. rice, wheat, chickpea etc have been reported.

Resource Person:
Pankaj Oudhia
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Homepage: www.celestine-india.com/pankajoudhia
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Mobile: 91-98271-15642
Fax: 91-771-536312

Pueraria lobata (Willd.) Ohwi

Fabaceae

Kudzu, Japanese arrowroot

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update October 7, 1996 by aw

Japanese Knotweed

Jointweed, Mexican Bamboo, Ong Toy

Polygonaceae *Polygonum cuspidatum* Sieb. and Zucc.

Source: Magness et al. 1971

Erect unarmed glabrous perennial with round-ovate leaves. The immature stems are edible and used especially by the Chinese in salads or cooked as a potherb. The long succulent young stems can be produced in the field or grown under glass. A crop grown under glass is under high humidity in water saturated soil and harvested continuously. Plants root very rapidly. This is a close relative to Smartweed.

Production in the U.S.: Limited.

Use: Mainly in salads.

Part of plant consumed: Immature stems.

Last update February 18, 1999 by ch

Japanese millet

Japanese barnyardgrass

Gramineae *Echinochloa crusgalli* var. *frumentacea* (Roxb.) W.F. Wight

Source: Magness et al. 1971

This is a warm season annual grass from Asia grown to a limited extent in the Northeastern States for green feed, silage and hay. It is superior under cool summers to sudangrass or foxtail millet. Stems reach to 4 feet or more. Leaves are large, more than 0.5 inch broad. Seed heads are dense and drooping. once exploited as "a billion dollar grass" it is now grown much less than formerly. It produces good tonnage but is coarse and only fair in feed value.

Last update February 18, 1999 by ch

Mentha spp.

Lamiaceae (Labiatae)

Mint, Apple mint, Bawles mint, Corn mint, Field mint, Pennyroyal, Peppermint, Red Mint, Scotch spearment, Spearmint

NewCrop offers information from several sources:

Peppermint and Spearmint - Midwest Vegetable Production Guide for Commercial Growers 2000

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use.

Sievers, A.F. 1930. The Herb Hunters Guide.
Peppermint
Spearmint

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Pennyroyal, *Mentha pulegium*

Outside Links to various *Mentha* information

Mentha Germplasm resources at the National Germplasm Repository, Corvallis Oregon

Information on Mint Production from Wrigley's Gum

Wm. Leman Company a leading industrial supplier of Natural and Redistilled Peppermint and Spearmint Oils

Rare and Endangered Mentha species from the Threatened Plants Database of the World Conservation Monitoring Fund

Labiatae or Lamiaceae - a taxonomic description of the mint family (from Texas)

Wild mint - *Mentha arvensis*

Egyptian mint, *Mentha niliaca*

Peppermint, *Mentha x piperita*

Corsican mint, *Mentha requienii*

JASMINE

Family: Oleaceae, *Jasminum* spp.

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

The *Jasminum* species, primarily represented by poet's *Jasminum officinale* L., and royal jasmine, *Jasminum grandiflorum* L., are an important source of natural fragrances. Poet's jasmine, also known as white jasmine, is native to the Himalayas of western China. The vine-like plant reaches a height of 10 meters, and has ovate leaves and clusters of fragrant white flowers that bloom in summer and fall. Royal jasmine, also known as Catalonian and Spanish jasmine, grows similarly to poet's jasmine but has leaflets of a different size, shorter branches, and larger flowers (11.1-50). This jasmine is most valued for its fragrance and is the most extensively cultivated. Jasmine is grown in France, Spain, Italy, and several North African and Middle Eastern countries.

The reported life zone for *Jasminum officinale* is 11 to 27 degrees centigrade with an annual precipitation of 0.3 to 2.8 meters and a soil pH of 4.9 to 8.3 (4.1-31). The perennial jasmine plants that grow outside in warm regions are grown inside as greenhouse plants in northern climates. Poet's jasmine is much more cold tolerant than royal jasmine, and cultivated jasmine plants are usually grafted onto poet's jasmine rootstocks (11.1-50, 14.1-4). Jasmine can be produced on almost any soil type, with ample water supply and full sun. Full production begins after grafting in the second year. Flowers are picked in the early morning, since they are the most fragrant at daybreak (11.1-50, 14.1-10). Flowers from higher altitudes are of a finer quality than those of lower altitudes (14.1-10).

Jasmine flower oil is extracted immediately after the flowers are collected by enfleurage or the use of volatile solvents (14.1-10). The extraction process to obtain high-quality jasmine oil is delicate and laborious. The oil contains benzyl acetate, terpineol, jasmone, benzyl benzoate, linalool, several alcohols, and other compounds 14.1-10). The concrete and absolute of jasmine are available commercially.

The flower oil is important in high-grade perfumes and cosmetics, such as creams, oils, soaps, and shampoos. Flowers are used in jasmine tea and other herbal or black teas. Several types of jasmine are used as ornamental plants.

As a medicinal plant, jasmine has traditionally been considered an aphrodisiac and calmative. The roots and leaves of some jasmine species have been used in folk medicine as an anthelmintic, active against ringworm and tapeworm (11.1-50). The plant has been employed against cancer (14.1-18).

Jasminum sambac (L.) Ait., commonly called Arabian jasmine, is a white-flowered evergreen plant, from 2 to 3 meters in height, of uncertain origin. The plant has been used to flavor teas and is reported to have antimicrobial activity (2.1-54). The names yellow jasmine and Carolina jasmine actually refer to *Gelsenium sempervirens* (L.) Ait. f., a poisonous plant of the Loganaceae family. Cape Jasmine is actually *Gardenia jasminoides* Ellis, a common gardenia of the Rubiaceae family that has fragrant flowers.

Jasmine is generally recognized as safe for human consumption as a plant extractive or essential oil (21 CFR section 182.20 [1982]).

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Jatropha curcas L.

Euphorbiaceae

Physic nut, Curcas oil, Purging nut

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links:

Physic nut—*Jatropha curcas* L.—Link to the publication on the International Plant Genetic Resources Institute web site

Twinleaf

Jeffersonia diphylla (L.) Pers.

Other common names.—Jeffersonia, rheumatism root, helmetpod, ground-squirrel pea, yellowroot.

Habitat and range.—Twinleaf inhabits rich shady woods from New York to Virginia and westward to Wisconsin.

Description.—Twinleaf is only about 6 or 8 inches in height when in flower but reaches a height of 18 inches at the fruiting stage. The long-stemmed, smooth leaves are almost completely divided into two leaflets and arise directly from the base of the plant. The white flowers measuring about 1 inch across. which appear early in spring, are borne singly on a slender stalk arising from the root and are followed by a leathery, somewhat pear-shaped capsule containing many seeds. Twinleaf has a thick, knotty, yellowish-brown, horizontal root. stock with man fibrous, much-matted roots.

Part used.—The rootstock, collected in autumn.

Figure 110.—Twinleaf (*Jeffersonia diphylla*)

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Polymnia sonchifolia Poeppig & Endlicher

Compositae

Erosus yam bean, *Jícama, Jícama de agua, Jícama, de leche*, Leafcup, Mexican potato, Potato bean, Yacón, Yam bean

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside links

Yacón can be found in Lost Crops of the Incas—from National Academy Press

Andean roots and tubers: Ahipa, arracacha, maca and yacon—by M. Hermann, J. Heller (eds.) from the International Plant Genetic Resources Institute

Walnut, Black

Juglandaceae *Juglans* sp.

Walnut, American black (Eastern black): *J. nigra* L.

Walnut, California black: *J. hindsii* (Jepson) Jepson

Walnut, Texas (New Mexico): *J. cordiformis* var. *ailantifolia* (Carr.) Rehder

Source: Magness et al. 1971

Black walnuts in the U.S. are widely distributed and are of several species, not all of which are listed. The trees vary from small, up to 20 feet, to very large, near 100 feet in height. All have long, compound leaves, with up to 20 or more leaflets. Leaflets are generally oblong-lanceolate, and smooth. In all, the nuts are encased in a semi-pulpy husk, which does not separate from the nut readily. The nut shell is thick and very hard. The kernel does not separate from the shell readily. Only the American or Eastern black is in any cultivation, and commercial cultivation of that kind is limited. Substantial quantities of the latter are gathered from native trees and marketed, mainly after shelling.

Last update June 27, 1996 bha

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Ziziphus mauritiana Lam.

syn: *Ziziphus jujuba* (L.) Lam.

Rhamnaceae

Ber, Indian jujube, Aprin, Dunks

We have information from several sources:

Indian Jujube—Julia Morton, Fruits of warm climates

New Crops as a Possible Solution for the Troubled Israeli Export Market—Y. Mizrahi and A. Nerd

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Bibliography of *Ziziphus mauritiana* from Fruits for the Future.

last update Tuesday, March 16, 1999 by aw

Juniperus communis L.

Pinaceae

Juniper

We have information from several sources:

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, April 20, 1998 by aw

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Juniperus virginiana L.

Cupressaceae
Red cedar

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Berries of some cedars have been roasted as substitutes for coffee or tea. Hemmerly (1970) gives an interesting account of the economic uses: In 1970 the uses of this species included fence posts, furniture, cedar oil, ornamental Plantings, Christmas trees, souvenirs, novelties, kindling, shavings, etc. Plastic bags of cedar shavings were used as bedding for pets. The bark of the tree is useful as tender in starting fires Boy Scout style. According to Guenther cedarwood oil comes from *Juniperus*, but white cedarwood and cedarleaf oil from *Thuja*. Cedarwood oil is used in insect repellants, perfumes and soaps. Cedar chips have been used as moth repellants. The oil also shows up in furniture polish. Refined oil is used in microscopy. Chippewa Indians used strips of bark in matting. They used the red inner bark as a source of a red dye. Widely used for boundary markers, reforestation, shelterbelt, and wild life plantings.

Folk Medicine

According to Hartwell (1967–1971), the powdered leaves are used in folk remedies for venereal warts and other excrescences. Reported to be abortifacient, diaphoretic, diuretic, emmenagogue, stimulant, sudorific, and taenifuge, red cedar is a folk remedy for arthritis, bronchitis, catarrh, debility, dropsy, rashes, rheumatism, skin ailments, venereal diseases, and warts (Duke and Wain, 1981). Cedar "apples" (see illustration), the fungal excrescences of red cedar are used as an anthelmintic. Leaves used as a stimulant, emmenagogue, and taenifuge. In Appalachia, a mixture of nuts, leaves, and twigs is boiled and inhaled as a treatment for bronchitis. In New Mexico, some Spanish-speaking people use a boiled mixture of bark and water to treat skin rash. Rappahannock used an infusion of the berries with wild ginger for asthma. Cree used the leaves as diuretic. Powdered leaves used for venereal warts and excrescences. Dakota, Omaha, Pawnee, and Ponca burned the twigs and inhaled the smoke for head colds, while patient and fumigant were enclosed in a blanket. Comanche regarded juniper as depurative; Creek used the fumes for neck cramps. Cedar decoctions or steam were also used to promote delivery. Chickasaw heated the limbs with elder in hot water and applied topically for headache. Chippewa decocted the twigs for rheumatism, Dakota used for cholera, cold, and cough; Pawnee used juniper smoke for bad dreams and nervousness, Ojibwa took bruised leaves and berries for headache. Delaware steamed juniper for rheumatism; Fox decocted the leaves to strengthen convalescents. Western Indians believed that juniper berry tea taken on three consecutive and appropriate days was considered contraceptive. Scully relates that in 1849–1850 there was an Asiatic cholera among the Teton Dakotas, killing many of them. After failing with many other medicines, Chief Red Cloud succeeded with a decoction of red cedar leaves (which does contain germicides).

Chemistry

Oil from the leaves contains borneol, cadinene, d-limonene, and α-pinene (Guenther, 1948-1952). Hager's Handbuch adds sabinene, γ-terpinene, elemoacetate, 3-carene, myrcene, 4-terpineol, citronellol, elemol, eudesmols, estragole, safrole, methyleugenol, elemicine, traces of thujene, cymene, and linalool (List and Horhammer, 1969–1979). The cedarwood oil contains ca 80% cedrene, some cedrol and pseudocedrol, and cedrenol. *Juniperus virginiana* contains the poisonous antitumor compound called podophyllotoxin (Lewis and Elvin-Lewis, 1977).

Description

Medium sized tree to 30 m, broadly pyramidical to narrowly columnar. Bark brown, shredded, short scale leaves in close overlapping pairs, forming 4-sided twigs; (juvenile leaves are longer, flat, pointed, more distant and in whorls of 3) leaves vary from yellowish green to bluish green; fragrant. Male cones 3–4 mm long, on tips of small twigs, shedding pollen as early as January, as late as March; female cones small, inconspicuous, on tips of short branches, generally receptive for pollen several days after the cones on male trees have started shedding pollen; mature as bluish black, glaucous "berries" by October–November of first year (Radford et al., 1968).

Germplasm

Reported from the North American Center of Diversity, red cedar, or cvs thereof, is reported to tolerate acid soils, frost, limestone, poor soils, sands, and slope (Duke, 1978). ($2n = 22$)

Distribution

Southwest Maine, west to Northern New York, Southern Quebec, Ontario, Michigan, Wisconsin, to Southwest North Dakota, south to West Kansas, Okalahoma to Central Texas, and east to Georgia, the most widespread and common juniper in the eastern US.

Ecology

No specific data available. Estimated to range from Warm Temperate to Boreal Dry to Moist Forest Life Zones, and to tolerate annual precipitation of 4 to 16 dm and annual temperature of 5 to 13°C. Although said to "prefer" calcareous soils, it thrives on dry hillsides and in swampy land.

Cultivation

Germination is delayed in most junipers because of embryo dormancy. Cold stratification for 30–120 days at 5°C is commonly recommended. Freezing temperatures during stratification have either arrested germination in after-ripened seed (for 3 months) or damaged them beyond germanability. Seeds should be fall-sown or stratified and spring- or fall-sown. Seeds may be drilled 6–7 mm deep in rows 15–20 cm apart, or broadcast, and seedlings should be shaded during the first summer. Do not be alarmed if seedlings turn purple in fall, but be prepared for frost heave.

Harvesting

Fruits may start bearing at age 10, and can be stripped, for seed purposes thereafter in the fall. Hemmerly (1970) mentions a Shelbyville Lumber Company in Tennessee for making oil from cedar stumps, then paying only $2/ton for stumps which were dried, chipped, and pulverized, and then steam-distilled and condensed with the oil rising to the top. The company was turning out nearly 150 kg oil per day using only three workers.

Yields and Economics

In 1950, when oil was derived almost exclusively from shavings and refuse from cedar wood utilization, more than 200 MT oil were produced. Chips and dust yield 2–2.5% oil. Following the Civil War, poor farmers along Mississippi tributaries solidified their fiscal positions by floating cedar logs to New Orleans where they were cut into staves destined for French wineries. At one time, red cedar was used for split rail fences, but the value of the wood for pencils became so high that fences were cut down and sold by the pound (Hemmerly, 1970).

Energy

Not a fast grower, trees 20–30 years old being only 6–8 m tall and 5–7.5 cm in diameter, this is not a productive firewood species, though the wood burns well. The residues after oil extraction (or pencil production) should make excellent fuels, enough to feed the distillation or sawmill.

Biotic Factors

According to Ag Handbook 271, few insects damage the trees seriously. Occasionally boring insects feed on living trees and bagworms eat the foliage. As an alternate host of cedar-apple rust, *Gymnosporangium Juniperi-virginianae*, red cedar is the enemy of apple growers. The following are reported to affect red cedar: *Aleurodiscus nivosus, Botryosphaeria ribis, Caliciopsis nigra, Cenangella deformata, Cercospora sequoiae* var. *juniperi, Chloroscypha cedrina, Coccodothis sphaeroidea, Cytospora cenisia, Daedalea juniperina, D. westii, Dothidella juniperi, Fomes annosus, F. juniperina, F. pini, F. roseus, F. subroseus, F. texanus, Gymnosporangium bermudianum, G. clavipes, G. corniculans, G. davisii, G. effusum, G. exiguum, G. exterum. G. floriforme, G. globosum, G juniperi-virginianae, G. nidus-avis, G. trachysorum, G. tubulatum, Lenzites vialis, Lophodermium juniperinum, Macrophoma,juniperina, Pestalotia funerea, Phomopsis juniperovora, Phymatotrichum omnivorum, Physalospora abdita, P. cupressi, P. obtusa, Pithya cupressina, Poria pupurea, P. subacida, Stagonospora pini, Streptothrix* spp., *Trametes americana, T. carnea, T. septum,* and *Valsa cenisia* (Browne, 1968; Ag Handbook 165). *Pratylenchus penetrans* is one nematode pest. (Golden, p.c., 1984)

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Pakchoi

Spoon cabbage, Japanese white celery mustard, Pak Choy Sum, Chinese chard, Mustard cabbage, Pak Choy, Pak Toy, Celery Mustard

Kai choy

Gai choy, Gai chow, Mustard cabbage

Cruciferae *Brassica campestris* L. (Chinese group)

Source: Magness et al. 1971

Pakchoi is quite closely related to Chinese Cabbage, which see. Pakchoi resembles miniature Swiss chard. As compared to Chinese Cabbage, the head is shorter and more loose. Kai Choy has broader petioles as compared to Pakchoi. and develops a loose bead as Pakchoi. Leaves are cupped or spoon-shaped. In culture and use Pakchoi and Kai Choy are similar to Chinese Cabbage, but exposure of edible parts to pesticides is somewhat greater. No data on production in the Continental U.S. are available, as it is included with Chinese Cabbage. Hawaii produced 655 tons on 80 acres in 1968.

Part of plant consumed: Leaves and petioles

Last update June 31, 1996 by aw

Tyler, V.E. 1999. Herbs affecting the central nervous system. p. 442–449. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Herbs Affecting the Central Nervous System

Varro E. Tyler

LAWS AND REGULATIONS GOVERNING HERBAL MEDICINES IN THE US

As a result of the existing laws and regulations, most herbal remedies (botanicals, phytomedicines) are currently marketed in the United States as dietary supplements, a food category, not as the drugs they are. This situation stems directly from the passage, in 1962, of the Kefauver–Harris Amendments to the Federal Food, Drug, and Cosmetic Act of 1938. These amendments required drugs to be proven effective prior to marketing, in addition to the purity and safety requirements already in effect.

Although the law specifically exempted from this requirement all drugs marketed prior to 1938, which included almost all of the herbal remedies, the Food and Drug Administration (FDA), by a clever application of administrative law, i.e., regulations, circumvented the will of Congress. The agency declared that although sale could continue, any unproven claim of efficacy would cause the herb to be considered as misbranded which could result in confiscation.

To determine efficacy of over-the-counter products, in 1972 the FDA established 17 panels to evaluate, on the basis of submitted information only, the data supporting such claims. The panels were not permitted to utilize anecdotal information, product popularity, nor did they conduct detailed literature surveys. Because proof of efficacy studies are extremely expensive—current estimates for new chemical entities range up to one-half billion dollars—a limited amount of data was submitted to the panels for the old botanical remedies for which patent protection and market exclusivity with consequent profitability were doubtful.

In consequence, very few herbal remedies were approved as drugs. The few that were found acceptable included capsicum (*Capsicum* spp.) as a topical analgesic, slippery elm (*Ulmus rubra* Muhl.) as a demulcent, psyllium seed and husk (*Plantago* spp.) as a laxative, and distilled extract of witch hazel (*Hamamelis virginiana* L.) as an astringent (due to the 14% alcohol added to the final preparation). On the basis of inadequate data submission, the FDA declared peppermint (*Mentha* × *piperita* L.) to be an unsafe and ineffective digestive aid and placed other useful remedies such as the antitussive eucalyptus (*Eucalyptus globulus* Labill.) and the laxative prune (*Prunus domestica* L.) concentrate in the same category.

Sales of such herbal products declined for a time but began to increase once again in the 1980s as consumers became more health conscious and displayed a significant interest in natural products. Finally in 1993, Commissioner David Kessler of the FDA threatened additional controls on such products. The public rebelled, and submitting to the will of the people, Congress passed the Dietary Supplement Health and Education Act of 1994. That Act permits any herb sold in the United States prior to October 1994 to continue to be marketed as a dietary supplement (food) without FDA approval.

Labeling of such products is, however, restricted. Therapeutic claims are not permitted. This prompts the potential user to turn to the herbal literature, much of which is hyperbolic and advocacy in nature—especially on the internet—designed to promote sale of the product. Claims regarding the effect of the remedy on the structure or function of the human body are permitted on the label, but such a statement must be followed by another indicating the claim has not been approved by the FDA. A third statement must then follow indicating the product is not intended to diagnose, treat, cure, or prevent any disease. That, of course, is why the potential user wanted to purchase the product in the first place, so the entire situation becomes very confusing, even to the sophisticated consumer.

Another serious problem with the herbal product status quo is the total lack of quality standards for such preparations. Products and the companies selling them range from very bad to very good. Consumers have few resources to determine which is which, and published analyses of particular brands have been quite limited, probably due to the fear of litigation.

Other advanced nations have solved the herbal problem in one of two ways. The first is simply to allow botanicals to be sold as "traditional" drugs whose efficacy is based on long usage and anecdotal information, not on scientific or clinical studies. This is not a satisfactory solution because many of such claims of utility remain unverified.

The best solution, without question, is to modify existing regulations to allow herbal remedies to be sold as drugs, with appropriate quality standards, following absolute proof of safety and "reasonable" proof of efficacy. The reasonable qualification would allow the marketing of a product with a research investment of perhaps a few million dollars as opposed to the hundreds of millions now required. Such an expenditure is just a small fraction of the marketing budget of many herbal product manufacturers.

This type of drug approval is the one that exists today in Germany. It has functioned well there for decades, and no serious problems have been encountered. Safety and efficacy are determined by an independent panel of experts, designated Commission E, appointed by the German equivalent of our FDA. The Presidential Commission on Dietary Supplement Labels recommended the appointment of a similar panel in the United States to evaluate herbal safety and efficacy. So far, the FDA has not acted upon that recommendation nor has the agency given any indication that it will do so. Likewise, the FDA has not acted upon a long-standing petition that would allow the safety and utility of herbs to be evaluated as OTC remedies on the basis of the voluminous scientific and clinical studies already carried out in European countries, especially Germany.

Adherence to standards for drug approval designed for new synthetic chemical entities is obviously not realistic for long-used herbal remedies. In view of the fact that one-third of the adult population in this country now employs herbal remedies and the retail market approximates $4 billion annually, serious consideration needs to be given to modifying outdated regulations. A change is urgently required to assure that consumers will be supplied with quality products providing appropriate information regarding their therapeutic utility directly on the label.

Among the numerous botanicals marketed in the United States today are several that produce significant direct or indirect effects on the central nervous system. Some of the more prominent ones have been extensively studied with respect to their chemical composition and physiological and therapeutic activities. Others continue to be employed largely on the basis of their folkloric reputations as useful remedies.

CONSIDERATION OF SPECIFIC HERBS

Ephedra or Ma Huang (*Ephedra* spp.)

Ephedra, commonly referred to by its Chinese name *ma huang*, has received much publicity recently. The herb consists of the dried green stems of several species of *Ephedra* native to Central Asia. These include *E. distachya* L., *E. equisetina* Bunge., and *E. sinica* Stapf. Ma huang has been used in China for the treatment of bronchial asthma and related conditions for more than 5000 years.

The therapeutic use of ephedra is due to its content of several closely related alkaloids of which ephedrine is both the most active and the one present in largest amount. A typical ephedra plant contains about 1.5% total alkaloids of which some 80% is ephedrine. American species of *Ephedra*, one of which is *E. nevadensis* S. Wats., often referred to as Mormon tea, contain no active alkaloids. Ephedrine was carefully researched here in the United States during the 1920s and was a standard over-the-counter (OTC) medication for many years. Like all other effective medications, it may also produce undesirable side effects.

The alkaloid's vasoconstricting effect makes it a useful nasal decongestant, but it also raises blood pressure and increases heart rate. It is an effective bronchodilator, but it also stimulates the central nervous system (CNS) with side effects ranging from nervousness to insomnia. This stimulation is greatly increased by consumption of caffeine or caffeine beverages such as coffee, tea, or cola. Consequently, ephedrine has been replaced to a large extent in over-the-counter cold and cough products by related chemicals such as pseudoephedrine or phenylpropanolamine. These have a similar action but much reduced CNS effects.

In recent years, ephedra and caffeine combination products have been promoted as appetite depressants and metabolic stimulants for weight loss, as athletic performance enhancers and, in very large doses, legal euphoriants or intoxicants. There is a considerable literature about the effects of ephedra on weight loss with some modestly favorable results. As one of my pharmacologist friends quipped, "You're bound to lose weight if you take ephedra and caffeine because you'll be so hyper the soup will slop out of the spoon before it reaches your mouth." That is, of course, a slight exaggeration.

Detailed studies of the herb's effect on athletic performance or its euphoriant activities do not exist. But that is of little moment because ephedra should not be taken chronically for any purpose unless the consumer is under the direct care of a competent physician. Many of the herbal products do not list the concentration of ephedrine present. Some manufacturers almost certainly "spike" their dosage forms with additional quantities of synthetic ephedrine.

As a result, the Food and Drug Administration (FDA) convened a special advisory group on ephedra in October 1995. That committee of experts made a number of recommendations regarding the sale of ephedra products, including strict dosage limitations, appropriate warning labels preventing chronic use, prohibition of sale to persons under age 18, and warnings to individuals with specific health risks.

These recommendations were never implemented, although in April 1996 the FDA did issue a warning cautioning consumers not to buy any high-dose ephedra products marketed as "legal highs." By August 1996, the FDA had compiled a list of some 800 adverse reactions, including 22 deaths and a number of serious cardiovascular and nervous system effects, including heart attack, stroke, and seizures, which they attributed to the consumption of ephedra, often in combination with caffeine-containing herbs. (The numbers in both categories have increased significantly since that time.) Consequently, another special advisory group meeting was held, but after lengthy discussion, no consensus was reached, and no concrete recommendations were made.

Food and Drug Commissioner David A. Kessler, who attended the meeting, said the agency would consider the matter and act quickly on ephedra's marketability, almost certainly before the end of 1996. He subsequently resigned, and no action was taken prior to the self-imposed deadline.

Finally, in June 1997, the FDA requested comment on a series of proposed restrictions on the sale of ephedra as a dietary supplement. These included a limitation of 8 mg per dose of ephedra alkaloids, labels warning consumers not to take more than 24 mg of ephedra alkaloids per day, labels advising at-risk persons not to consume ephedra, and limitation of consumption to a maximum of 7 days. As of June 1999, these proposed regulations have never been implemented.

Several states have acted, or are considering action, to control ephedra products. Most authorities continue to believe that small doses of ephedra, equivalent to not more than 40 mg of ephedrine per day, consumed on an occasional, not a chronic, basis for the relief of bronchial asthma, are safe for otherwise normal persons.

Another concern often expressed about ephedra is the possibility that the contained ephedrine may be illegally converted to methamphetamine or "speed," a common drug of abuse, by basement chemists. Although this is possible, it is not likely because of the difficulty in separating the product from the accompanying plant material. A much more likely starting product is pseudoephedrine which is readily available in pure form. Indeed, large-scale sales of that alkaloid are now monitored by the Drug Enforcement Administration (DEA).

Ephedra remains a prime example of an age-old dilemma in medicine. Must a useful therapeutic agent be banned because of its abuse potential? In many cases, this has proven to be necessary. Whether ephedra herb falls in this category remains to be seen.

Ginkgo (*Ginkgo biloba* L.)

An important breakthrough in herbal medicine took place in October 1997 when the *Journal of the American Medical Association* published the results of the first clinical trial conducted in the United States of the effect of *Ginkgo biloba* extract (GBE) on patients suffering from mild to severe dementia caused by Alzheimer's disease or multiple clots in the blood vessels. The generally positive results showing modest improvement in the cognitive performance and social functioning of the demented patients basically confirmed results previously obtained in European studies. Some 36 clinical trials with GBE had been conducted there between 1975 and 1996.

The ginkgo tree is well-known, particularly to residents of our large cities where its resistance to pollution and its overall toughness has caused it to be much planted as an ornamental along the very busy streets. This resistance to stress has enabled the species to survive for at least 70 million years; it is often referred to as a living fossil.

The seeds of the tree, after removal of the smelly, outer fleshy layer, have been used in China, both as a medicine and a food, for thousands of years, but it is the dried green leaves, not the seeds, that yield the herbal medicine that has become so popular today. Research beginning in the 1930s identified a number of constituents in the leaves, and in 1965 a product containing 24% flavone glycosides and 6% terpenes (ginkgolides A,B,C, and bilobalide) was first marketed for the treatment of conditions resulting from cerebral and peripheral circulatory disturbances. The product subsequently became very popular as an approved drug in Germany where sales in 1996 exceeded $163 million.

GBE is used primarily to treat cognitive deficiency, a condition caused by inadequate blood flow and nerve degeneration in the brain and expressed by symptoms such as vertigo, tinnitus, headache, short-term memory loss, reduced vigilance and concentration, and confusion. It is also useful in peripheral vascular disorders, having been shown to increase pain-free walking distance in patients with intermittent claudication. Evidence is also accumulating to support the value of GBE in alleviating sexual problems in males, particularly in those whose erectile dysfunction has been induced by the consumption of various antidepressant drugs.

Just how does GBE function to produce all of these beneficial effects? As is often the case with herbs, no single compound and no one mechanism is responsible. The ginkgo flavonoids reduce harmful brain effects by preventing the activity of enzymes that produce damaging free radicals.

They also act as antioxidants scavenging any free oxygen radicals that are formed. In addition, they affect calcium transport which has a powerful influence on brain metabolism.

The sesquiterpene bilobalide reduces increased water and electrolyte levels in damaged brain tissue. The diterpene ginkgolides are potent platelet activating factor (PAF) inhibitors. PAF can contribute to brain damage not only by inducing thrombosis but also by increasing the permeability of blood vessels, allowing liquid to seep through them into brain tissue. This is likely to result in nerve damage.

In contrast to many synthetic drugs (halperidol, fluoxetine, and tacrine) for the treatment of dementia, GBE exerts its beneficial action with a much lower incidence of side effects. Only 1.67% of 10,632 patients treated with ginkgo experienced mild stomach upsets, headache, or allergic reactions in comparison to 5.42% of 2,325 patients treated with synthetic drugs who suffered these or more serious reactions.

The customary daily dose of GBE is 120–240 mg taken in 2 or 3 separate doses. A minimal 8-week course of treatment is recommended for cognitive deficiency. Contraindications to ginkgo therapy are not known, but because it does inhibit PAF, the herb should be administered cautiously in patients undergoing anticoagulant therapy utilizing either other herbs, e.g., garlic (*Allium sativum* L.), ginger (*Zingiber officinale* Roscoe), feverfew [*Tanacetum parthenium* (L.) Schultz Bip.], or synthetic drugs (warfarin).

Consumption of unprocessed ginkgo leaves in any form, including teas, should be avoided because they contain several potent allergens known as ginkgolic acids. These compounds, removed during processing of GBE, are chemically related to urushiol, the active principle in poison ivy [*Toxicodendron radicans* (L.) Ktze.]. Current regulations in Germany limit the concentration of ginkgolic acids in ginkgo preparations to a maximum of 5 parts per million. No standard has been established in the United States, but quality products do not exceed that level.

The GBE preparations long marketed worldwide are concentrated about 50-fold and contain 24% flavone glycosides and 6% terpenes, often designated 24/6. Recently, one company has made available a 27/7 product prepared by a method that increases the ginkgolide B concentration. Studies show that it produces a higher concentration of ginkgolides in the blood for a longer period of time, thus enhancing the effects of the herb.

In contrast to such improved products, it is believed that there are many substandard GBE preparations on the market today. Because of the extensive processing required, ginkgo is relatively expensive to produce, and the standard 50–60 mg tablets usually retail in the $10–$15 range for 60 capsules, depending on the brand. So-called bargain herbs, sometimes selling for a dollar or two for the same quantity, are very likely not bargains at all.

Sometimes one sees ginkgo advertisements touting it as a "smart pill" that improves the cognitive function of persons in the absence of any pathological condition. There is practically no evidence to show that the herb produces significant beneficial effects in the normal human brain.

St. John's Wort (*Hypericum perforatum* L.)

Depression, at least in its milder forms, is a condition that seems to afflict many Americans, occasionally if not chronically. In this country, the disease is the fourth most likely reason for one to consult a family physician and costs our economy more than chronic respiratory illness, diabetes, arthritis, or hypertension. The treatment and rehabilitation expenses in the United States exceed $12 billion annually; but the true cost, including loss of earnings, absenteeism, and loss of productivity, totals nearly $44 billion annually.

Depression is characterized by a number of subjective complaints ranging from despondency and loss of interest to irritability and sleep and digestive disorders. One authority has noted that the depressed patient suffers from melancholia about the present, guilt about the past, and anxiety about the future. Mild to moderate depressive symptoms occur in 13–20% of the population; major depression, often characterized by suicidal tendencies, plagues 1.5–5%.

More than a dozen prescription drugs are routinely used to treat America's depression. All of them are synthetic, and they all produce more or less unpleasant side effects ranging from skin rashes to overtly violent behavior. Meanwhile, in Germany the most popular prescription drug of any type, natural or synthetic, for the treatment of depression is a concentrated extract of the flowers and leaves of St. John's wort, often simply called hypericum. More than 200,000 prescriptions per month are filled for a single brand (Jarsin) there compared to about 30,000 per month for fluoxetine (Prozac). This figure does not include sales of other hypericum products, whether prescribed or self-selected. Actually, 80–90% of the sales in Germany are prescriptions, which allows their cost to be reimbursed by the health insurance system.

During the past two years, St. John's wort has become extremely popular in the United States. In 1996, it was not even listed among the best-selling herbs. Now it is one of the five most popular botanicals. Favorable publicity on television, and subsequently in the popular press, had much to do with this phenomenal increase in use.

Many clinical trials show St. John's wort to be especially useful in treating mild to moderate depressive states. Studies in 3,250 patients found improvement or total freedom from symptoms in about 80% of the cases treated, with only 15% not responding. These results are typical of all drug therapies for depression. However, the side effects were far fewer than those observed with conventional antidepressants. The incidence was less than 2.5% and consisted mainly of gastrointestinal disturbances and allergic reactions.

The herb's multiple constituents apparently function in several different ways. Initially, St. John's wort was thought to act as a monoamine oxidase (MAO) inhibitor. This effect has now been shown to be insignificant. Some evidence supports its effect as a selective serotonin reuptake inhibitor (SSRI).

It may also inhibit COMT (catechol-*O*-methyltransferase), an enzyme capable of destroying biological amines. Still another mechanism seems to suppress interleukin-6 release, affecting mood through neurohormonal pathways. The advantage of this combined action is fewer side effects for the patient because the total response is not due to a single type of activity.

Some authorities have warned against exposure to sunlight while consuming hypericum because it may induce photosensitivity with its dermatitis and associated inflammation. However, while light-skinned animals grazing on great quantities of the herb have had such reactions, photosensitivity is very uncommon in people taking it in normal amounts. It has occurred in patients injected intravenously with very large amounts of hypericin—50 to 70 times the normal oral dose.

Although St. John's wort is marketed as a drug in Germany and has been approved there by the German equivalent of our Food and Drug Administration for the treatment of depression, anxiety, and nervous unrest, it is sold in the United States only as a dietary supplement. The most effective preparations are capsules containing an extract of the herb standardized on the basis of 0.3% hypericin. Dosage is 300–900 mg daily. Improvement of mild to moderate depression should result after 2 to 6 weeks of treatment.

Kava (*Piper methysticum* G. Forst.)

The first Europeans to observe the kava plant and its ritualistic consumption by natives of Oceania were Dutch explorers Jacob Le Maire and William Schouten. In 1616, they encountered the plant in the Hoorn Islands, now a part of the French territory Wallis and Fatuna. Later travelers in the Pacific region provided a wealth of detail regarding this highly valued and widely used pepper plant.

Long cultivated and known by a number of common names, including *kava-kava*, *ava*, *yagona*, and *yangona*, the plant is now classified by botanists as *Piper methysticum*, meaning "intoxicating pepper." In religious and social rituals that naturally vary somewhat from island to island, the rhizome of the plant is grated (originally chewed by young people with sound teeth), mixed with water in a bowl, strained, and the resulting beverage drunk to produce a feeling of well-being.

Observers and even scientists long disagreed on the effects of kava. Captain James Cook, who observed its use during his world voyage of 1768–1771, thought the symptoms resembled those of opium. Lewis Lewin, a pioneer pharmacologist in the field of mind-altering drugs, referred to it in the 1880s as a narcotic and sedative, but noted these effects followed a period of quiet euphoria. Modern authorities call kava a psychoactive agent; it reduces anxiety much like the potent, synthetic benzodiazapines (e.g., Valium) and is a potent muscle relaxant. Kava does promote relaxation and sociability, but its effects are very different from those produced by either alcohol or synthetic tranquilizers. It does not produce a hangover, and, even more significant, it does not cause dependency or addiction.

Naturally, people were interested in finding out how kava produced these interesting effects. It was once thought that chewing the root converted its starch into sugar which then fermented to produce alcohol. Although this sounds far-fetched, *chicha*, a corn-based beer brewed by natives in Peru and Bolivia, is prepared in just this fashion. Lewin said a resinous material was the active component. Finally in the 1950s and 60s, two teams of German scientists headed by H.J. Meyer in Freiburg and R. Hänsel in Berlin found that the various activities of the kava plant were due to some 15 different chemical compounds known as pyrones. Collectively named kavapyrones or kavalactones, the compounds were found to increase the sedative action of barbiturates, to have both analgesic and local anesthetic effects, to cause muscles to relax, and to have antifungal properties.

Shortly after these findings, preparations of kava extract began to appear on the European market, usually standardized to provide a daily dosage in the range of 60–120 mg of kavapyrones. German Commission E, the group responsible for evaluating the safety and efficacy of botanical medicines, reviewed the data on kava and, in 1990, approved its use for conditions such as nervous anxiety, stress, and restlessness. It is frequently marketed as an anxiolytic. Use of kava is contraindicated during pregnancy, nursing, and in cases of depression caused by internal factors.

With an herb as potent as this one, there is naturally concern about side effects. Observations on 4,049 patients consuming 105 mg of kavapyrones daily for 7 weeks noted 61 cases (1.5%) of undesired effects. These were mostly mild and reversible gastrointestinal disturbances or allergic skin reactions. A 4-week study of 3,029 patients taking 240 mg of kavapyrones daily produced a slightly greater incidence (2.3%) of similar side effects. This would be expected because of the larger dosages used.

Long-term consumption of very large quantities of kava may result in a yellow coloration of the skin, nails, and hair, allergic skin reactions, visual and oculomotor equilibrium disturbances. For this reason, Commission E recommends that kava not be consumed for longer than 3 months without medical advice. Driving and operating machinery during consumption should be avoided.

The results of 5 controlled, double-blind clinical trials carried out with a total of 410 subjects over periods ranging from 28 to 84 days, using daily doses of kavapyrones between 30 and 210 mg, were all positive. For example, in 1995, 100 patients suffering anxiety and stress symptoms were given 210 mg of kavapyrones daily. After 8 weeks, the treated subjects were clearly improved in comparison to those receiving a placebo. As for side effects, 15 persons receiving the placebo reported them in comparison to only 5 taking kava extract.

Kava products have been steady but unspectacular sellers in Europe for several decades. Until recently, no one in the United States seemed much interested in them. Ironically, when the Food and Drug Administration began to express concern over the safety of ephedra, a stimulant herbal product, herb marketers became enthusiastic about kava, a depressant. Both herbs have psychoactive properties, but the effects are almost exactly opposite.

Kava and its contained pyrones are, without question, effective medications. They are also subject to abuse. The kava scenario in this country is just beginning. It is too early to predict whether it will continue to be marketed freely or will eventually be subjected to rigid controls.

Valerian (*Valeriana officinalis* L.)

The dried rhizome and roots of this tall perennial herb have enjoyed a considerable reputation as a minor tranquilizer and sleep aid for more than 1000 years. They contain from 0.3% to 0.7% of an unpleasant-smelling volatile oil containing bornyl acetate and the sesquiterpene derivatives valerenic acid and acetoxyvalerenic acid. Also present is 0.5% to 2% of a mixture of lipophilic iridoid principles known as valepotriates. These bicyclic monoterpenes are quite unstable and occur only in the fresh plant material or in that dried at temperatures under 40°C. In addition, various sugars, amino acids, free fatty acids, and aromatic acids have been isolated from the drug.

Identity of the active principles of valerian has been a subject of controversy for many years. Initially, the calmative effect was attributed to the volatile oil; indeed, this kind of activity was long associated with most herbs containing oils with disagreeable odors. Then, beginning in 1966 with the isolation of the valepotriates, the property was attributed to them for a 20-year period. This was done in spite of the fact that they were highly unstable and were contained in most valerian preparations only in small amounts. Finally, in 1988, it was shown that although valerian did produce CNS depression, neither the tested valepotriates, nor the sesquiterpenes valerenic acid or valeranone, nor the volatile oil itself displayed any such effect in rats. Although the active principles of valerian remain unidentified, it seems possible that a combination of volatile oil, valepotriates, and possibly certain water-soluble constituents may be involved.

Because the valepotriates possess an epoxide structure, they demonstrate alkylating activity in cell cultures. This caused concern that the herb might possess potential toxicity. However, those valepotriates decompose rapidly in the stored drug and also are not readily absorbed. For these reasons, no toxicity has ever been demonstrated in intact animals or human beings, so there is no cause for concern.

Eight clinical studies conducted between 1977 and 1996 have shown that valerian is not a suitable herb for the acute treatment of insomnia. Rather, its principal utility lies in its ability to promote natural sleep after several weeks of use, without risk of dependence or adverse health effects. Users should realize the prolonged length of time required for valerian to exert its effectiveness. When properly employed, it offers a gentle alternative to synthetic hypnotics and benzodiazapines in patients with chronic sleep disorders. Recommended dosage is 2–3 g one or more times daily.

Miscellaneous CNS-Depressant Herbs

There are several botanicals with a folkloric reputation for utility in the treatment of restlessness and sleep disturbances whose efficacy is largely unproven by scientific methods. Some of them are frequently used in combination with other CNS depressants in proprietary herbal products.

Hops, the dried strobiles of *Humulus lupulus* L., is one of these. Although very small amounts of methylbutanol, a compound with sedative effects, have been detected in hops, clinical studies have not verified any such activity of the herb in human subjects.

Balm or lemon balm, the leaves of *Melissa officinalis* L., has long been purported to have sedative effects. In the only experimental study to date, its volatile oil did show some activity, but the results were not dose dependent. This suggests the effects were nonspecific.

Passion flower, the dried above-ground parts of *Passiflora incarnata* L., has an ancient reputation as a sleep aid. However, no controlled clinical trials have ever been conducted on single-herb preparations, so preliminary positive results in the few animal studies have not been verified.

Lavender, the dried flowers of *Lavandula angustifolia* Mill., yield a volatile oil, the calming and relaxing effects of which are better documented by both empirical medicine and experimental studies than the three previous herbs. Apparently, its actions are mediated by olfactory receptors, but it may possibly act directly on the CNS following systemic administration. Suitable research in human subjects is required to verify preliminary observations.

The German Commission E approved hops as a calming and sleep promoting drug, lemon balm as a sedative, passion flower for nervous restlessness, and lavender flower as a sedative. There is little or nothing in the published scientific or clinical literature to substantiate these recommendations.

This concludes a brief survey of the herbs that have either been demonstrated to have significant effects on the central nervous system or are postulated to have such effects. Because this broad overview does not present original research findings, specific references to previously established facts are not listed. They are simply too numerous to include. Instead, a general list of recommended reading in which all appropriate references may be found is presented here.

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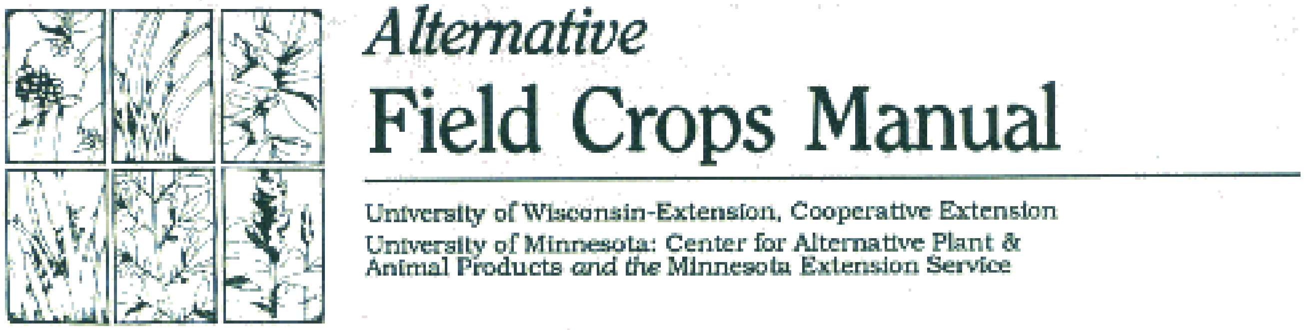

Kochia

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I. History:

Kochia (*Kochia scoparia* (L.) Roth), also known as fireweed, burning bush or summer cypress, was introduced to the United States around 1900 as an ornamental from Eurasia. Gardeners like this annual plant for its bright red foliage in autumn.

Farmers in dry areas, including the Southwest, have grown kochia as a drought-resistant forage crop on lands where other crops are difficult to grow -- hence the nickname "poor man's alfalfa." Because of kochia's low water requirements and resistance to diseases and insects, interest in it as a forage crop has increased in the last decade. Researchers at South Dakota State College have selected seeds from wild plants and produced satisfactory yields of leafy foliage.

Kochia, with its high protein content, requires relatively large amounts of nitrogen (100 to 250 lb/acre). If too much nitrogen is applied at once, however, toxic levels of nitrate may accumulate in the plants. Oxalate toxicity, which causes rough hair, humpback, jaundice, photosensitization and a stiff gait in livestock, is another potential problem for cattle that graze only on kochia for periods of 90 to 120 days.

Kochia grows wild throughout most of the northern half of the United States, except for parts of the Pacific Northwest. **The plant has become a serious drought-resistant weed in the Plains states.** Because of the wide genetic variability in wild kochia, it is possible that the problems associated with the plant as a forage crop can be overcome with plant breeding.

II. Uses:

Kochia is grown as a forage crop for sheep and cattle and as an ornamental. As a forage crop its feed value is slightly lower than that of alfalfa. Protein content ranges from 11 to 22%, and decreases as the plant matures. When cut at the recommended stage, kochia hay contains up to 60% leaves and has good aroma. Palatability of kochia is better than that of grasses, such as bromegrass, but a little lower than that of alfalfa. No objectionable milk flavor results from feeding kochia hay.

Oxalate levels for kochia range from 6 to 9%. Feeding calcium phosphate and other kinds of feed (such as alfalfa) tends to reduce oxalate toxicity. Animals with symptoms of oxalate toxicity should be removed from kochia immediately.

Kochia can be used in revegetation programs for erosion control. It will germinate and grow at any time in the growing season, and it thrives in sandy, alkaline and other poor soils. Kochia can be sown by airplane on large areas that need revegetation, such as areas that have been devastated by fire. It provides a quick groundcover to protect topsoil and provide a food source for wildlife until native grasses take over.

III. Growth Habits:

Kochia is an annual forb that reproduces by seed. The bushy plants grow 1 to 7 ft tall and have taproots. The erect, striated stems are light green and much branched. The many alternate leaves are hairy, 1 to 2 in. long, narrow, pointed and attached directly to the stems. Small, green flowers and seeds are produced in narrow heads at the leaf axils. The plant is dark green when young and turns red as it matures. The seeds, when mature, are rough, flat, triangular and grayish-black in color. In the fall, the plants often break away from the roots and tumble over the ground, scattering the seeds.

IV. Environment Requirements:

A. Climate:

Kochia grows wild throughout much of the country, including the Upper Midwest. It can produce forage with as little as 6 in. of annual rainfall and is relatively cold hardy. It can be planted when soil temperatures are as low as 50°F.

B. Soil:

Kochia is grown on dry pastures, rangelands and cropland with alkaline soils. It will grow on land where other crops will not. Wild kochia has not spread to areas with very acid soils, and it is not known how well kochia would perform in such soils.

C. Seed Preparation and Germination:

The seed needs no treatment prior to planting. A properly managed kochia field will reseed itself. Grazed plants appear to produce more seed than the ungrazed ones, providing there is enough plant remaining at normal seeding time to provide seed shoots.

V. Cultural Practices:

A. Seedbed Preparation:

For best results, the soil should be plowed or disked to provide a firm, even and relatively weed-free seedbed. Nitrogen at 50 to 100 lb/acre should be applied prior to planting.

B. Seeding Date:

Kochia should be seeded as early as the soil temperature reaches 50°F (late April to early May) and anytime thereafter throughout the growing season.

C. Method and Rate of Seeding:

Seeding rates vary from 1 to 4 lb/acre, depending on the seeding method. Drilling as little as 1 lb/acre in 36 in. rows with a standard drill will result in a good stand; broadcast or airplane seeding requires more seed.

Though kochia seed does not need to be incorporated, research conducted in New Mexico indicates that a 1/4 in. seeding depth results in best emergence. Emergence is poor when seed is planted 3/4 in. deep or deeper.

Most kochia stands need thinning to prevent the crop from crowding itself out, particularly if a volunteer crop emerges the second year. The crop can be thinned to 2 to 10 plants/ft of row by chiseling at right angles or windrowing portions of the field and letting livestock clean up the dry feed as they graze the green material. Another method is to let cattle graze the kochia field for a short time when the plants are only 2 in. high.

D. Fertility and Lime Requirements:

Kochia is well adapted to alkaline soils, but it is not known how well it does on acid soils. Therefore, lime to a pH of 6.0; or try liming to different pH levels and observe the performance at each.

Because kochia is not a legume, nitrogen needs to be applied in proportion to the amount removed. This amounts to 40 to 60 lb N/ton of hay removed, or 100 to 250 lb N/acre. Do not apply more than 150 lb N/acre in one application, or nitrate toxicity can result. Apply 50 to 100 lb/acre prior to planting, and topdress the remainder later in the season based on anticipated yield.

Kochia responds very little to phosphorus and is low in this element. Cattle grazing on kochia should be fed supplemental phosphorus. Under conditions of adequate moisture, high phosphorus, zinc and boron levels suppress yield. The use of manure to supply nitrogen will likely result in excess phosphorus. Because the potash requirements of kochia are not known, adjust soil K to a medium level. Experiment with additional potash to find a rate suitable for your growing conditions. Suggested rates are 24 to 50 lb K_2O/ton of hay harvested.

E. Variety Selection:

Though there is wide genetic variability in wild kochia, no improved varieties have been developed.

F. Weed Control:

Kochia does not compete well with grasses. This will be a major limitation to use in the Upper Midwest. It is best to plant kochia on a relatively weed-free seedbed with no quackgrass or other grassy weed history. There are no herbicides registered for use in kochia.

Volunteer kochia will be a problem in crops following kochia, thus cultural or chemical control of kochia will be needed in these crops.

G. Diseases and Their Control:

Kochia appears to be free of diseases that cause commercial loss.

H. Insects and Other Predators and Their Control:

Kochia is relatively unharmed by grasshoppers. No information is available on other predators.

I. Harvesting:

1. For pasture: To prevent oxalate toxicity, livestock should not graze on only kochia for more than 90 to 120 days. Rotational grazing of other crops will prevent oxalate poisoning. In contrast to perennials, the entire kochia plant can be eaten.

2. For hay or silage: Kochia should be cut for hay or silage when it is 18 to 26 in. tall and before it has produced seed. In the Southwest, three or four cuttings are possible in a growing season if live branches are left on the stubble each time.

If the kochia crop is thin, it can be cut with a mower with a windrower attachment. Thick stands should be windrowed with a side-delivery rake. The hay can be cured in the windrow or in shocks.

3. For seed: Seed can be harvested using a combine.

J. Drying and Storage:

It may take up to one day longer to field cure kochia hay than it does for alfalfa hay. Because kochia plants are hairy, the cured forage has a gray color which may resemble mold or spoilage. Hay can be stored in stacks or bales.

VI. Yield Potential and Performance Results:

Kochia produces hay yields of 1 to 4 ton/acre (dry matter) and seed yields of 1,500 to 2,000 lb/acre.

VII. Economics of Production and Markets:

Kochia is relatively inexpensive to produce and well adapted for use on dry or low fertility land. Markets for seed are few in number and may be difficult to identify.

VIII. Information Sources:

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References to seed dealers and pesticide products in this publication are for your convenience and are not an endorsement of one product over other similar products. You are responsible for using pesticides according to the manufacturer's current label directions. Follow directions exactly to protect people and the environment from pesticide exposure. Failure to do so violates the law.

Kohlrabi

Stem turnip, Colinabo

Cruciciferae *Brassica oleracea* L. (Gongylodes group)

Source: Magness et al. 1971

Kohlrabi is a cabbage relative. grown for the turnip-like enlargement of the stem just above ground level. Plants are grown from seed, and must be grown rapidly for good quality "bulbs." Leaves rise from the enlarged stem. The enlargement is globose or flattened, and 2 to 3 inches across at harvest. The "bulbs" are tender and succulent if rapidly grown and harvested, but become tough and fibrous with age. For eating, the peel is removed, and the interior sliced or diced and boiled.

Season, seeding to harvest: 2 months.

Production in the U.S.: 147 acres reported in 1954 census. No later data. Mainly in home gardens.

Use: Fresh or cooked vegetable.

Part of plant consumed: Enlarged, bulb-like stem, after peeling.

Last update February 18, 1999 by ch

Sunolgrass

Graminea *Phalaris coerulescens* Dessf.

Koleagrass

***P. tuberosa* var *hirtiglumis* Batt. and Trab.**

Source: Magness et al. 1971

Sunolgrass, introduced from Australia in 1935, and Koleagrass, introduced from Morocco in 1955, are not being grown commercially at present in the United States but are in testing proorams to determine their usefulness. Both are bunchgrasses that have round bulb-like enlargements at the base of the stems. Both are rapid growers. Sunolgrass is a poor seed producer so Koleagrass, which produces ample seed, is of more promise. Adaptation of both is limited to areas having mild winters.

Last update February 18, 1999 by ch

Korean lespedeza

Leguminosae *Lespedeza stipulacea* Maxim.

Source: Magness et al. 1971

Korean is an annual lespedeza introduced into the United States in 1919. It is adapted to a more northern area than striate varieties. It is mainly grown from Eastern Oklahoma and Kansas eastward to the Atlantic Seaboard. Leaves are broader and somewhat larger than striate leaves, and seed is borne somewhat differently. Otherwise, the two annual lespedezas are quite similar. Korean lespedeza is excellent both for hay and pasture, especially on soils that are acid or of low fertility. It reseeds readily to give semipermanent pasture.

Last update February 18, 1999 by ch

New Crop FactSHEET

Kura Clover

Contributor: Norman L. Taylor

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Common Names

USA: Pellet's clover, honey clover, kura clover
Australia & New Zealand: caucasian clover
Other languages: unknown

Scientific Names

Species: *Trifolium ambiguum* Bieb
Family: Leguminosae (Fabaceae)

Uses

Cultivated as a forage legume for grazing. Formerly some usage as a source of nectar for honey production.

Origin

Caucasian Russia, Crimea, and Asia Minor

Crop Status

A strong perennial spreading by rhizomes. It is receiving some interest in USA, New Zealand, and Australia for use in pasture mixtures. It is apparently quite nutritious and persists many years in mixtures with grasses. Persistency is due in part to its heavy root biomass; up to 20 metric tons/ha. Root:shoot ratios in a 13 -year old stand were reported to be up to 4.6:1. Little or no domestic use occurs in countries of origin. In USA, livestock producers have sown very few acres primarily because of seed limitations. The cultivar Rhizo is being increased by commercial seed companies.

Botany

Taxonomy

The species is classified by most authorities in section Lotoidea, subsection VII Platystylium of the genus *Trifolium*. Three ploidies occur; diploid, tetraploid, and hexaploid, which are reproductively isolated. Hexaploids are generally, but not always, the most vigorous but cultivars have been developed at each ploidy level. Kura clover is closely related to *T. repens* and *T. hybriduum* with which it has been hybridized. Kura, like most perennial clovers, is self-incompatible, requiring cross-pollination by bees (honey, bumble, leafcutter, alkali) to produce seeds. The yellow brown seeds are about 1.2 mm long and average about 670/g, roughly the same size as red clover (*T. pretense*) and larger than white clover (*T. repens*). Corolla is white to pale pink turning flesh colored after anthesis. Typical legume inflorescences are grouped into heads, usually upright but with the lower ones deflexed. Pods are 1 to 2 seeded.

Crop Culture

Kura clover is adapted to about the same latitude as its origin, about 40 to 50 degrees. Consequently, it is very cold hardy and tends to be more productive in cooler than in warmer climates. However, breeding efforts are being made to extend its area of usage southward in the U.S., and northward in New Zealand. The clover performs best on well drained, fertile soil but may survive occasional swamping, and lower pH (5.0-6.0) than other forage legumes. During droughts in southern U.S., it tends to go dormant in the summer producing very little growth until moisture becomes available in the fall. The primary difficulty of the crop is slow seedling establishment. It generally flowers only once per season, but cultivars differ.

Cultivars

Cultivars or breeding populations (some not yet released) may be classified as to ploidy and country of release. They include:

Australia

- Alpine (2*X*)
- Summit (2*X*)
- Forest (2*X*)
- Treeline (4*X*)
- Prairie (6*X*)

New Zealand

- Manaro (6*X*)
- KZ-2 (6*X*)

USA

- Rhizo (6*X*)
- Cossack (6*X*)

Production Practices

In central and northern US., kura clover is usually sown in a similar fashion as other small seeded perennial legumes, in the spring, on a well prepared seed bed. Because of low seedling vigor it is mandatory to sow it without companion grasses or small grains. Renovation sowings are not recommended. Optimally, pH and fertility should be adjusted prior to sowing based on soil tests. Special inoculation is required because only one *Rhizobium* strain specific to kura clover is effective, and pains should be taken to assure that inoculation is effective. Some investigators claim that special seed coating techniques are helpful. Seeding rate probably should be 12 to 15 kg/ha. The use of herbicides such as balan, treflan, preincorporated to control weeds is necessary, and if weeds develop later it is necessary to control them with appropriate herbicides (Poast, Basagran, or Fusilade). **Failure to control competition may result in stand failure.** Very little growth is expected in the first season and flowering in most cultivars does not occur until the second season after induction by low temperature in the winter. Flowering in the next season will occur in early May in central U.S. If seed is to be produced, this flowering crop must not be removed as abundant flowering occurs only once per season. If saved for seed, yields may be expected to be 100 to 200 kg/ha. The primary usage of the forage is for grazing, and it may be desirable to sow grasses after the kura is established. In the central bluegrass region of the U.S., bluegrass may invade the clover stand, ultimately resulting in a mixture. Kura stands are slow to establish but, once established, may be expected to last indefinitely, depending upon management, because of its large root biomass. Rotational grazing may be more productive than continuous grazing.

Germplasm

Collections

USDA Western Regional Plant Introduction Station, Pullman, Washington.

USDA Curator location: Department of Agronomy, University of Kentucky, Lexington, KY.

Commercial Seed Sources

Norfarm Seeds, Inc., PO Box 725, Bemidji, MN 56601, USA.

Peterson Seed Company, Inc., PO Box 346, Savage, MN 55278, USA.

Key References

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Last update Tuesday, February 24, 1998 by aw

Lactuca spp.

Compositae, or Asteraceae

Asparagus lettuce, Bibb lettuce, Boston lettuce, Butterhead lettuce, Celtuce, Cos, Crisphead lettuce, Curled lettuce, Garden lettuce, Green oak-leaf lettuce, Green romaine lettuce, Head lettuce, Iceberg lettuce, Lettuce, Limestone lettuce, Lolla rossa, Loose-leaf lettuce, Perella Red, Red oak-leaf lettuce, Red romaine lettuce, Romaine lettuce, Tango lettucee

We have information from several sources:

New Directions in Salad Crops: New Forms, New Tools, and Old Philosphy—Edward J. Ryder and William Waycott

The New Salad Crop Revolution—Edward J. Ryder

Leaf Lettuce: An Alternative for Virginia's Eastern Shore—S.B. Sterrett and C.P. Savage, Jr.

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark

Midwest Vegetable Production Guide for Commercial Growers 2000

Lettuce and Endive production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Lactuca sativa var. *asparagina*
Lactuca sativa var. *capita*
Lactuca sativa var. *crispa*
Lactuca sativa var. *longifolia*
Lactuca sativa

Prickly Lettuce

Lactuca scariola L.

Synonym.—*Lactuca virosa* Amer. auth., not L.

Other common names.—Wild opium, wild lettuce.

Habitat and range.—The prickly lettuce occurs in fields and waste places from Vermont to Georgia and westward to the Pacific coast.

Description.—This is a bright-green plant, from 2 to 7 feet high, covered with a whitish bloom. It has an erect, rigid stem sometimes smooth throughout but at times hairy at the base, with numerous clasping, oblong lance-shaped leaves with finely toothed margins and spiny bristles along the under side of the midrib. The lower leaves are at times 10 inches long and 3 inches wide, but the upper ones are much smaller. The pale yellow flowers, which appear in the early fall, occur in very numerous heads up to a third of an inch broad, having the feathery appearance of the ripe dandelion bloom, arranged in open clusters, each head consisting of 6 to 12 flowers.

Figure 88.— Prickly lettuce (*Lactuca scariola*)

Part used.—The leaves.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Laguncularia racemosa (L.) Gaertn. f.

Combretaceae
White mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Branchlets are browsed by camels in Africa (Irvine, 1961). The hard heavy wood is used for carpentry, construction, posts and tool handles. The bark is used for tanning and for dying fishermen's nets. Considered a honey plant (Duke, 1972)

Folk Medicine

Reported to be astringent and tonic, white mangrove is a folk remedy for dysentery (Duke and Wain, 1981), Hager's Handbook mentions that the bark is used for aphthae, fever, and scurvy (List and Horhammer, l969–1979). "The antitumor activity of the bark extract is attributed to its tannin content" (Morton, 1981).

Chemistry

Bark contains 10.3% tannin, gall's 10.7%, leaves 16.8%. Irvine (1961) puts the bark tannin at 12–24%, dry leaf tannin at 10 20%. According to Hager's Handbook, (List and Horhammer, 1969–1979), the bark contains maclurin ($C_{13}H_{10}O_6$).

Description

Evergreen tree to 12 m tall and 30 cm diameter, with rounded or irregular spreading crown. Bark gray-brown, becoming rough and fissured; inner bark light brown. Pneumatophores often present. Leaves Opposite, elliptical, 4–10 cm long, 2.5–5 cm wide, rounded at both ends, entire, glabrous, leathery, slightly fleshy, without visible veins. Petiole 10–13 mm long, stout, reddish, with 2 raised gland-dots near blade. Panicles at ends and sides of twigs, mostly branched and spreading, 3–10 cm long. Flowers mostly bisexual ca 5 mm long, bell-shaped, whitish. Petals, 5, rounded, whitish, 1 mm long, and stamens, 10. Pistil with inferior 1-celled ovary with 2 ovules, slender style, and tiny 2-lobed stigma. Drupes several, stalkless, obovoid, 12–20 mm long, flattened, ridged, gray-green with velvety hairs when immature, turning brownish, Seed 1, large, sometimes viviparous (Little, 1983).

Germplasm

Reported from the African and American Centers of Diversity, white mangrove, or cvs thereof, is reported to tolerate diseases, insects, pests, salt, and waterlogging (Little, 1983; NAS, 1980a).

Distribution

Both coasts of tropical America, northern Mexico to Brazil and Ecuador, Galapagos Island's and northwestern Peru. West Indies, Bermuda, southern and central Florida. Western Africa from Senegal to Cameroon. Not widely introduced elsewhere (Little, 1983).

Ecology

Ranging from Tropical Dry to Rain through Subtropical Dry to Rain Forest Life Zones, white mangrove is reported to tolerate annual precipitation of 10.4 to 23.4 dm (mean of 6 cases = 18.0), annual temperature of 24.9 to 26.4°C (mean of 5 cases = 25.7), and estimated pH of 6 to 8.5. Surely it tolerates rainfall up to 80 dm and annual temperature down to 18°C, without frost. Usually in well-drained brackish or saline soils along shores of lagoons and tidal rivers (Little, 1983).

Cultivation

According to the NAS (1980a) planting is usually not needed because natural regeneration is so successful. In Avicennia and Rhizophora direct seeding results in ca 90% survival.

Harvesting

May flower and fruit precociously (less than 2 years old). Harvested for fuel as needed. After cutting, there may be a multistemmed coppice.

Yields and Economics

It is stated that Brazilian tanneries use a million and a half kilos of mangrove leaves (e.g. *Laguncularia racemosa*) annually (Morton, 1965).

Energy

The wood, moderately hard and heavy (sp. grav. 0.6), is used for fuel and charcoal (Morton, 1981).

References

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Tamarack

Larix laricina (DuRoi) K. Koch.

Synonym.—*Larix americana* Michx.

Other common names.—American larch, black larch, red larch, hackmatack.

Habitat and range.—This tree frequents swamps and moist places from Canada south to New Jersey, Indiana, and Minnesota.

Description.—The tamarack, a slender tree with horizontally spreading branches, sometimes reaches a height of 100 feet. The pale-green leaves, which have a feathery appearance early in spring, are very slender and needle shaped, from 20 to 40 being together in a bundle, similar to the manner in which pine needles grow. Unlike the pine, however, the tamarack loses its leaves upon the approach of winter. Male and female flowers are produced, the latter developing into small, erect cones. The bark is thin and close, becoming scaly with age.

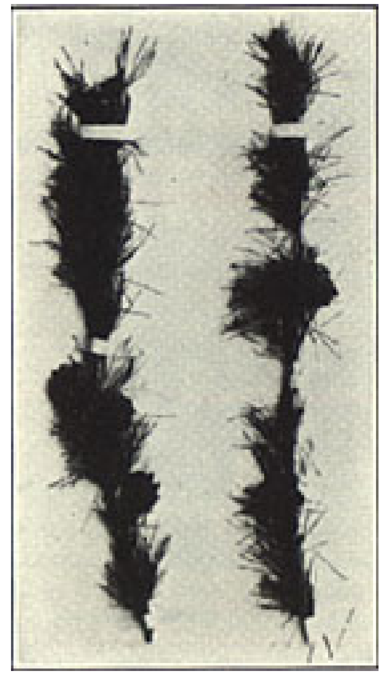

Figure 106.—Tamarack (*Larix laricina*)

Part used.—The bark.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Neglected Crops: 1492 from a Different Perspective. 1994. J.E. Hernándo Bermejo and J. León (eds.). Plant Production and Protection Series No. 26. FAO, Rome, Italy. p. 273-288.

Grain legumes for animal feed

The author of this chapter is L. López Bellido (Department of Agricultural Sciences and Resources, University of Córdoba, Spain).

The author thanks H. López Córcoies for the information provided on *Vicia narbonensis* and F. Varela for the data on the collections of the Madrid Centre for Plant Genetic Resource Conservation.

Among the grain legumes from the Old World, we may single out two species of the genus *Lathyrus* (*L. sativus* L. and *L. cicera* L.), one species of the genus *Trigonella* (*T. foenum-graecum* L.) and three species of the genus *Vicia* (*V. ervilia* (L). Willd., *V. monanthos* (L). Desf. and *V. narbonensis* L.) on account of their current state of marginalization. In Spanish, *L. sativus* is called by the popular names almorta, gija, muela and tito and in Latin America by the names alverja and chícharo (in Portuguese it is known as chicharo, in English as chickling vetch and in India as khesari). *L. cicera* is known as titarro, almorta de monte, chícharo, galgana and cicércula. *T. foenum-graecum* is known as alhlova and also heno griego or fenogreco (in English, fenugreek). *V. ervilia* corresponds to the yeros, also known as alcarceña, alverja, alcarraceña, ervilla, lenteja bastarda, etc. (in Portuguese, ervilha de pombo and gero, and in English bitter vetch). *V. monanthos* is the name of algarroba, garroba and lenteja de Aragón (in English, one-flowered or one-leaved vetch, and in Portuguese ervilhaca parda). Finally, *V. narbonensis* is known as alverjon and haba loca (in Portuguese ervilhaca de Narbona, and in English Narbonne vetch).

Figure 32. Grain legumes: A) one-leaved vetch (*Vicia monanthos*); A1) calyx; A2) flower; A3) legume; B) bitter vetch (*V. ervilia*); B1) flower; B2) legume; C) Narbonne vetch (*V. narbonensis*); C1) flower; C2) legume

Figure 33. Grain legumes: A) chickling vetch (*Lathyrus sativus*); A1) flower; A2) legume; B) vetchling (*Lathyrus cicera*); B1) legume; C) fenugreek (*Trigonella foenum-graecum*); C1) flower; C2) legume

This species, along with the garden pea (*Pisum sativum* L.), broad bean (*Vicia faba* L.) and chickpea (*Cicer arietinum*) were the first cultivated legumes, according to archaeological findings of the neolithic period, Bronze Age and Iron Age in Europe, the Near East and the Nile Valley.

Their location has demonstrated the spread of these species from their centre of domestication. Because of their larger size, the seeds that have been found are considered to be cultivated rather than wild forms.

Columela, in *De re rustica* (first century), mentions *Trigonella foenum-graecum* (fenugreek), *Vicia ervilia* (bitter vetch) and *Lathyrus cicera* (vetchling or flat pod pea), referring to their use, soil requirements, tillage and sowing dates. He refers specifically to *L. cicera* as it is cultivated in what is today Andalusia for feeding oxen as a replacement for *V. ervilia*—in the form of milled grains, moistened with water and mixed with straw - also stating that it is not an unpleasant food for humans. Libro de agricultura by Abu Zacarla (twelfth century) also mentions *T. foenum-graecum* and *V. ervilia*, referring to their soil requirements, methods and dates of sowing, fertilization and types of use in animal feeding as well as describing their use as a human medicine and other uses. In *Agricultura general*, by Alonso de Herrera (1513), *V. ervilia* and *L. sativus* are also mentioned, with different cultivation techniques and methods of use for feeding livestock and treating ailments recommended. *L. sativus* is used in the human diet in a similar way to chickpeas and is mixed with other grains to make bread.

Table 10 sets out the origin and distribution of the wild or cultivated form of the various species. Because of their marginal character, there are no data on a worldwide basis relating to the cultivated area of this group of legumes. Chickling vetch (*L. sativus*) is widely grown in India, with an area of 1.6 million ha referred to by Duke (1981). Vetchling (*L. cicera*) is currently grown only in Spain, although it was formerly grown throughout southwestern Europe. Fenugreek (*T. foenum-graecum*) is cultivated in the Mediterranean region, the Near East, Ethiopia, India and southern California. In North Africa, it has been grown for fodder around the Saharan oases from very early times. Bitter vetch (*V. ervilia*) is grown in Asiatic Turkey, central and northern Spain and other countries of the Mediterranean region and western United States; the seed is exported to the United Kingdom and other countries for feed, especially for sheep. There are barely any references to one-leaved vetch (*V. monanthos*) or Narbonne vetch (*V. narbonensis*), in spite of the fact that both species, particularly the former, were widely cultivated in the Mediterranean in past times. Figure 34 shows the regressive pattern of cultivation of these legumes in Spain; some of them are practically on the verge of extinction.

Table 10. Origin, distribution of cultivation and ecology of grain legumes

Species	Origin	Distribution	Climate	Soils
Lathyrus sativus L. (2n=14)	Mediterranean, central Asia	Central, southern and eastern Europe, India, Iran, South America	Suited to dry climates although tolerates an excess of rain. Annual precipitation: 320-1 360 mm. Annual mean temperature: 13°C	Suited to poor soils, it tolerates heavy, clayey soils. Sensitive to acid soils
Lathyrus cicera L. (2n=14)	Mediterranean, western Asia	Southern and eastern Europe Near East North Africa	Tolerates cold and frosts in the Mediterranean region, with autumn sowing; resistant to drought in the spring	Suited to poor soils, not too damp or saturated. Prefers heavy, well-limed soils with alkaline pH
Trigonella foenum-graecum L. (2n=16)	Mediterranean, Near East	Southern Europe North Africa, Near East India, Ethiopia, United States	Suited to regions with moderate or light precipitation Development favourable during the cool, temperate growth season. In a Mediterranean climate, with mild winters, it is sown in winter and ripens in spring. Annual precipitation: 380-1 530 mm. Annual mean temperature: 16°C	Grows well on drained, deep. Ioamy soils and on gravel and sandy soils III-suited to clayey, acid soils It is damaged by excessive soil dampness

Vicia ervilia (L.) Willd. (2n=14)	Mediterranean, Near East	Mediterranean, Turkey, United States	Very resistant to cold during the growing period because of its sparse habit and branching and slow growth. Very resistant to drought, even in spring. A harvest is obtained even during excessively dry years. In favourable conditions, high yields are obtained. Annual precipitation: 3601 160 mm. Annual mean temperature: 14°C	Suited to neutral or lightly acid soils Tolerates limy types of soil. provided they are not too clayey
Vicia monanthos (L.) Desf. (2n=14)	Mediterranean	Mediterranean	Very resistant to low temperatures during vegetative development and to prolonged drought. Suitable crop for regions with late dry autumns. Sensitive to drought during the flowering period, which reduces the yield drastically. Annual precipitation: 350-1230 mm. Annual mean temperature: 11°C	Suited to a wide range of soils provided they are not too damp Prefers soils that are not very clayey. that are deep and contain lime lime This is one of the legumes which requires the least soil fertility
Vicia narbonensis L. (2n=14)	Mediterranean	Central Europe Mediterranean, Near East Ethiopia, central Asia India	Temperature requirement greater than the broad bean (Vicia faba) and lesser humidity requirements. Replaces this species advantageously in warm dry areas. It does not tolerate cold, and is damaged by frost	The most suitable soils are loose and sandy deep and with a good lime content. Tolerates clayey soils that are not too damp

Sources: Duke, 1981; Mateo Box, 1960; Pascual, 1978; Villax, 1963.

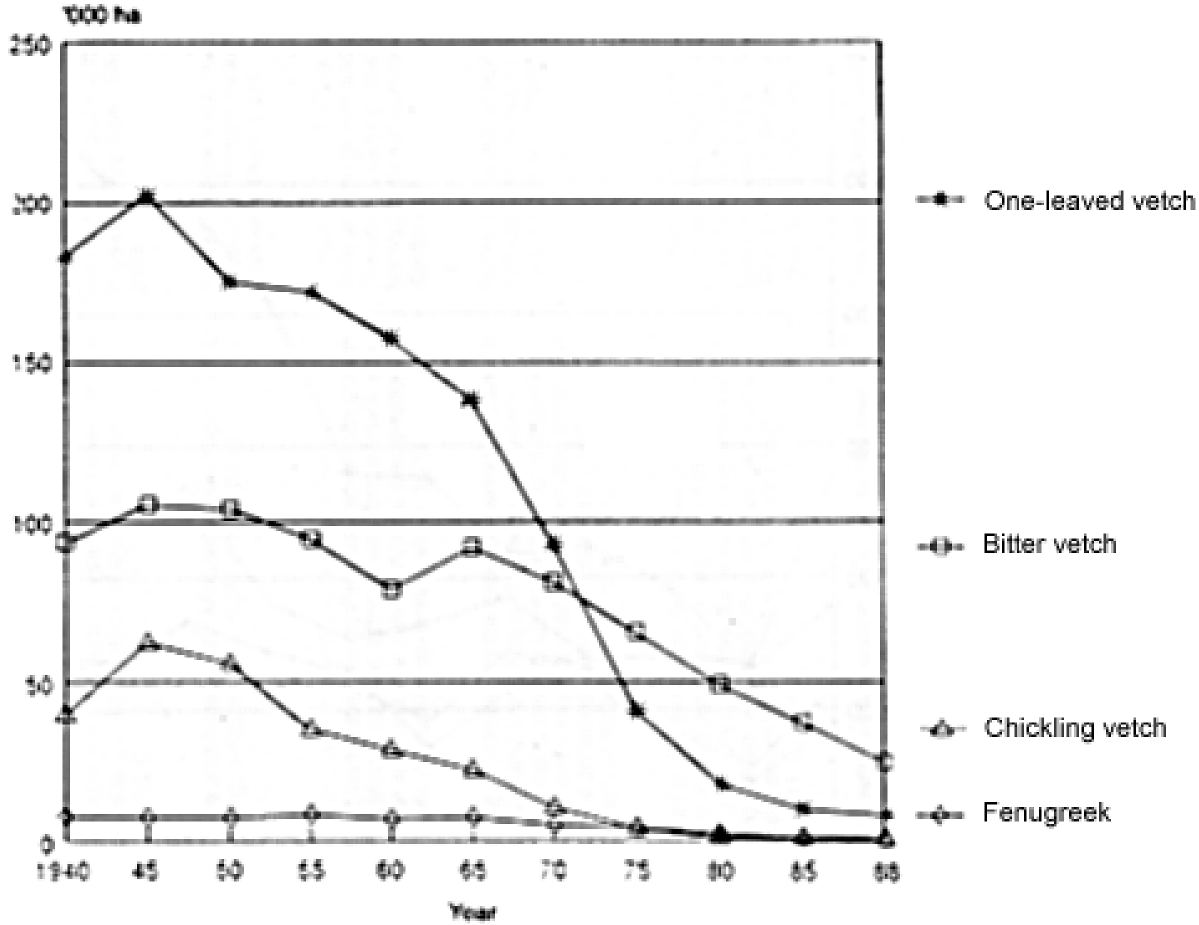

Figure 34. Changes in the cultivated area of legume species for animal feed in Spain

Composition and Use

Table 11 sets out the seed composition of the species studied. Protein content ranges between 20 and 30 percent and the fat content is generally very low except in the case of fenugreek (*T. foenum-graecum*). As in the other legumes, lysine is the most favourable amino acid and methionine is the most limiting. Several antinutritional properties are also present in the grain (Table 12). Chickling vetch and vetchling (*L. sativus* and *L. cicera*) contain a neurotoxic amino acid called ODAP (β-N-oxalyl-L-α–β-diaminopropionic acid) which causes neurolathyrism in humans and animals. This disease causes paralysis of the lower joints through neurological lesions brought about by degeneration of the spinal cord, particularly in equine stock, if the seed is eaten continually for months as the main component of the diet. In extreme cases it even causes death. Occasional consumption is not harmful and does not appear to affect sheep, so stockfarmers use these legumes for gestating females, fattening lambs and serving males. Macerating or soaking the seed in water, followed by cooking and treatment at high temperatures, seems to inactivate the lathyrogenic component, preventing its toxicity. Chickling vetch (*L. sativus*), which has a white flower and seeds, has a lower ODAP content. In some localities of northern Spain, selected white chickling vetch is traditionally eaten because of its lower content of lathyrogenic substances. There is a negative correlation between the total protein content of the Lathyrus and its ODAP content, which is of interest for improving varieties. The ODAP content of chickling vetch grown in Spain is lower than that of Asiatic chickling vetch. It has also been shown that the ODAP content of *L. cicera* is lower than that of *L. sativus* (0.146 and 0.205 percent, respectively).

Table 11. Composition of grain legume seeds

		Amino acids		Total		

Species	Proteins	Lysine	Methionine	Fat	carbohydrates	Fibre	Ash
	(Percentage of weight)						
Lathyrus sativus L.	25-28	1.84-2.47	0.1-0.15	0.6-1.9	55-61	4-15	3
Lathyrus cicera L.	25-27	--	--	1-1.3	56	6	3
Trigonella foenum-graecum L.	23-30	1.48-2.3	0.35	6-8	55	8-10	3.6-4.3
Vicia ervilia (L.) Willd.	17-21	1.53-2.02	0.37	1.3-2	61-64	4-6	2.4-3
Vicia monanthos (L.) Desf.	22	1.29	0.25	1.6	60	4.8	3.3
Vicia narbonensis L.	23-25	1.44-1.76	0.11-0.18	1-1.5	53	7.5-10	2.7-2.9

Sources: Duke, 1981; Franco Jubete, 1989; Gómez Cabrera, 1983: Mateo Box, 1960; Villax, 1963.

Table 12. Antinutritional factors of grain legumes

Species	Antinutritional factors	Remarks
Lathyrus sativus L.	β-N-oxalyl-L-α- β-diaminopropionic acid (ODAP), trypsin inhibitors, hydrocyanic acid, maltose, saponins, quercitin, flavins	Neurolathyrism
Lathyrus cicera L.	ODAP	Neurolathyrism (content less than *L. sativus*)
Trigonella foenum-graecum L.	Complex polysaccharides (gums and mucilages), trypsin inhibitors, sapogenins	Contains numerous chemical components of interest to the pharmaceutical, food, perfume and cosmetics industries (diosgenin mucilages, coumarin, lecithin, etc.)
Vicia ervilia (L.) Willd.	Cyanogenic glucoside, canavanine, trypsin inhibitors	
Vicia monanthos (L.) Desf	Cyanogenic glucoside, canavanine Cyanogenic glucoside	
Vicia narbonensis L.	Cyanogenic glucoside	

Sources: Arora, 1983; Harborne, Boulter and Turner, 1971; Gómez Cabrera, 1983; Mateo Box, 1960; Villax, 1963.

Fenugreek (*T. foenum-graecum*) has a high content of gums and mucilages (around 28 percent) which makes its direct use in the diet of monogastric species difficult. It contains other substances which give the plant an unpleasant smell, which permeates all its surroundings and is conveyed to the meat and milk of animals that eat it.

The antinutritional factors of the species of the genus *Vicia*, in addition to affecting the nutritional value of the grain, can cause pathological changes of varying extent in animals that consume them, especially birds.

The seed is the part mainly used in this group of legumes, although they are also grown as green fodder or hay and play an important role as a green manure, which is dug in at the end of the winter to improve soil fertility. The straw of these legumes is of high nutritional value for livestock.

Among the entire group, it is chickling vetch (*L. sativus*) which is most used for human consumption, in the form of green vegetables; the dry seed especially is soaked in water and boiled or else husked and made into flour for mixing with cereals and making bread or porridges. The latter method of preparation is usual in India (for *dhal*), and it was a popular recipe during times of scarcity and famine in the Spanish regions of Castilla-La Mancha and Extremadura, where many serious cases of neurolathyrism occurred as a result of it being consumed in the wrong way in the 1940s. The current Spanish Food Code prohibits human consumption of chickling vetch seed and the products obtained from its preparation. Mixtures with oilseed cake are used for sheep although, in Spain, its use in animal nutrition is not very widespread because of the fear of lathyrism.

Vetchling (*L. cicera*) is used as both a fodder plant and grain producer. The name *comuña* is given to the mixture of cereal grains, legume grains or both (as well as to their combined cultivation) which provides a complete food for livestock. Its etymological origin is from "*común*" in its meaning of mixture, referring to the mix of seeds obtained when cleaning the grain and which contaminate the main grain, generally wheat. The combination, which was of very variable content, was first formed from spontaneous plants which the farmer improved by introducing other species with a higher yield or quality. In the Spanish region of Tierra de Campos, vetchling began to dominate in *comuña* as a consequence of mechanical selection, since its grain was bigger than that of the vetches and tares, the two names used nowadays without distinction. There is therefore an ancestral knowledge of the use of *comuña* and its lathyrogenic side-effects. The use of *L. cicera* for sheep does not pose any lathyrism problems if doses do not exceed 50 percent of the ration in concentrates.

Fenugreek (*T. foenum-graecum*) is primarily grown for the production of its seed. Its strong smell somewhat discourages livestock from eating it. It must be used in low doses, since it imparts an unpleasant flavour to meat and milk and also causes animals to put on weight, which is not suitable for draught animals. Livestock dealers sometimes use it to tone animals up and give them a transient good appearance. It is also grown as a condiment, an essential oil being extracted for flavouring different foods and drinks, such as cheeses, sweetmeats, pickles and liqueurs. It is also used in the pharmaceutical and cosmetics industry because of the vast range of chemical products that it contains. The plant also has insecticidal properties and is used in stored grains as a repellent. Popular medicine attributes tonic and vermifugal properties to its seeds, the mucilaginous components being used to treat stomach ailments. In Hindu medicine, the seed extract is used because of its cardiotonic, diuretic, antiphlogistic, hypoglucemic and antihypertensive properties. It has active ingredients which act on the metabolism of fats and cause weight loss in women. In India, consumption of the seed is believed to stimulate lactation.

The species of the genus *Vicia* are traditionally used for feeding ruminants, particularly sheep, but they are practically unused for monogastric species in view of the seed's toxicity and its negative effect on growth. Bitter vetch (*V. ervilia*) must not exceed 25 percent of the ration in sheep and cattle feed. One-leaved vetch (*V. monanthos*) is more readily eaten by sheep, but refused by other types of livestock because of its slightly bitter taste. Birds, with the exception of pigeons, do not take to it. The seed of *V. narbonensis* can be used as feed for cattle which accept it more readily than pigs and sheep, provided it is fed to them in ground form. Like common vetch (*V. sativa*), it has a slightly bitter taste which animals grow accustomed to, but which can be passed on into milk.

Botany and Ecology

Table 13 describes the main botanical characteristics of the various leguminous species studied. Because of their origin, distribution and cultivation, they are suited to Mediterranean ecological conditions. Their cycle takes place in the autumn to spring period and they are resistant to cold and frosts as well as drought, especially in the final phase of cultivation. They are suited to poor soils and frequently to marginal ones

(Table 10).

Table 13. Botanical characteristics of grain legumes

Species	Structure of the plant	Flowers	Pods	Seeds
Lathyrus sativus L.	Branched. Stems suberect and climbing. Height: 40-90 cm. Main root: 50-70 cm. Secondary roots very numerous	Solitary, axillar with a long peduncle. Colour bluish-purple, pink or white	2.5-5 cm long, wide and flattened. Contain 1-5 seeds	Wedge-shaped. Cream or greyish brown, sometimes dark speckled and with a small hilum on the wider edge
Lathyrus cicera L.	Smaller than *L. sativus*. Height: 30-50 cm. Deep taproot (80-120 cm) and fewer secondary roots	Solitary, reddish colour	Typically grooved with 3-5 seeds	Similar to those of *L. sativus* but less angular and more rounded. Greyish colour with dark spots. 17000-18000 grains/kg
Trigonella foenum-graecum L.	Stems erect. Height: up to 40-80 cm. Branched only if there is a high planting density. The plant and seeds have a characteristic strong odour	Solitary or in pairs, axillar and sessile. Colour yellowish white, stained violet at the base of the corolla	7.5-15 cm long erect and sometimes curved. Longitudinal veins with a long point (2-4 cm). Contain 10-20 seeds	Oblong, quadrangular, sometimes compressed. Yellow or light-chestnut colour. Approximately 50000 grains/kg
Vicia ervilia (L.) Willd.	Low height (20-70 cm) and little branching. Very trailing habit. Highly developed root system	Inflorescence with 1-3 pendulous flowers joined at the axis by a small pedicel. Whitish colour sometimes with a violet tinge	2-3 cm. Seeds are prominent as the valves adhere to them closely. 2-4 seeds per pod	Tetrahedral, sometimes angular. Light colour, from cream to reddish brown. 25000-35000 grains/kg
Vicia monanthos (L.) Desf.	Trailing stems, polygonal in cross-section. Height: up to 80 cm. Deep, very branched roots	Uniflorous inflorescence with pedicellate, pendulous flowers. Whitish colour	Flattened, from 3-4 cm long. Light-brown colour. 2-5 seeds per pod	Similar to the lentil but smaller and less flattened. Colour variable, from light, pinkish yellow to dark chestnut, with black dots. 10000-20000 grains/kg

Vicia narbonensis L.	Stems erect and branched of quadrangular cross-section. Height: up to 70-80 cm. Deep well-developed roots	Inflorescence with large violet or reddish flowers and different contours in the various parts of the corolla	5-7 cm long, wide, ending in a short, curved point. Almost black in colour. 6-7 seeds	Spherical with dents, 4000-5000 grains/kg

Sources: Duke, 1981; Mateo Box, 1960; Villax, 1963.

Genetic Diversity

There is very little information on the genetic diversity, infraspecific variability and relations of these species with other related wild species. Few cultivars are known or well defined. Only limited areas of cultivation remain in some areas of the world and, in many of them, the individuals are threatened. The material available in gene banks is scarce. Consequently, there is the risk that important plant material obtained over thousands of years of cultivation might disappear, while only a few isolated works on classification and selection are to be found.

In the species *Lathyrus sativus*, there are a great number of varieties and types which differ in flower colour, form of growth and colour and shape of the seeds. Two varieties can be distinguished: lesser white chickling vetch and greater white chickling vetch. The first is possibly the original form of the species. Greater white chickling vetch is perhaps a selection of the former, featuring bigger seeds, a lighter colour and a more flattened shape. In India, 56 types have been identified. As in almost all this species group, the types sown are heterogeneous populations of botanical varieties. The centres of diversity are central Asia and the Mediterranean.

L. cicera is considered to be a semi-domesticated plant, with local varieties and spontaneous plants existing in Spanish cultivation regions, especially in the centre and north. There are local, primitive indigenous varieties in Castilla-León made up of very heterogeneous and widely varying material suited to adverse conditions. This material has traditionally been cultivated in combination with other plants (comuna) and its domestication has been rare, in spite of the fact that the plant has been grown for thousands of years. The main changes introduced in these varieties are: a more erect and compact habit of the plant, lesser dehiscence of pods and greater seed size. The wild populations of *L. cicera*, which are abundant in Spain, have characteristics very close to those of the cultivated plants. Domestication of *L. cicera* occurred in southern France and Spain when cultivation of chickling vetch (*L. sativus*) spread to those countries from its area of origin and domestication, which it subsequently replaced. Descriptors have been proposed for *L. cicera* and three botanical varieties are recognized: *pedunculatus, foliolatus* and *palentinus*.

Improvement programmes have been designed for fenugreek (*T. foenum-graecum*) to increase the yield of diosgenin, a steroid which is present in the seed and which is used in medicine, as well as to study the behaviour of a spontaneous mutant with earlier flowering and bigger sized seed. Twenty-nine different ecotypes have been recognized. The centre of diversity of fenugreek is situated in the western Mediterranean and the Near East.

The cultivated types and varieties of bitter vetch (*V. ervilia*) are very heterogeneous populations which frequently appear mixed with other cultivated or spontaneous species of Vicia. In Spain, the variety most used is common red bitter vetch but, in recent years, four selected varieties have been recorded. Comparative tests between these varieties and local controls, carried out in central Spain, have demonstrated the higher yield of the selected material. The centre of diversity of the bitter vetches is situated in the western Mediterranean and in the Near East.

Also in the case of one-leaved vetch (*V. monanthos*), the cultivated varieties are botanically very heterogeneous populations from which selections, lines and ecotypes adaptable to different environments could be obtained. In Spain, two types of one-leaved vetch can be distinguished: the white seed type and the black seed type, depending on the different shades of the background colours of the seed, the black type being grown in a greater proportion and the white type more rarely. The western Mediterranean, the Near East and the Euro-Siberian regions are quoted as centres of diversity.

Vicia narbonensis is considered to be a species very close to *Vicia faba*. It was once even thought that this was the original form of broad bean, although cytogenetic studies showed that this theory was without foundation. It is thought that the var. *serratifolia* is the origin of the current forms of *V. narbonensis*. Since ancient times, attempts have been made to cross *V. faba* and *V. narbonensis* to obtain an interspecific hybrid that combines the valuable characteristics of both species. In recent years, these crossings have been possible through genetic manipulation and through the embryo recovery technique, enabling valuable material to be obtained when using the appropriate genotypes as parents. Compared with *V. faba*, *V. narbonensis* has a high level of resistance to aphids (*Aphis fabae*), with intraspecific variations for resistance, hence it shows good agronomic potential. It also seems to have greater resistance to broomrape (*Orobanche* spp.), which is why farmers have grown it in the past.

Table 14 sets out the existing collections of germplasm of the legume species studied, according to the country and institution which keeps them. Probably the most complete collection is to be found in Spain. According to the most recent data, there are 49 lines of *L. sativus* from Spain and Portugal; 92 lines of *L. cicera* from Spain; 177 lines of *V. ervilia* from Spain and Portugal; 76 lines of *V. monanthos* from Spain; and ten lines of *V. narbonensis*.

Table 14. Collections of grain legume germplasm

Country	Species	Institution
Afghanistan	*Vicia ervilia*	Plant Research and Soil Science Department, Ministry of Agriculture, Kabul
Australia	*Lathyrus sativus*	Department of Agriculture, Adelaide, South Australia
Bulgaria	*Vicia ervilia*	Institute of Plant Introduction and Genetic Resources, Sadovo
CIS	*Lathyrus* spp.	N.I. Vavilov All-Union Institute of Plant Industry, St Petersburg
Cyprus	*Vicia ervilia*	Agricultural Research Institute, Ministry of Agriculture and Natural Resources, Nicosia
Czechoslovakia	*Lathyrus* spp.	Plant Breeding Research Institute of Technical Crops and Legumes, Tumemce
Germany	*Vicia ervilia Vicia narbonensis Lathyrus* spp.	Institut für Pflanzenbau und Pflanzenzüchtung, Braunschweig; Zentralinstitut für Genetik und Kulturpflanzenforschung Gatersleben
Ethiopia	*Trigonella foenum-graecum*	Plant Genetic Resources Center, Agriculture Research Institute, Addis Ababa
France	*Vicia narbonensis*	Station d'amélioration des plantes, INRA, Dijon

Iran	*Trigonella foenum-graecum*	Seed and Plant Improvement Institute, Plant Genetic Resources Division, Karaj
Pakistan	*Lathyrus* spp.	Agricultural Research Council, Islamabad
Portugal	*Vicia ervilia*	Estação Agronómica Nacional, INIA, Oeiras
Spain	*Lathyrus cicera Lathyrus sativus Vicia ervilia Vicia monanthos Vicia narbonensis Vicia ervilla*	Centro de Conservación de Recursos Fitogenéticos, Ministry of Agriculture, Fisheries and Food Madrid Estación Experimental del Aula Dei, CSIC, Zaragoza
Turkey	*Lathyrus* spp.	Aegean Agricultural Research Institute, Menmen, Izmir

Source: Esquinas, 1983.

Cultivation Practices

The cultivation techniques of these legumes are very rudimentary, given their marginal character, the small yields obtained and the little benefit which they bring the grower. Soil preparation is reduced and no type of fertilization is applied, as sowing is carried out in autumn or at the beginning of winter Nor is any type of herbicide applied. Harvesting is sometimes done manually and threshing is carried out on the threshing floor, although it is frequently done with a motorized reaper, followed by threshing and cleaning and, less often, with a combine harvester.

Table 15 sets out the traditional cultivation techniques for each species. Some tests on new cultivation techniques have been carried out in Spain recently. For L. cicera in addition to a better selection of seed, it has been proposed that 125 kg of seed per hectare be used and herbicides applied (propyzamide + diuron or trifluralin + linuron), while harvesting should be done by reaping and leaving the crop in rows to ripen, or else using a modified cereal harvester. For bitter vetch (V. ervilia) which, among these species, has the biggest cultivated area in Spain and of which selected varieties exist, the use of herbicides (alachlore + linuron, metholachlore + promethrin, cynazine or metazole) is recommended, as is harvesting with a cereal harvester during the first hours of the morning and harvesting only in one direction to avoid the problem of grain loss.

Table 15. Traditional cultivation techniques of grain legumes[1]

Species	Tillage	Fertilization	Sowing	Herbicides	Harvesting
Lathyrus sativus L. and *L. cicera* L.	First tillage (sometimes with cultivator or harrow)	None (sometimes 100-200 kg/ha of 18% superphosphate)	In autumn, after the first rains: 150-200 kg/ha of seed (sometimes barley is used as a support at 15-20 kg/ha). With cereal drill, 15-40 cm between rows	None (*Avena* sp., *Papaver* sp. and crucifers)	With cereal harvester (losses 20-30% because of dehiscence and plant's low habit). Also cut with motor scythe (in rows, dried) and harvester with pick-up

Trigonella foenum-graecum L.	Harrowing and rolling	None (sometimes 100-150 kg of 18% superphosphate)	In October: 110-130 kg/ ha of seed. With cereal drill, 15-18 cm between rows	None (*Avena* sp., *Papaver* sp. and *Veronica* sp.)	With cereal harvester (difficulties from flattening and grain drop)
Vicia ervilia (L.) Willd.	Harrowing and/or cultivator and rolling	None (exceptionally 100 kg/ ha of 18% superphosphate)	In October-December: 100-130 kg/ha of seed. With cereal drill, 15-20 cm between rows, sometimes broadcast	None (*Avena* sp., *Lolium* sp., *Papaver* sp., *Cirsium* sp., *Veronica* sp., *Poligonum* sp. and crucifers). Very sensitive to hormonal herbicides of cereals which cause serious damage	With cereal harvester and motor scythe, threshing and cleaning. Sometimes manual, with threshing on floor
Vicia monanthos (L.) Desf.	Tilling, harrowing and rolling	None	In October-December: 95-100 kg/ha of seed. With cereal drill, 15-20 cm between rows	None (*Avena* sp. *Lolium* sp., *Papaver* sp., *Matricaria* sp. and *Cirsium* sp.)	Motor scythe threshing and cleaning. Sometimes pulled up by hand, with threshing on floor

Note: There are no data on *Vicia narbonensis*, as its cultivation is practically non-existent in Spain.

Table 16 shows the grain yields of each species in different regions and countries, both in normal cultivation conditions and in trials.

Table 16. Grain yield of various legumes

Species	(kg/ha)	Region	Remarks	Authors
Lathyrus sativus L.				
	500-2600	Spain	Cultivation	Guerrero & López Bellido, 1983
	1000-1500	-	Cultivation	Duke, 1981
	312	India	Cultivation	Duke, 1981
	2126-6242	Northern Spain	Trials	Franco Jubete, 1989
Lathyrus cicera L.				

	1500-2500	Southern Europe	Cultivation	Villax, 1963
	1580-3037	Northern Spain	Trials	Franco Jubete, 1989
Trigonella foenum-graecum L.				
	750-3800	Spain	Cultivation	Guerrero & López Bellido, 1983
	500-3320	-	Trials	Duke, 1981
	3700	Great Britain	Trials	Duke, 1981
	1000	Morocco	Trials	Duke, 1981
	800-1500	Western Mediterranean basin	Cultivation	Villax, 1963
	338-1490	Northern Spain	Trials	Franco Jubete, 1989
Vicia ervilia L.				
	400-2200	Spain	Cultivation	Guerrero & López Bellido, 1983
	1000-200	Western Mediterranean basin	Cultivation	Villax, 1963
	1299-2830	Northern Spain	Trials	Various
	2600-3000	Central Spain	Trials	Various
	1580-2358	Northern Spain	Trials	Franco Jubete, 1989
Vicia monanthos L.				
	400-1800	Spain	Cultivation	Guerrero & López Bellido, 1983
	106-249	Northern Spain	Trials	Franco Jubete, 1989
Vicia narbonensis L.				
	1070-3307	Northern Spain	Trials	Franco Jubete, 1989

Prospects For Improvement

Since the appearance of modern agriculture, biological, technical and economic limitations have caused the present marginalization of these cultivated legumes, the situation of which varies according to the geographical area. Of the countries of the Mediterranean basin, particular reference will be made here to Spain.

The biological limitations lie in the absence of genetic improvement in a plant material that is extremely diverse and has been cultivated for thousands of years, which is evident from the stability of yields during the last 50 years (Figure 35), depending on the ecological conditions (the differences in the trend of barley yield during the same period can be seen)

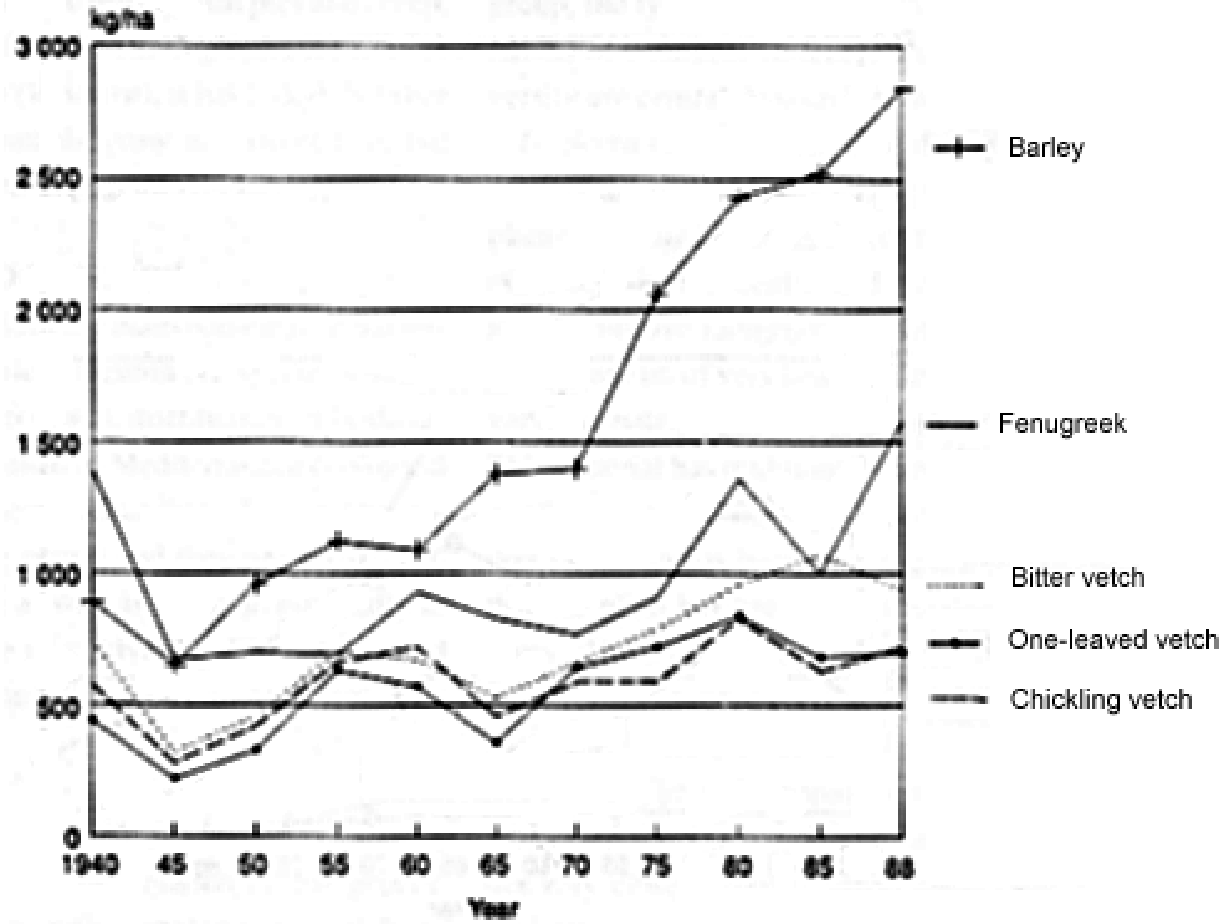

Figure 35. Changes in the grain yield of legume species for animal feed grown in Spain

The presence of toxic elements or antinutritional factors, the elimination or reduction of which would have to be tackled in breeding programmes, is a restriction on its use in human consumption and particularly in animal feed. Although the list of pests and diseases that attack this group of legumes is very extensive, there are important gaps owing to the low extent of its cultivation and the paucity of studies carried out. However, generally speaking, attack by pathogens is not found to be a serious limitation on cultivation.

Fenugreek (*T. foenum-graecum*) has been found to be tolerant to insects and diseases, chickling vetch (*L. sativus*) to rust and viruses, and *V. narbonensis* to *Aphis fabae*. Among the pests and diseases of economic importance are *Aphis craccivora* and *Myzus persicae* for fenugreek and *Ascochyta pisi* and *A. orobi* for the chickling vetches in India. In Spain, the major pests are aphids (not specified) in fenugreek and one-leaved vetch; *Bruchus* spp. in *V. ervilia, L. sativus* and *L. cicera*; and *Apion* spp. in *L. sativus* and *L. cicera*. The major diseases are rusts (*Uromyces pisi* or *U. fabae*) in one-leaved vetch, and nematodes (unspecified) in *V. ervilia*.

From the agronomic point of view, the precariousness of the techniques used has prevented yields from increasing. The use of such techniques is unavoidable because of the lack of response of cultivation to new practices and the low profitability of their application. The difficulty of mechanizing harvesting, given the aerial structure of the plant and its propensity to shedding its grain on ripening, is undoubtedly the factor of greatest importance. Also, competition from wheat has been a limiting factor on yields when suitable herbicides have not been used. For these reasons, there has been an increase in cereal monoculture and in the area of fallow, while new crops have been introduced on fallow land, for example sunflower, which has been extensively promoted by the extractive industry through the spread of techniques, machinery loans, the granting of advances to farmers and guaranteed purchases. Moreover, changes in irrigation have given rise to the introduction of much more profitable crops such as beetroot and maize.

Traditionally, there has not been a policy for the protection of these legumes (whereas there has been for cereals), nor any marketing channels; there have been shortages in regulation of the supply and the producer sector has been separated from the feedstuffs industry. The latter has been developed under the protection of measures that have favoured soya meal: low-price imports and all types of facilities and aid to producers. As an example, in its common organization of the market, the EEC has recently only provided for aid in the case of fenugreek production, completely disregarding the rest of this legume group.

Within the framework of a sustainable agriculture and the Common Agricultural Policy that seeks to encourage alternative crops, the several million hectares of fallow land in Spain could benefit from promotion of the cultivation of these legumes, which are sources of protein and which improve soil fertility. The role of the legumes in soil conservation and environmental improvement should not be forgotten, nor should their non-food uses, such as the production of pharmaceuticals and cosmetics in the case of fenugreek.

In addition, thorough research needs to be carried out in the short and medium term to provide a knowledge and evaluation of the plant material and its genetic improvement, as well as to develop more suitable cultivation techniques for increasing production. Such techniques would then be passed on to farmers, encouraging the cultivation of the different species according to the different cultivation systems and regions. The animal feedstuffs industry must take part in this process, gradually integrating the utilization of these raw materials into their processes.

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Rabat, INRA.

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last update Friday, June 12, 1998 by aw

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Rough pea, Winter pea

Singletary pea, Wild winter pea

Leguminosae, Fabaceae *Lathyrus hirsutus* L.

Source: Magness et al. 1971

This plant, native to the Mediterranean region, is a winter annual adapted to the southern third of the United States. The stems are weak and trailing except in dense stands. The leaves have one pair of long, narrow leaflets and terminate in a coiled tendril. The seed pods are rough and hairy. Seeds are usually sown in the fall. Plantings are used for pasture, for hay, or for turning under for soil improvement. Livestock may be injured from grazing plants with mature seeds or feeding hay from such plants, but prior to seed ripening good pasturage and hay are produced. Growing of rough pea has declined greatly in recent years as Austrian winter peas and hairy vetch make more growth. Acreage harvested for seed was 34,631 in 1949 and only 8,109 in 1959, according to census figures.

Last update July 1, 1996 bha

Laurel, Cherry

Rosaceae *Prunus laurocerasus* L.

Source: Magness et al. 1971

The plant is an evergreen bush, up to 10 feet, with thick, glossy, oval to lanceolate leaves, widely grown as an ornamental; and with many horticultural varieties. The leaves have a taste and flavor resembling bitter almond, due to a glucoside, laurocerasin. The leaves are used in cookery, particularly to flavor puddings and custards. A distillate from the leaves is used medicinally.

Last update February 18, 1999 by ch

Laurus nobilis L.

Lauraceae

Bay laurel

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update December 30, 1997

Index | Search | Home | Aromatic, Spice and Medicinal Plants

Lavandula spp.

Lamiaceae (Labiatae)

Lavender

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Herbs Affecting the Central Nervous System—Varro E. Tyler

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Lemon, Garden

Orange melon, Mango melon, Melon apple, Vine peach, Vegetable orange, Naudin

Cucurbitaceae *Cucumis melo* L. (Chito group)

Source: Magness et al. 1971

This is a close relative of the muskmelon which it resembles, but has a less vigorous vine and smaller leaves. Leaves and vines are hairy. Fruit is of size, shape and color of an orange or lemon, with a smooth surface. Fruit flesh is white or yellow, resembling cucumber. It is not edible in its natural state, but is useful for preserves and pickles.

Season, seed to first harvest: 2 to 3 months.

Production in U.S.: No data. Very limited.

Use: Preserves, pickles.

Part of plant used: Whole fruit.

Last update February 18, 1999 by ch

Lens culinaris Medik.

Leguminosae or Fabaceae

Black lentil, Brown lentil, Green lentil, Green mung bean, Large-seeded lentil, Lentil, Red mung bean, Small-seeded lentil, Wild lentil, Yellow lentil, Adas (Arabic), Mercimek (Turkey), Messer (Ethiopia), Masser (India), Heramame (Japanese)

We have information from several sources:

FactSHEET—contributed by F.J. Muehlbauer and Abebe Tullu

The Potential of Zero Tannin Lentil—A. Matus, A.E. Slinkard, and A. Vandenberg

Lentil—Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Dry Pea and Lentil as New Crops in Saskatchewan: A Case Study—A.E. Slinkard, R.S. Bhatty, B.N. Drew, and R.A.A. Morrall

Food and Grain Legumes—Fredrick J. Muehlbauer

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark

Grain Legumes—Theodore Hymowitz

New Crops for Canadian Agriculture—Ernest Small

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Legume—FAO/IBPGR Technical Guidelines for the Safe Movement of Legume Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Lepidium meyenii Walp.

Brassicaceae (Cruciferae)

Maca

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside Links

Maca, *Lepidium meyenii* can be found in Lost Crops of the Incas—from National Academy Press

Andean roots and tubers: Ahipa, arracacha, maca and yacon—by M. Hermann, J. Heller (eds.) from the International Plant Genetic Resources Institute

Cress, Garden

Cruciferae *Lepidium sativum* L.

Peppergrass

L. *virginicum* L.

Source: Magness et al. 1971

Cress plants are grown for the leaves, which are used as salads andgarnishes. The plant is an annual. attaining a height of 1 to 2 feet. Theleaves are aromatic and peppery in flavor. They rise from the root crown at thesoil surface, and are variable in shape, some forms being greatly divided likeparsley, others curled. If only lower leaves are removed, new leaves willcontinue to be formed on the central stalk. Growth habit and leaf exposure aresimilar to spinach.

Peppergrass is a closely related plant, native in the U.S., which is notcultivated, but often is gathered and used as with garden cress.

Season, seeding to harvest: 6 to 8 weeks.

Production in U. S.: No data. Minor importance.

Use: Fresh for salads, garnishes.

Part of plant consumed: Leaves.

Last update June 28, 1996 by aw

Stott, K. and A. Broderick. 1996. Response of Australian strains of the mushroom *Lepista nuda* to temperature and substrate. p. 476-479. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Response of Australian Strains of the Mushroom *Lepista nuda* to Temperature and Substrate

Karen Stott* and Andrew Broderick

Taxonomic classification of macrofungi is constantly changing as new species are discovered in North America, South Africa, and Australia. In Australia there are probably 3000 to 5000 species, most of which have not been properly described (Wood 1992). Improved techniques have enabled microscopic details to be better researched and this has resulted in changes in taxonomic classification.

The recent increase in consumption of wild mushrooms in many countries has provided the impetus to explore new sources of edible mushrooms. In addition, the wild harvesting of edible mushrooms must be curbed to ensure that the environment and ecosystems where these mushrooms grow are not destroyed. Mycologists need to explore new mushroom sources (Purkayastha and Chandra 1985) and develop cultivation techniques.

Worldwide there are 200 edible fungi of which only 25 species are widely accepted as human food and are cultivated (Hashioka and Arita 1978; Chang 1981; Pathak 1986). Fungi other than *Agaricus bisporus* represent about 30% of world production (Olivier 1991). The influx of migrants with a European heritage into Australia has created a demand for edible mushrooms produced locally. Amongst the gilled fungi, there are a number of edible species in the Agaricaceae, Bolbitiaceae, Lepiotaceae, and Tricholomataceae.

The fungus *Lepista nuda*, Tricholomataceae (syn: *Tricholoma nudum, Rhodopaxillus nudus, Clitocybe nuda*) is found in Europe, the Americas, and Australia. It has an international reputation as an excellent edible species and the combination of its lilac color, solid fleshy structure, good shelf life, flavor, and aroma makes the development of commercial cultivation techniques highly desirable. Developing techniques for commercial cultivation requires a detailed understanding of environmental and nutritional parameters which optimise vegetative growth and induce fruiting bodies.

The development of an appropriate substrate requires the chemical, physical, and biological conditioning of composted matter. This creates an environment selective for a particular species that is critical for fruit body production. Factors to be considered in the substrate are microbial activity, physical characteristics, pH, chemical components, aeration, water content, substrate composition, and extent of composting undergone by the substrate. Some species require the application of a casing layer of peat or soil to enhance yield and quality. Casing assists the induction of fruit bodies, but how this occurs is largely unknown. It is thought that casing provides a high water holding layer for hyphae, entraps volatiles released by compost, has a different mycoflora to the substrate, and physically supports the growing fruit body. The physical and chemical characteristics, optimal depth and number of applications for a given casing material can be different for each species. Temperature, light, O_2 , CO_2 , watering and care must be managed to encourage fruit body formation. Previous studies on substrate requirements of European *Lepista* (Vaandrager and Visscher 1981) indicate that fruit body production is enhanced by the addition of 10% uncomposted straw to commercial *Agaricus* compost. Guinberteau et al. (1989) and Brian et al. (1979) reported that a cold shock is essential for the formation of fruit bodies of *L. nuda* and temperatures of 8° to 15°C have been found to be effective. However Australian isolates (Young 1994) have been found under more variable environmental and substrate conditions than European isolates (Moser 1978, Breitenbach and Kranzlin 1991).

The objective of the present study was to provide the Australian mushroom industry with viable commercial cultivation techniques for Australian species of *Lepista*. This paper describes Australian forms of *L. nuda* isolated from the wild and examines the effect of temperature and substrate on hyphal growth and fructification.

METHODOLOGY

Isolates

Under Australian conditions *Lepista* appears in the wild from April to July. Isolates of *Lepista* were collected from various sites and voucher documentation, identification, and isolation of strains was carried out. Most isolates were confirmed as *L. nuda* and comparisons were undertaken with French isolates of *Lepista*, provided by Dr. Guinberteau of Station de Recherches sur les Champignons at Institut National de la Recherche Agronomique, France (Table 1).

Temperature

Optimum temperature for hyphal growth is a critical factor in obtaining rapid colonisation of substrate and casing. Isolates were selected from locations with different temperature and environmental characteristics to enable comparison with French isolates. Growth response of four Australian (A1, A2, A3, A4) and four French (F1, F2, F7, F8) isolates of *L. nuda* from warm (A1, A2, F1, F2) and cool (A2, A3, F7, F8) climates were compared at different temperatures to determine maximum and minimum temperatures for hyphal growth.

Isolates were grown on malt extract agar plus 2% yeast (MEAY) at 5°, 12°, 15°, 20°, 25° and 30°C. Radial growth of hyphae was measured on day 8 in two directions and the average taken. Data was analysed by analysis of variance.

Substrate and Cold Shock

Agaricus compost alone or suplemented with 10% uncomposted cereal straw (w/w) was inoculated with *Lepista* at 2%-3% w/w. Trays were sealed and placed at 25°C in a cabinet with temperature and light control. After 12 days substrate was cased with a 75% moisture content 50/50 mix of blond/dark peat. After hyphae had grown through casing, lids were loosened to allow air movement over substrate and cold shock of 12° or 15°C was applied to replicates of both substrates.

RESULTS

Isolates

The location and environment of selected isolates are shown in Table 1. Cool climate isolates (4° to 25°C during growing season) were found in leaf litter under *Rhododendron, Cedrus deodara, Quercus suber* or grass (*Poa pratensis*). Basidiocarp very robust and fleshy, lilac to lilaceous brown; pileus 75-132mm, lilaceous brown, shiny, convex to shallow convex with age; stipe 50-78 mm x 25-33 mm.

Warm climate isolates (8° to 35°C during growing season) were found in Kikuyu (*Pennisetum*) and Couch (*Cynodon dactylon*) grass in groups or rings. Basidiocarp strong lilac to lilaceous brown; pileus 30-75 mm, strong lilac, shallow convex with umbo at all stages; stipe 65 mm, bright lilac to deep lilac or lilaceous brown.

Temperature

The optimum temperature for Australian isolates was found to be higher than for French isolates as was the minimum growth temperature. The growth rate of Australian isolates is more than double the rate of French isolates at all temperatures except 5°C (Table 2).

Substrate and Cold Shock

The addition of 10% uncomposted cereal straw encouraged hyphal growth, but discouraged the initiation of fruiting bodies and was not beneficial to Australian isolates. A cold shock of 12°C encouraged more hyphal aggregations than 15°C. No fruit bodies were produced.

CONCLUSION

Australian isolates differ from overseas isolates morphologically in shape, form, and size. They are found at different temperatures and in different environments than European species. Whether they are new species or varieties resulting from the Australian environment and habitat has yet to be determined.

The response of Australian isolates to temperature indicates that these isolates have the capacity to colonise substrate more rapidly than French isolates. This would be advantageous to commercial growers as cropping time could be reduced.

The addition of 10% uncomposted straw to *Agaricus* compost had no beneficial effect on the initiation of fruit bodies. Whether it would effect quality or yield is unknown and further research into this area is recommended.

Information from this study can provide the basis for the development of viable commercial cultivation techniques for the exotic mushroom industry in Australia. The differences in cultivation requirements and growth rates of Australian and French strains indicates that a shorter production cycle than is currently achieved with French isolates will be possible.

REFERENCES

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- Olivier, J.M. 1991. Champignon comestibles et diversification. Mushroom Info. 4:20-21.

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- Nair and S. Balakrishnan (eds.), Beneficial fungi and their utilisation. Symposium of the Mycological Society of India, held at the College of Agriculture, Vellayani, Trivandum. Feb. 1984. Scientific Publishers, Jodhpur, India.
- Purkayastha, R.P. and A. Chandra. 1985. Manual of Indian edible mushrooms. Today and Tomorrow's Printers and Publishers, New Delhi.
- Vaandrager, M. and H.R. Visscher. 1981. Experiments on the cultivation of *Lepista nuda*, the wood blewit. p. 749-760. In: N.G. Nair and A.D. Clift (eds.), Proc. Eleventh Int. Scientific Cong. on the Cultivation of Edible Fungi, Australia, 1981. Sydney. vol. 11.
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Table 1. Location and environment of *Lepista* isolates at time of fruiting.

Country	Strain	Location	Environment
Australia	A1, A4	New South Wales	Warm^{z}
	A2, A3	New South Wales	Cool^{y}
France	F1	Landes	Warm^{x}
	F2	Gironde	Warm^{x}
	F7	Pyrenees	Cool^{w}
	F8	Haute Alps	Cool^{w}

^{z}Maximum temperature 24°C, minimum temperature 8°C
^{y}Maximum temperature 20°C, minimum temperature 4°C
^{x}Average day temperature 14°C
^{w}Average day temperature 11°C

Table 2. Response of Australian and French *Lepista* isolates temperature.

Isolate	Maximum radial growth (mm^2)^{z}	Optimal temperature (°C)
A1	32.6	25-30
A2	25.7	25
A3	24.7	30
A4	24.7	25
F1	12.7	22-25
F2	14.0	24

F7	13.0	22-24
F8	12.0	24-25

[z]Australian isolates almost double hyphal growth of French isolates.

Last update June 24, 1997 aw

Lespedeza

Leguminosae *Lespedeza* sp.

Source: Magness et al. 1971

Lespedezas are of major importance for pasture and, to a lesser extent, for hay production in the southeastern quarter of the U.S. Average seed production, 1966-67, was about 46 million pounds - sufficient to seed 2 million acres. Since pastures are generally self reseeding, acreage in lespedeza is probably near 40 million. The species grown in the U.S. are Sericea lespedeza, Korean lespedeza, and Striate lespedeza

Last update February 18, 1999 by ch

Sericea lespedeza

Leguminosae, Fabaceae Lespedeza cuneata (Dumont) G. Don

Source: Magness et al. 1971

Sericea is the only perennial lespedeza of importance agriculturally in the United States. Seed from Japan was first tested in North Carolina in 1896. From this and later introductions seed of vigorous, productive lines was widely distributed. The plants are long-lived, leafy, erect, with rather coarse stems reaching 2 to 4 feet high. Leaflets are long, narrow and blunt at the terminals. Annual growth dies in winter, new growth rising from crown buds. Range of adaptation is roughly from the Atlantic Coast west to Texas and Kansas and north to the Ohio River. Where adapted the crop is useful for pasturage, hay and soil improvement.

Last update June 28, 1996 bha

Striate lespedeza

Kobe

Leguminosae, Fabaceae *Lespedeza striata* (Thunb.) Hoak. & Am.

Source: Magness et al. 1971

Although some 140 species of lespedeza have been described, mostly native to Eastern Asia, only 3 are of importance in American agriculture. Striate lespedeza is an annual of which one variety, common, was established in Georgia by 1850. Its mode of introduction from Asia is unknown. The plant has slender, branched stems up to a foot or more in height and small, trifoliate leaves. An introduction from Kobe, Japan, called Kobe, was made in 1919. It is taller and larger growing than common and is useful both for pasture and hay. Although plants of both kinds are annuals they produce seed in late summer and reseed readily, so stands are long lived if properly handled. Striate lespedezas are palatable and nutritious both as pasture and hay. They are best adapted to the area suitable for cotton from East Texas to the Eastern Seaboard.

Last update June 28, 1996 bha

Levisticum officinale L.

Apiaceae (Umbelliferae)

Common lovage, Garden Lovage, Italian lovage, Italian parsley, Lovage, Love parsley, Smallage, Wild parsley

We have information from several sources: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Licania platypus F.

Chrysobalanaceae

Sansapote

We have information from several sources:

Sansapote—Julia Morton, Fruits of warm climates

South American fruits deserving further attention. Campbell, R.J. 1996. p. 431-439. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Last update Friday, February 05, 1999 by ch

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Citrus aurantifolia

Rutaceae

Green lemon, Key lime, Lime, Mexican lime, Persian lime, Sour lemon, Tahiti lime, West Indian lime

We have information from several sources:

Mexican Lime—Julia Morton, Fruits of warm climates

Tahiti Lime—Julia Morton, Fruits of warm climates

Sweet Lime—Julia Morton, Fruits of warm climates

Mandarin Lime—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

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Limnanthes alba Hartw.

Limnanthaceae

White foam, Meadowfoam

NewCrop has information on *Limnanthes* from:

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Chemistry of New Oilseed Industrial Crops—Robert Kleiman

New Temperate Oilseed Crops—Steven J. Knapp

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

New Crops Research and Development: A Federal Perspective—L.H. Princen

Alternate Crops for Dryland Production Systems in Northern Idaho—Kenneth D. Kephart, Glen A. Murray, and Dick L. Auld

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Breeding Advances and Germplasm Resources in Meadowfoam: A Novel Very Long Chain Oilseed—Steven J. Knapp and Jimmie M. Crane

Oil Content Distribution of Meadowfoam Seeds by Near-Infrared Transmission Spectroscopy—Brett E. Patrick and Gary D. Jolliff

Establishment of Meadowfoam as a New Crop in Virginia—Harbans L. Bhardwaj, Muddappa Rangappa, and Anwar A. Hamama

Meadowfoam Industry Update—Gary D. Jolliff and George D. Hoffman

Farmer-University Collaboration with Meadowfoam Research—George D. Hoffman, Doug Duerst, and Gary D. Jolliff

Introduction and Establishment of Meadowfoam as a New Crop in Virginia: History and Lessons

Learned—Harbans L. Bhardwaj

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Meadowfoam: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Outside links:

Meadowfoam seed oil Natural Plant Products, LLC

Vaccinium vitis-idaea L.

Ericaceae

Cowberry, Foxberry, Lingberry, Lingen, Lingonberry, Mountain cranberry, Partridge berry, Rock cranberry, Whimberry

We have information from several sources:

Lingonberry: Potential New Fruit for the Northern United States—Elden J. Stang, Gavin G. Weis, and John Klueh

Temperate Berry Crops—Chad Finn

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Lingonberry Corporation of America

Litchi chinensis Sonn. Mill.

Sapindaceae

Lychee, Litchi, Lychee Nut

NewCROP has Lychee information at:

Lychee—Julia Morton, Fruits of warm climates

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Lychee info:

LYCHEE"FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Lychee Information from the University of California Fruit & Nut Research and Information Center

Lychee info from the California Division of Plant Industry.

Current Comments

"In Davie, South Florida, I've managed to grow about 60 lychee trees. Lychees grow well in South Florida. The trees are very delicate when they are small, they may suffer from chlorosis, but this may be corrected with nutritional sprays and/or chelated iron supplements. Use fertilizer very sparingly or not at all until the trees are well established, I'm convinced that people kill more lychee trees by overfertilizing than by any other means.

There are significant differences in growing the different lychee cultivars. While some seem to tolerate the highly alkaline soils of Dade County quite well, such as the 'Brewster', others such as the 'Sweetcliff' simply will not grow unless the soil has an neutral or acid reaction.

Where I live the soil is mostly muck, which I suspect has an acid reaction. have ten different varieties of lychees and they all seem to grow well here. You should not have any problems growing lychees provided that you irrigate during dry spells."
- *Mario Lozano, April 1998*

Lobelia inflata L.

Campanulaceae

Indian-tobacco, wild tobacco, asthma weed, gagroot, vomitwort, pukeweed, emetic herb, bladder pod, low belia, eyebright

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Monday, October 05, 1998 by aw

Lolium perenne L.

Poaceae

Darnel, English ryegrass, Italian ryegrass, Perennial ryegrass

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Cool-Season Grass Seed Production: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Nelumbo nucifera Gaertn.

Nymphaeaceae

Lotus root, East Indian lotus, Egyptian lotus, Lian, Lin ngau, Hasu, Renkon

We have information from several sources:

Asian Vegetables—Mas Yamaguchi

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update October 10, 1997 by aw

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Weeping lovegrass

Gramineae *Eragrostis curvula* (Schrad.) Nees

Source: Magness et al. 1971 This is a vigorous perennial bunchgrass, introduced from Tanganyika, Africa, in 1927. It has proved well adapted in the Southern States, particulariy the Southern Plains. Seed stalks are numerous and slender, reaching to 5 feet under the best conditions. Basal leaves are numerous, slender, 10 to 20 inches long, palatable while succulent, but of low palatability when ripe. Plants are semihardy, enduring temperatures to about -10°F. They are readily established by seeding and make a quick ground cover.

Last update June 27, 1996 bha

Pouteria obovata Baehni.

syn: *Pouteria lucuma*

Sapotaceae

Lucuma, Lucmo, Eggfruit

We have information from several sources: Lucmo—Julia Morton, Fruits of Warm Climates

South American Fruits Deserving Further Attention—Richard J. Campbell

Outside links: Lucuma can be found in Lost Crops of the Incas from National Academy Press

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Canistel

Egg fruit, Ti-es

Sapotaceae *Lucuma nervosa* A. DC.

Source: Magness et al. 1971

The tree is a rather small, up to 25 feet, tropical evergreen native to Central America. Leaves are oblong-lanceolate, up to 8 inches long, and glabrous. Fruit is globose to ovoid, 2 to 4 inches long, 2 to 4 seeded, with a fairly smooth skin. Flesh is yellow and mealy. The fruit is edible, but not highly regarded.

Luffa aegyptiaca Mill.

L. cylindrica (L.) Roem

Cucurbitaceae

Luffa

We have information from several sources:

New Opportunities in the Cucurbitaceae—Timothy J. Ng

Luffa Sponge Gourds: A Potential Crop for Small Farms—Jeanine M. Davis and Charles D. DeCourley

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

last update October 14, 1997 by aw

Lunaria annua L.

Cruciferae, Brassicaceae

Money plant, Honesty

We have information from several sources:

New Crops In The UK: From Concept to Bottom Line Profits—Francis H. Nicholls

New Temperate Oilseed Crops—Steven J. Knapp

last update Monday, November 30, 1998 by aw

Lupinus albus L.

Fabaceae

Lupin, Lupine, Lupini, Sweet Lupin

There are also many other Lupins which are used as food and forages including:

- ***Lupinus angustifolius*** **- Blue Lupin**
- ***L. luteus*** **- Yellow Lupin**
- ***L. mutabilis*** **- Andean Lupin, Pearl Lupin, Tarwi, Chocho**
- ***L. cosentenii***
- ***L. albicaulis***
- ***L. perennis*** **- Wild Lupine**

NewCROP has the following lupin information:

An Interdisciplinary Approach to the Development of Lupin as an Alternative Crop.—Daniel H. Putnam.

White Lupin: An Alternate Crop for the Southern Coastal Plain.—D.W. Mask, Reeves, E. van Santen, G.L. Mullins, and G.E. Aksland.

White Lupin: An Example of New Crop Development Projects in Maine—L.C. Merrick.

Evaluation of Lupin as a New Food/Feed Crop in the US Mid-Atlantic Region—Harbans L. Bhardwaj

Alternate Crops for Dryland Production Systems in Northern Idaho—K.D. Kephart, G.A. Murray, and D.L. Auld.

Grain Legumes—T. Hymowitz.

Evaluation of Herbicides for Sweet White Lupin (Abstract)—R. Leep, and D.C. Penner.

The Western Regional Plant Introduction Station: A Source of Germplasm for New Crop Development—V.L. Bradley, R.C. Johnson, R.M. Hannan, D.M. Stout, and R.L. Clark.

New Crops for Canadian Agriculture—Ernest Small

Chickpea, Faba Bean, Lupin, Mungbean, and Pigeonpea: Potential New Crops for the Mid-Atlantic Region of the United States—Harbans L. Bhardwaj, Muddappa Rangappa, and

Anwar A. Hamama

Lupines In: Magness, J.R. et al. 1971. Food and Feed Crops of the United States.

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Lupine: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

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And outside links to more Lupin info:

Tarwi can be found in Lost Crops of the Incas from National Academy Press

Lupins A Modern Herbal by Mrs. M. Grieve

Lupins From the U.C. SAREP Cover Crop Database.

ILABIB A Growing Bibliography for Lupin Researchers

Lycopersicon esculentum Mill.

syn. *Solanum esculentum* L.

Solanaceae

Tomato, Beefsteak tomato, cherry tomato, Italian tomato, plum tomato, pomi di mori, pomme d'amour, pomodoro, Roma tomato, sunny tomato, tomate, tomatl

We have information from several sources:

"New" Solanums—Charles Heiser and Gregory Anderson

Processing Tomatoes: Old Crops in New Areas—William Reinert

Genetically Engineered High Solid Tomato

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Tomatoes production links

Tomatoes—Cooperative Extension Service, Purdue University, West Lafayette, Indiana. PDF version

Outside Links:

Midwest Vegetable Production Guide for Commercial Growers 2000

How the Tomato Succeeded can be found in Lost Crops of the Incas from National Academy Press

Tomato—Descriptors for Tomato (*Lycopersicon* spp.)—Link to the publication on the International Plant Genetic Resources Institute web site

Nutmeg and Mace

Nuez moscada

Myristicaceae *Myristica fragrans* Houtt.

Source: Magness et al. 1971

While other species of *Myristica* produce nutmegs, the principal nutmeg of commerce is *M. fragrans*. The tree is a tropical evergreen, reaching up to 60 feet, with entire oval leaves up to 10 inches long. The fruit is oval or pyriform about 2 inches long, and consists of an outer fleshy husk and inner seed. The husk splits when ripe, exposing the seed. Immediately surrounding the seed coat is a crimson network of tissue, the mace. The mace is rather leathery in texture. Nutmeg is the inner seed or kernel. Both nutmeg and mace are used mainly as spices. The distinctive flavors are due to volatile oils, present in both tissues. The oil of nutmeg, used as a nutmeg butter, is obtained by crushing and pressing the seed.

Last update February 18, 1999 by ch

Scutellaria spp.

Lamiaceae

Skullcap

We have information from several sources:

Skullcap: Potential Medicinal Crop—Nirmal Joshee, Thomas S. Patrick, Rao S. Mentreddy, and Anand K Yadav

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Chinese Medicinal Herbs: Opportunities for Domestic Production—Lyle E. Craker and Jean Giblette

O'Brien, B.C. 1996. Xeriscaping: Sources of new native ornamental plants. p. 536-539. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Xeriscaping: Sources of New Native Ornamental Plants

Bart C. O'Brien

The use of the word xeriscape as a landscaping term has not received widespread public acceptance, even though its precepts are sound and widely followed. "Xeriscape" has often been interpreted by the general public to mean "zero-scape" and was equated with severe minimalist drought tolerant plantings. The terms "sustainable landscapes" and "appropriate horticulture" better convey the full intent of "xeriscape." Native plant materials are a vital and viable element of the future of xeriscape landscapes and gardens across America and are the primary focus of this paper. As more gardens and landscapes are designed and installed true to their local conditions, opportunities will continue to expand for the use and development of new native plants for ornamental horticulture.

THE XERISCAPE CONCEPT

The word xeriscape was coined in 1981, to capture the idea of water conserving landscapes but conceptually xeriscape involves much more. There are seven essential components of xeriscaping: appropriate planning and design; appropriate/minimal turf areas; appropriate soil preparation and analysis; appropriate plant selection; appropriate watering methods; appropriate use of mulches; and appropriate landscape maintenance. In essence, the underlying concept behind xeriscape is the doctrine of regionally appropriate horticulture.

In practice, however, xeriscape often has been reduced to the landscaping idea of maximizing the efficient use of water in gardens and landscapes by creating areas which group plants by their water requirements. Typically this has been interpreted as growing the plants with the greatest water need nearest the home and transitioning to very low to no irrigation at the zone furthest from the home. This zoning of the landscape according to water use may also have additional benefits pertaining to fire breaks, wildlife value, and in enhancing the diversity of plants that may be grown in the garden.

HISTORY

Due to the dominance of our primarily temperate European horticultural heritage, there has always been a predisposition toward water-loving exotic plants in our landscapes and gardens. The westward expansion and settling of the country brought these same traditions and plants into increasingly dry and warmer regions that are prone to long periods of drought. As long as water was cheap and abundant there wasn't a problem and a more or less standard set of coast-to-coast plants thrived in spacious green havens. Over much of the country, water is the limiting resource governing the use of ornamental plants in gardens. The huge increase in population in the U.S. Southwest has in many areas outstripped local water supplies. In some areas of the country, water for landscape or garden use is seasonally rationed or restricted. The cost of water, even during years of abundant rainfall, is always increasing. Water quality issues, including salinity and contamination by nitrates and bacteria, lead to increased costs due to necessary water treatment programs. As time passed, our use of gardens and landscapes changed from seasonal retreats and visual frames for our homes and buildings to heavily used outside multi-purpose spaces. These changes resulted in the establishment of the xeriscape concept.

CURRENT TRENDS

There are a number of trends in home landscapes and gardens which will influence the ornamental plant industry. Those which I consider to be among the most important are: (1) the decrease in the amount of time, money and expertise that most households have to invest in properly planting and maintaining gardens; (2) the shrinking in average size of new gardens; (3) the increasing use of gardens as living spaces and outdoor rooms; (4) the increasing cost of water, labor, fertilizers, and chemicals; and (5) the restriction or limiting of water use for garden and landscape purposes.

Although there is always a market for colorful annuals, biennials, and short-lived perennials, these are generally more difficult groups to depend upon in landscapes and gardens. Longer lived perennials, subshrubs, shrubs and trees are the backbone of landscapes and gardens and will constitute the primary nursery market.

Under current conditions, I am convinced that a greater diversity of plants which flourish under existing climatic conditions across the country are needed. These changes should be viewed as potential opportunities and require the search for, and development of, perennials, subshrubs, shrubs and trees in the following categories: dwarf or compact forms of existing plants; new plants of small stature; plants that are all season performers; low maintenance plants; long, or continuous, seasons of color, be it flowers, foliage, fruits, stems or bark; good-looking, water-thrifty plants; and plants that attract wildlife.

Native plants which fall into any or all of these categories will be particularly desirable as they have the additional benefit of fitting into the local and regional conditions both visually and ecologically. This opportunity creates a new, relatively unexploited regional niche market for the nursery industry, and should eventually lead to a more striking regionalism in the American landscape vernacular.

THE SEARCH FOR NEW NATIVE ORNAMENTAL PLANTS

There are a number of people and institutions throughout the country looking at our native plants as a direct or secondary source of new introductions for the nursery industry, but anyone can become involved in this process. The methods employed to create new native ornamentals can be as informal as selection from the wild or as sophisticated as plant breeding including even genetic engineering.

A good place to begin the investigation of new native plants for drier portions of our landscapes is to look at the large plant families and genera in the region you are serving, and to concentrate the search on those plants inhabiting drier habitats. In California and the southwest, these would likely include some of the following: Agavaceae (*Agave, Nolina*, *Yucca*), Alliaceae (*Allium*), Amaryllidaceae (*Brodiaea*, *Dichelostemma*, *Triteleia*), Asclepidaceae (*Asclepias*), Asteraceae (*Artemisia*, *Erigeron*, *Senecio*, *Haplopappus*--*Ericameria*, *Hazardia*, *Isocoma*), Cactaceae (*Opuntia*), Crassulaceae (*Dudleya*, *Sedum*), Cyperaceae (*Carex*), Ericaceae (*Arctostaphylos*), Fabaceae (*Astragalus*, *Lupinus*), Fagaceae (*Quercus*), Grossulariaceae (*Ribes*), Iridaceae (*Iris*, *Sisyrinchium*), Hydrophyllaceae (*Phacelia*), Lamiaceae (*Lepechinia*, *Monardella*, *Salvia*), Liliaceae (*Calochortus*, *Lilium*), Malvaceae (*Malacothamnus*, *Sidalcea*, *Sphaeralcea*), Poaceae (*Festuca*), Polygonaceae (*Eriogonum*), Ranunculaceae (*Aquilegia*, *Delphinium*, *Ranunculus*), Rhamnaceae (*Ceanothus*, *Rhamnus*), Rosaceae (*Adenostoma*, *Cercocarpus*, *Heteromeles*, *Holodiscus*, *Prunus*, *Purshia*, *Rosa*, *Spiraea*), Saxifragaceae (*Heuchera*), and Scrophulariaceae (*Penstemon*).

The majority of these large genera and families have yet to be tested or evaluated for horticultural purposes in a serious systematic fashion including most perennial members of *Phacelia*, *Monardella*, *Eriogonum*, and *Astragalus*. A number of these large genera have well known propagation problems (such as commercially viable method for asexual propagation of *Quercus* and *Calochortus*) or are known to be especially difficult to grow and/or maintain under nursery conditions (like *Calochortus* and many native *Delphinium* and *Lupinus* species).

The selection of an individual plant for possible introduction is generally accomplished by finding a desirable feature or set of features that are deemed desirable. These individuals can be found in the wild or in the garden and often represent extremes of the natural variation: compact growth habit, different foliage, albinos, and unusual color forms. Additional factors such as mutations including witch's brooms, variegated foliage, and natural hybrids also contribute to the possible pool of plants to choose from. Traditionally these matters of chance have been the most frequently reported sources of many excellent cultivars: *Heterotheca* (*Chrysopsis*) *villosa* 'San Bruno Mountain', a sterile, free-flowering dwarf selection; *Artemisia pycnocephala* 'David's Choice', a heat tolerant compact selection; *Erigeron* 'W.R.', a compact, free-flowering, heat and cold tolerant chance wild hybrid between *Erigeron glaucus* and an unknown species; and *Acer macrophylla* 'Seattle Sentinel', a fastigiate selection.

Another especially rich area for horticultural selection can be found in nearly all taxonomically confusing groups at either the generic [example: *Arctostaphylos* and *Zauschneria* (*Epilobium*)] or specific [example: *Mimulus aurantiacus* or *Mahonia* (*Berberis*) *aquifolium*] level. Taxonomic chaos is often indicative of the extreme plasticity found naturally in the group and by inference the potential horticultural availability of variation to select from. Similarly, there are a number of extremely variable species that are nearly as ripe for selection as the taxonomically complicated groups listed above. These species include *Rhamnus californica*, *Erigeron glaucus*, *Ceanothus maritimus*, *Quercus chrysolepis*, and *Juniperus communis*.

Peripheral populations of a desirable plant are another source of native plants for landscapes and gardens. Plants from these populations may be more tolerant of heat or cold, higher or lower elevations, drought or wetness, may exhibit resistance to diseases or pests, or may be adaptable to a different soil type or condition. An excellent example of this phenomena is *Arctostaphylos uva-ursi* 'Point Reyes', a selection from the fog-bound headlands of the Point Reyes peninsula in Marin County that is extremely tolerant of heat and drought in comparison to typical members of the species. The small relictual San Bernardino Mountains population of *Populus tremuloides* is remarkably well adapted to growing conditions at low elevations in southern California. When plants from these peripheral populations are not themselves horticulturally desirable, they may carry genes which may be useful in a breeding program.

Another particularly rich source of new plants to investigate are the genera that have been dependably used in landscapes and gardens before, and look for a different species with desirable characteristics. Cultivars of the "new" species can be selected directly or the "new" species may be used to create hybrids with the "established" species. The named *Heuchera maxima* x *Heuchera sanguinea* hybrids: 'Genevieve', 'Opal', 'Santa Ana Cardinal', 'Susanna', and 'Wendy', created by Dr. Lee W. Lenz are excellent examples of this approach.

Breeding programs involving controlled crosses and hybridization between species are relatively rarely encountered in the native flora. There are, however, a few exemplary programs which have yielded many fine plants: the pacific coast hybrid irises, the *Mimulus* hybrids (of the section *Diplacus*), the *Lewisia cotyledon* complex, and *Lilium* hybrids.

All new cultivars should be named, described, published and registered with the proper registration authority. A list of all currently accepted registration authorities for ornamental plants is available from the American Association of Botanical Gardens and Arboreta (AABGA).

TESTING, EVALUATION, AND MARKETING

All too frequently, a promising native plant species or cultivar does not live up to its potential. Almost without exception, these plants are victims of poor testing and evaluation.

Establishing a set of desirable traits and characteristics of plants which the public actively wants or desires is a critical first step in the development of a new plant introduction strategy. Consulting with focus groups from the nursery industry, the gardening public, native plant enthusiasts, realtors, horticultural groups and others should provide the researcher with plenty of input on a variety of desirable plant traits. As progress is made in the selection process, the new plants should be planted out in a number of test sites. Test plantings should then be evaluated by a number of outside reviewers. Plants surviving through the testing and evaluation process are then ready to be introduced and marketed to potential user groups. The most recent successful example of a western native plant to go through such a thorough program is *Arctostaphylos uva-ursi* 'Vancouver Jade', an introduction out of the University of British Columbia's well known plant introduction program.

CONSERVATION OF GENETIC RESOURCES

Everyone involved with the selection, use and promotion of new native plant species and cultivars and/or any of their close relatives must be fully aware of the potential negative consequences of their use in gardens and landscapes. Most of these concerns center around the issue of conservation of genetic resources and the genetic pollution of native plant populations in the wild. Three examples from the California flora will serve to illuminate this issue.

Nevin's Barberry [*Mahonia* (*Berberis*) *nevinii*], an extremely rare plant in nature, is found in widely distributed and ecologically varied small populations in southern California. It is, however, a relatively commonly seen landscape plant throughout the state. A molecular level study of these plants showed that there is little to no variation present in the gene pool. Therefore, the seed source of plants to be planted in the vicinity of the remaining individuals in the wild is not of concern--there will be no adverse consequences to the gene pool.

The California dandelion (*Taraxacum californicum*) from the wet meadows in the San Bernardino Mountains is a rare plant whose continued existence is threatened by ongoing hybridization with the common European dandelion (*Taraxacum officinale*), a weedy pest plant that is common throughout the range of the rare species.

The Monterey pine (*Pinus radiata*) is known from five geographically isolated populations (three are from central coastal California and two are on islands off Baja California). This tree is a significant forest tree in the southern hemisphere, particularly in New Zealand. Material from all five populations has been grown together on a massive scale in New Zealand, such that the primary seed source of Monterey pine (even in California) is from New Zealand. The issue of primary concern here is that the "mongrel" Monterey pines of New Zealand mixed origin will genetically pollute the "pure" native stands of these trees, such that the unique genetic character of the California populations will be lost due to homogenization of the gene pool over time (the Baja California populations are not threatened in this way at this time).

CONCLUSION

The development of new native plant crops for use in xeriscape landscapes and gardens is still wide open with innumerable opportunities waiting for the interested or inspired investigator. As more work is done to select and develop the native flora for use in gardens, the more likely it will be that these deserving plants will be used and appreciated by the general public. When the public is aware and appreciative of the beauty and utility of native plants they will be much more open to the conservation and preservation of this essential component of our natural heritage. The single most important caveat regarding the horticultural use of these native plants is that their use should not be allowed to adversely impact native plant genetic resources.

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Last update June 25, 1997 aw

Pterocarpus indicus Willd.

Fabaceae
Malay padauk

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Sometimes recommended as an ornamental avenue tree. The reddish hard wood is an excellent timber in southern Asia. Listed among the most valuable timbers in the Philippines. Used for cabinetry, cart wheels, carving, construction, furniture, and musical instruments. Planted occasionally in Puerto Rico for shade and ornament (Little and Wadsworth, 1964). The young leaves and flowers are said to be eaten. The flowers are a honey source. The leaf infusion is used as a shampoo. The beautiful, termite resistant, rose-scented timber is marketed as Amboyna, Blanco's Narra, Burmese Rosewood, Malay Padauk, Narra, Philippine Mahogany, Prickly Narra, and Tenasserim Mahogany. The wood gives a reddish dye, more fugitive than that of *Pterocarpus santolinus.* It is also a source of kino.

Folk Medicine

According to Hartwell (1967–1971), the red latex is used in folk remedies for tumors, the plant for cancers, especially of the mouth. Endo and Miyazaki (1972) reported that the leaves "significantly inhibited the growth of Ehrlich ascites carcinoma cells in mice. A dried cold water extract of the leaves injected in mice bearing Ehrlich ascites carcinoma. All controls died within 21 days; of the treated group, 40/50 survived more than 84 days. The nuclei and cytoplasm of tumor cells became soft and larger, and then disintegrated. The active principle was isolated by gel filtration of aqueous extract. It was an acidic polypepticide, consisting of 17 amino acids. The LD_{50} in mice is 122 mg/kg i.p. Malayans apply the kino to sores of the mouth, and the root juice to syphilitic sores (Burkill, 1966). Javanese apply the young leaves to boils, prickly heat and ulcers. In the Carolyn Islands, finely powdered leaves are applied to a ruptured vagina. The kino, containing kinotannic acid, was once administered in diarrhea, often combined with opium (Lewis and Elvin-Lewis, 1977). Reported to be antibilious, emetic, and sternutatory, Malay padauk is a folk remedy for bladder ailments, diarrhea, dropsy, headache, sores, stones, thrush, and tumors of the abdomen (Duke and Wain, 1981). *Lignum nephriticum* (Latin for kidneywood) was the wood of this Philippine species and also of kidneywood (*Eysenhardtia polystachya*) from Mexico. It was known throughout Europe from the 16th to early 18th centuries for its reputed diuretic properties but is no longer employed in medicine. However, infusions of the wood are fluorescent, and this odd response to light may have been associated with remedies.

Chemistry

Wood contains the red coloring matters, narrin and santalin, and angolensin. Narrin is a dark red amorphous powder which yields phloroglucinol and resorcinol on fusion with alkali. Hager's Handbook (List and Horhammer, 1969–1979) reports pterocarpin and pterostilben homopterocarpin, prunetin (prunusetin), formonoetin, isoliquiritigenin, p-hydroxyhydratropic acid, pterofuran, pterocarpol, and β-eudesmol. Distilled wood gives a moderately heavy tar. Cups made from the wood and chips of wood impart to water a beautiful blue and yellow color, which changes in light and shadow (Little and Wadsworth, 1964).

Description

Large, deciduous tree, 30 m or more high, with large and high buttresses. Stipules caducous, linear, ca 7–15 mm long, hairy on both sides. Leaves ca 12–22 cm long in all, the petiole ca 2–4 cm, the rachis ca 6–18 cm, sparsely hairly, glabrescent; leaflets 5–13, chartaceous to subcoriaceous; surfaces concolorous, greyish-brown, sometimes greenish, above slightly shiny, glabrous, beneath slightly dull, sparsely hairy, glabrescent, petiolules ca 3–5 mm long, blade generally ovate, ca 1.6–2.5 times as long as wide, ca 4–5 by 6–10 cm; base generally rounded or sometimes obtuse to acute or very rarely attenuate, apex usually acuminate, sometimes acute, rarely obtuse, tip generally pointed. Inflorescences of laxly branched axillary panicles, sometimes together with a terminal one or with axillary racemes. Flowers few to numerous; calyx ca 5–6 mm long, hairy, all the lobes hairy inside towards the top, corolla with standard ca 16–18 mm long.

Fruit orbicular or semiorbicular, brown to blackish, densely hairy, ca 4–6.6 cm in diameter, stipe ca 5–9 mm long, the style (beak) lateral. Wing more or less membranaceous. The seed-bearing part ca 1 1/2–3 cm in diameter, thickened, ca 6–9 mm thick, more or less woody. Seeds 1–2, ca 2–5 by 8–10 mm, widest at or below the hilum; testa dark brown, smoothish.

Germplasm

Reported from the Hindustani and Indochina-Indonesian Centers of Diversity, Malay Padauk, or cvs thereof, is reported to tolerate waterlogging. The variety echinatus differs only in having prickles on the seed bearing part of the fruit. It does poorly in lalang wasts, shallow soils, and stiff clays. ($2n = 20$)

Distribution

According to Rojo (1977) its western limit is southern Burma, extending eastward to peninsular Thailand to Vietnam, farther eastward reaching the Solomons (eastern limit) in the Pacific via Sumatra, West Java, Borneo, Philippines, Sunda Islands, the Moluccas, New Guinea, and the Pacific (Ryukyu, Carolines). Rojo suggests that most species of *Pterocarpus* "prefer" seasonal climate, but *P. indicus* is a rainforest or evergreen forest species (able to withstand dry areas).

Ecology

Probably ranging from Tropical Very Dry to Wet through Subtropical Dry to Wet Forest Life Zones, Malay Padauk is reported to tolerate annual precipitation of 9.6 to 21.8 dm (mean of 10 cases = 16.4), annual temperature of 24.3 to 26.6°C (mean of 6 cases = 25.2), and estimated pH of 4.0 to 7.5. According to Rojo, it grows in forests, mostly evergreen, in the lowlands up to 600 m.Seems to prefer a seasonal climate, more everwet in New Guinea. Flowers (Philippines, N. Borneo, Malay Peninsula) mostly in February–May, occasionally in August–November and (Celebes, Moluccas, Carolines, Solomons, and New Guinea) mostly in July–December, occasionally in February–May; fruit seems to ripen within 4–6 months.

Cultivation

Grows rapidly from seeds and cuttings. Probably best started in seed nurseries and then outplanted with the rainy season.

Harvesting

The kino, the resin, and the timber are usually harvested as needed. Those people who eat the flowers and leaves probably concentrate such meals during the leaf flush and flowering periods.

Yields and Economics

Although this is regarded in the Philippines e.g. as one of the best furniture timbers, I find no yield data.

Energy

Although the wood is not necessarily recommended as firewood, it certainly could be used for firewood. Some *Pterocarpus* burn green. The wood is hard and heavy (625 kg/m^3), and can be air seasoned without difficulty. Studies in Hawaii, Malaysia, the Philippines, and Singapore, indicate that the species fixes nitrogen (Allen and Allen, 1981).

Biotic Factors

Browne (1968) lists *Ganoderma lucidum*, *Ganoderma pseudoferreum*, *Schizophyllum commune*, and *Sclerotium rolfsii* (fungi); *Hypomeces squamosus* (coleoptera); *Parasa lepida* (lepidoptera), and *Sus scrofa* (mammalia). According to Arroyo, *Pterocarpus* is visited by large numbers of bee species, representing many different genera.

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Last update Thursday, January 8, 1998 by aw

Verkade, S.D. and G.E. Fitzpatrick. 1990. Development of the threatened halophyte *Mallotonia gnaphalodes* as a new ornamental crop. p. 470. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Development of the Threatened Halophyte *Mallotonia gnaphalodes* as a New Ornamental Crop

Stephen D. Verkade and George E. Fitzpatrick

Climatic and ecological adaptability coupled with desirability for use in habitat restoration programs have increased consumer demand for rare and endangered plant species. Certain of these species have great potential for horticultural development once production barriers have been overcome. The sea-lavender, *Mallotonia gnaphalodes* is very rare in nature, but exhibits many desirable landscape characteristics. The recent delineation of successful propagation procedures for sea lavender has provided an opportunity for further economic development of this species.

Research has been conducted to determine optimum rooting conditions for sea-lavender and to evaluate transplant procedures. Successful rooting of cuttings was accomplished using fog propagation, 8,000 ppm indolebutryic acid, and a well-aerated rooting medium. Optimum transplant success on nonirrigated beach sites was achieved using organic topdressings composed of municipal solid waste compost.

Armitage, A.M., J.M. Laushman, and F. Vogel. 1990. Photoperiodic control of flowering of *Salvia leucantha* L. p. 470. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Photoperiodic Control of Flowering of *Salvia leucantha* L.

Allan M. Armitage, J.M. Laushman, and F. Vogel

Salvia leucantha, velvet sage, has potential as a cut flower crop grown under protected environment or in the field. In the field, flowering naturally occurs in August in north Georgia (34°N), and continues until frost. Yields of *Salvia leucantha* in the field ranged from 250 to 330 stems per square meter. Investigations were conducted to determine the response of *Salvia leucantha* to photoperiod and to light drift. Macrobud development occurred when the photoperiod

was 12 hours or less but anthesis required photoperiods of 10 hours or less. A minimum of 14 SD cycles (8 hr) resulted in macrobud development but at least 42 cycles were necessary for anthesis. Low irradiance drift resulted in inhibition of macrobud development and anthesis. Inhibition occurred when plants received more than 0.13 umoles m-2 s-1 irradiance from 2200 to 0200 hours.

Kitto, S. and P. Geiselhart. 1990. Regeneration and proliferation of *Veltheimia bracteata*. p. 470. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Regeneration and Proliferation of *Veltheimia bracteata*

Sherry Kitto and Pamela Geiselhart

The common red-flowered, as well as the rarer yellow-flowered, forms of *Veltheimia bracteata* would be valuable to the ornamental market if available in large quantities. Conventional propagation techniques are slow; however, rapid mass propagation may be possible via tissue culture. Red- and yellow-flowered *Veltheimia bracteata* scape sections (0.5 cm thick) and floral parts (ovary, immature seeds and bracts) have been cultured on medium containing Murashige and Skoog (1962) salts and the following addenda in mg/liter: sucrose, 60,000; nicotinic acid, 0.5; thiamine-HCl, 0.4; pyridoxine-HCl, 0.4; glycine, 2; washed Difco Bacto agar, 6,000 and growth regulators (NAA; 0, 1, 2, 4 and BA; 0, 1, 2). Cultures were maintained at 23±2°C with a 16 hour photoperiod (60 µmol m^{-2} s^{-1}) and were recultured every 4 weeks. Bulblets have been regenerated from scape sections and bracts. Histological analysis has demonstrated that bulblets regenerate from callus. Proliferating cultures have been established from regenerated bulblets. Immature seeds have germinated to produce plantlets when cultured on growth regulator-free medium.

Last update March 21, 1997 by aw

Mamea americana L.

Guttiferae

Mamey

We have information from several sources:

Akee—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Melicoccus bijugatus Jacq.

Melicocca bijuga L.

Sapindaceae

Spanish Lime, mamoncillo, genip, genipe, ginep, ginip, honeyberry

We have information from several sources:

Mamoncilla —Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Thurday, February 13, 2003 by ch

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Mangifera indica L.

Anacardiaceae

Mango, *Manga*, Man-gay, Mangga, Man-kay

NewCROP has Mango information at:

Mango—Julia Morton, Fruits of warm climates

Tropical Fruits—Mary Lamberts and Jonathan H. Crane

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more Mango info:

MANGO "FRUIT FACTS" (Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Mango propagation from Cornell University.

Mango Info from the FAO Tropical Feeds Database.

Mango Disease Index from Texas A&M University.

Agroforestry Uses of Mango from Cornell University.

Mango Production Regions and other information.

Mango photographs by Ian Maguire of the The University of Florida's Tropical Research Education Center (TREC) in Homestead

Mango—from Mark Reiger, Dept of Horticulture, University of Georgia.

Mango Information from the University of California Fruit & Nut Research and Information Center

Manioc

Cassava, Mandioca, Tapioca plant, Sweet potato tree, Yuca

Euphorbiaceae *Manihot esculenta* Crantz, *Manihot* sp.

Source: Magness et al. 1971

Manioc, or Cassava, is a highly important food crop of the tropics and is grown to some extent in the Southern States, mainly for stock feed. The plant is a large herbaceous shrub up to 10 feet, resembling castor bean in appearance, with large, compound leaves. It is cultivated for the large, tuberous roots which are rich in starch and are the source of tapioca, Brazilian arrow root, and other foods. The tuberous roots form in a cluster at the stem base. Plants are propagated by stem pieces laid horizontally in furrows, somewhat like sugar cane. The roots used as food sources are formed entirely underground. Only 15 acres were reported for continental U.S., 1954 census, but there is substantial production in Puerto Rico and Hawaii.

Last update February 18, 1999 by ch

Sugar maple

Hard maple, Rock maple, Black Maple

Aceraceae *Acer saccharum* Marsh.

Source: Magness et al. 1971

Last update June 28, 1996 bha

Yuquilla

Arrowroot, Tapioca

Marantaceae *Maranta arundinacea* L.

Source: Magness et al. 1971

Yuquilla is the true arrowroot of the West Indies. Perennial to 6 feet in height. The underground tubers are a source of tapioca. A similar crop is Leren, which see.

Last update June 26, 1996 bha

spp.

Asteraceae

We have information from several sources:

Tagetes minuta: A Potential New Herb from South America—Jacqueline A. Soule

Novel Annual and Perennial *Tagetes*—Jacqueline A. Soule

Marigold Flowers as a Source of an Emulsifying Gum—Ana L. Medina and James N. BeMiller

Origanum spp.

Lamiaceae (Labiatae)

Knotted marjoram, Oregano, Pot marjoram, *Rigani*, Spanich oregano, Sweet marjoram, Wild marjoram

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.
Dittany of Crete
Marjoram

Savory Herbs: Culture and Use—Lowman, M.S. and M. Birdseye. 1946. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Oregano—Promoting the conservation and use of underutilized and neglected crops. 14. Proceedings of the IPGRI International Workshop on Oregano, 8–12 May 1996, CIHEAM, Valenzano, (Bari), Italy—Link to the publication on the International Plant Genetic Resources Institute web site

Oregano—New Zealand Institute for Crop & Food Research Ltd

Marmaladebox

Genipap, Genip

Rubiaceae *Genipa americana* L.

Source: Magness et al. 1971

This fruit is borne on a medium-size tree, native to the Caribbean area. Leaves are up to a foot long and are clustered at branch tips. Fruits are ovoid in shape, up to 3 inches broad and 4 inches long. The skin is thin, enclosing a granular pulp and a seed cavity with numerous small seeds. The fruit is popular in Puerto Rico, especially for macerating the pulp in water to make a refreshing drink. The fruit is rarely eaten out of hand.

Last update February 18, 1999 by ch

Martynia

Unicorn plant, Proboscis flower

Martyniaceae *Proboscidea louisianica* (Mill.) Thell.

Source: Magness et al. 1971 This is an annual plant, up to 2 to 3 feet in height, with entire leaves, round to cordate, 4 to 12 inches wide. The fruit is hairy, about 1 inch thick and 4 to 6 inches long at maturity, about half the length consisting of a slender curved beak. The small, immature pods are made into pickles, like cucumbers. The plant is grown as an ornamental, and sparingly as a pickling vegetable.

Season, seeding to first harvest: 3 to 4 months.

Production in U.S.: No data. Of minor importance.

Use: Pickles.

Part consumed: Entire young pods.

Last update February 18, 1999 by ch

Sclerocarya birrea subsp. *caffra*

Anacardiaceae

Marula, King's nut

We have information from several sources:

Domestication and Introduction of Marula (*Sclerocarya birrea* sbsp. *caffra*) as a New Crop for the Negev Desert of Israel—Avinoam Nerd and Yosef Mizrahi

Introduction and Domestication of Rare and Wild Fruit and Nut Trees for Desert Areas—Avinoam Nerd, James A. Aronson, and Yosef Mizrahi

New Crops as a Possible Solution for the Troubled Israeli Export Market—Y. Mizrahi and A. Nerd

CHAMOMILE

Family: Asteraceae (Compositae)

ROMAN CHAMOMILE (*Chamaemelum nobile* [L] All.)

GERMAN CHAMOMILE (*Matricaria recutita* L.)

Source: Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone. Archon Books, 770 pp., Hamden, CT.

Roman chamomile, *Chamaemelum nobile* (L.) All., and German chamomile, *Matricaria recutita*, are two different species of plant commonly known as the same herb.

Formerly classified as *Anthemis nobilis* L. and called English or Russian chamomile, Roman chamomile is a creeping, herbaceous perennial native to western Europe and North Africa. Reaching a height of about 0.3 meters, the aromatic plant is characterized by downy stems and yellow-disc, white-ray flowers that appear in late spring or early July. Roman chamomile is cultivated in Europe, especially in Belgium, France, and England.

German chamomile, *Matricaria recutita* L., is also known as matricaria, wild chamomile, Hungarian chamomile, and sweet false chamomile. This many-branched, erect-growing annual, formerly classified as *Matricaria chamomilla* L., reaches a height of about 0.3 meter and has yellow disc white ray flowers. Cultivated in Germany, Hungary, Russia, and several other European countries, German chamomile is native to Europe and western Asia and naturalized in North America.

The reported life zone for the chamomiles is 7 to 26 degrees centigrade with an annual precipitation of 0.4 to 1.4 meters and a soil pH of 6.5 to 8.0 (Roman) or 4.8 to 8.3 (German) (4.1-31). Seeded or transplanted into the field for cultivation, Roman chamomile requires full sun but will grow in most soils having good drainage. Cultivated from seed, German chamomile grows in poor, clay soils. With Roman chamomile, the flower heads are hand picked and dried at the height of bloom about five times each growing season. The short, two-month growing season of German chamonile allows it to be interplanted with other biennial herbs or planted as an early or late crop.

The essential oil of Roman chamomile consists chiefly of chamazulene, angelic acid, tiglic acid, and several sesquiterpene lactones (1.4-34, 14.1-10). Other constituents of Roman chamomile include anthemic acid, athesterol, anthemene, resin and tannin (14.1-35). The essential oil of German chamomile contains chamazulene, -bisabolol, -bisabololaxides A and B, spathulenol cis-En-yn-dicycloether and farnesene (1.7-121, 2.3-74). Other constituents of German chamomile include a volatile oil, anthemic acid, antheminidine, tannin, matricarin, and apigenin (11.1-136, 14.1-35).

Dried flowers from Roman and German chamomile are employed in herbal teas. Flower heads of Roman chamomile have been used in the manufacture of herb beers (11.1-49). The essential oils are used as agents in alcoholic beverages, confections, desserts, perfumes, and cosmetics. Roman chamomile is often grown as a ground cover or as an ornamental in flower gardens.

As medicinal plants, the chamomiles have been traditionally considered to be antispasmodics, carminatives, diaphoretics, emmenagogues, sedatives, and stomachics. The plants have been used as bitters, tonics, insect repellents, and as a folk remedies against asthma, colic, fevers, inflammations, and cancer (14.1-13). German chamomile has been used to induce sleep and as an anthelmintic. Roman chamomile is a pharmaceutical aromatic bitter, and chamazulene, obtained from German chamomile, is a pharmaceutical anti-inflammatory and antipyretic agent (14.1-35). Extracts of Roman chamomile have shown antitumor activity and extracts of German chamomile are reported to have antiseptic, antibacterial, and antifungal properties (1.4-34, 1.8-13, 7.2-19). Chamomile in tea may cause toxic reactions in individuals sensitive to ragweed or allergens (11.1-96). The chamomiles can also cause contact dermititis (11.1-96).

Roman and German chamomile are generally recognized as safe for human consumption as natural seasonings/flavorings and as plant extracts/essential oils from the flowers (21 CFR sections 182.10, 182.20 [1982]).

For further information, see:

Mann, C. and E.J. Staba. 1986. The Chemistry, Pharmacology, and Commercial Formulations of Chamomile. In: L.E. Craker and J.E. Simon (eds). Herbs, Spices, and Medicinal Plants. Recent Advances in Botany, Horticulture, and Pharmacology. Food Products Press Vol. 1: 235-280.

[Note: References listed above in parentheses can be found in full in the original reference].

Aromatic and Medicinal Plants Index | Purdue Guide to Medicinal and Aromatic Plants

Last modified 6-Dec-1997

Yaniv, Z., D. Schafferman, M. Zur, and I. Shamir. 1996. *Matthiola incana*: Source of omega-3-linolenic acid. p. 368-372. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Matthiola incana: Source of Omega-3-Linolenic Acid*

Zohara Yaniv, D. Schafferman, M. Zur, and I. Shamir

Current research in nutritional medicine indicates that the omega-3 fatty acids are receiving more and more attention as essential components of the human diet (Adam et al. 1986; Simopoulos 1986). The observed low incidence of arteriosclerosis and chronic inflammatory heart disease in Greenland Eskimos has been attributed to their traditional ethnic diet, consisting in great part of marine foods rich in two omega-3 fatty acids: C22:6 and C20:5.

Dietary fish oils containing omega-3 fatty acids are increasingly recommended for their antithrombic and hypolipidemic effects to persons consuming typical western diets (Phillipson et al. 1985). Additional benefits include improving immunologic function and fighting allergies (Leaf and Weber 1988). Omega-3 fatty acids from vegetable oils could provide health benefits without any concomitant intake of cholesterol (Hunter 1990).

Based on preliminary evaluations (Yaniv et al. 1991) we have chosen to investigate germplasm of *Matthiola incana* (Brassicaceae) with an average oil content of 20%-24% in the seeds and maximum levels of 65% omega-3-linolenic acid (omega3LA) of the total fatty acids in the oil (Ecker et al. 1992). This is one of the highest known content of omega3LA in a plant species (Table 1). A second important aspect of this vegetable oil is its quality as drying oil, due to the high content of omega3LA. Various *Matthiola* lines were tested and evaluated as a potential new-oil crop for dietary supplement and industrial uses.

METHODOLOGY

Cultivation

Five lines of *M. incana* selected from a collection of commercial lines for flower production, having a high content of omega3LA were tested. Plants were grown in the experiment stations at Bet Dagan, Ramat haGolan, and Jerusalem, Israel, representing three different climatic regions, during the 1991/92 growing season. Each line was replicated four times in a random block design. Seeds of each line were sown in small plots of 1.2 m^2 consisting of four rows with 30 cm between rows. Basic fertilization was done at the time of soil preparation, at rates of 2N-2P-1K. 'Trifluralin' (2.5 kg/ha) was applied as a herbicide. The plots were irrigated until seedling establishment. Mean monthly temperatures at the three sites during the growing period (Nov. 1991 to June 1992) are presented in Fig. 1.

Observations were made on plant height, percent of fertile plants, and seed yield (number of pods/plant, number of seeds/pod, and weight of 1000 seeds). Plants were harvested at each location according to the time of full maturity. Fully mature seeds from each line were oven-dried overnight at 50°C and analyzed for oil content and fatty acid composition (Yaniv et al. 1991).

Lipid Extraction

Seeds were dried overnight at 50°C and ground into powder in a Moulinex coffee grinder; 5 g of powder was mixed with 100 cc petroleum ether (40° to 60°C), and the lipid fraction was extracted in a Soxhlet apparatus for 16 h at 60°C. The solvent was evaporated, and the lipid fraction residues were weighed (Yaniv et al. 1991).

Direct Transesterification from Seeds

Seeds (200 mg) were dried overnight at 50°C and ground into powder with a mortar and pestle, after which 0.3 cm^3 of dichloromethane and 2.0 cm^3 of 0.5 N sodium methoxide (MeONa) were added. The tube was heated to 50°C and shaken for 30 min. The reaction was stopped by adding 5.0 cm^3 of water containing 0.1 cm^3 of glacial acetic acid. The esterified fatty acids were extracted with 2.0 cm^3 of petroleum ether (40° to 60°C). The clear fraction was kept at -20°C until further analysis. Samples of 2.0 mm^3 were injected into the gas chromatograph for fatty acid analysis.

Gas Chromatography of Methylated Fatty Acids

A Megabore column (DB-23, 0.5 mm film thickness, 30 m x 0.54 mm, J&W Scientific) was used in a gas chromatograph equipped with a flame ionization detector (Varian model 3700 GC) and an automatic area integrator (3390A HP). The flow rate of N_2 (carrier gas) was 30 cc/min and the oven temperature was 135° to 200°C, programmed at a rate of 4°C min. The following fatty acids were identified using known standards (Supelco): C16:0, palmitic; C18:0, stearic; C18:1, oleic; C18:2, linoleic; C18:3, linolenic; C20:1, eicosenoic; and C22:1, erucic acid.

RESULTS AND DISCUSSION

Agronomy

Table 2 summarizes the results of the evaluation of five lines of *M. incana* cultivated in the Bet Dagan (BD), Jerusalem (JM), and Ramat haGolan (RG) experiment stations during autumn 1991 to spring 1992. The best location was BD with all lines showing higher yield potential at that site. Yield per plant was by far the highest at BD (3.5 g vs. 0.9 g at JM and 0.7 g at RG). Number of pods/plant was 73.3 in BD as compared with 36.7 in JM and 26.7 in RG. Number of seeds/pod, plant height, pod length, and 1000 seed weight were also slightly higher at BD than at the two other sites. The best performing lines were ROZ 45 and ROZ 19. At BD, both lines showed the highest yield potential. Under the low temperature conditions prevailing in winter at JM and RG (Fig. 1), ROZ 45 and ROZ 19 maintained the highest yield. ROZ 45 and ROZ 19 had the highest fertility rate (close to 90%) at all sites tested.

Oil Content and Quality

Table 3 summarizes the oil content and fatty acid evaluation of the three test sites. Oil quantity ranged from 21% (V6) to 28%-29% (ROZ 19 and ROZ 46), with the best sites at Jerusalem and Ramat haGolan.

Seeds of ROZ 46 and ROZ 19 accumulated 29% oil in JM and RG, as compared to 25% at BD. Temperatures during seed maturation were lower at JM and RG than at BD (Fig. 1) and it is known that low temperatures during seed development have a positive effect on oil quantity (Canvin 1965; Yaniv et al. 1989). Difference in oil quantity of the three sites is probable due to temperature.

Our main goal is to obtain a high concentration of omega3LA (C18:3) in the seed oil. The levels obtained ranged from 50% to 60%, with ROZ 45, the highest at all three locations. The best locations were JM and BD. Temperature plays a major role in the relative concentration of unsaturated fatty acids of seed oils (Mazliak 1988), and cooler conditions usually favor the production of polyunsaturated fatty acids (Yaniv et al. 1995). When *Matthiola* were grown under controlled temperature in a Phytotron, the content of seed unsaturated omega3LA was 69% at 12°C night 17°C day as compared to 58% at 22°/27°C (Yaniv et al. 1992). However, in spite of the fact that the coolest temperatures prevailing during seed maturation were in RG (Fig. 1), the highest content of C18:3, was obtained at JM and BD, and did not go above 60% (Table 3). It is important to note that temperatures never dropped below 15deg.C during the maturation period (May-June). It could be that in order to induce a significant increase in the level of C18:3, maturation should occur under a much cooler temperature regime than tested by us in the three sites.

Potential Yield

A yield of 750 kg seeds/ha, calculated on the basis of 17 plants/m^2, was obtained at BD. With 20% to 25% oil in the seed, this yield is equivalent to 150 liters oil/ha. A 50% content of omega3LA in the oil will yield 75 liters/ha pure omega3LA. Due to the fact that the research is in an early stage, we can't predict the profit per ha of the producte. This will be evaluated in during the second stage of the research.

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- Simopoulos, A.P. (ed.). 1986. Health aspects of polyunsaturated fatty acids in seafoods. p. 3-29. Academic Press, New York.
- Yaniv, Z., R. Ecker, and D. Schafferman. 1992. Earliness and lateness of flowering in *Matthiola incana* and their relationship to oil quantity of mature seeds. Israel. J. Bot. 41:279-284.
- Yaniv, Z., Y. Elber, M. Zur, and D. Schafferman. 1991. Differences in fatty acid composition of oils of wild cruciferae seed. Phytochemistry 30:841-843.
- Yaniv, Z., C. Ranen, A. Levy, and D. Palevitch. 1989. Effect of temperature on the fatty acid composition and yield of evening primrose (*Oenothera lamarkiana*) seeds. J. Expt. Bot. 40:609-613.
- Yaniv, Z., D. Schafferman, and M. Zur. 1995. The effect of temperature on oil quality and yield parameters of high-and low-erucic acid Cruciferae seeds (rape and mustard). J. Ind. Crops Prod. 3:247-251.

*Contribution No. 1521-E, 1995 series from the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel.

Table 1. Comparison of the fatty acid composition of five seed lipids.

	Fatty acid composition (%)				
	Palmitic 16:0	Stearic 18:0	Oleic 18:1	Linoleic 18:2	Linolenic omega318:3
Canola oil	6.0	1.0	62.0	20.0	11.0
Cocoa butter	26.4	31.0	37.7	3.8	T
Safflower oil	7.0	2.3	12.8	78.0	T
Soybean oil	15.0	T	24.0	54.0	7.0
Matthiola oil	9.0	2.0	13.0	11.0	65.0

Table 2. Yield parameters (mean of 4 replications) of *Matthiola incana* cultivated at three locations in Israel during the 1991/1992 growing season.

Site[z]	Line	Plant ht. (cm)	Fertility (%)	Pods/plant	Seeds/pod	1000 seeds weight (g)	Yield/plant (g)
BD	V-6	123 d[y]	37 b	68 c	48 b	1.9 ab	1.8 d
	ROZ17	139 b	30 b	87 a	49 b	1.9 ab	3.4 bc
	ROZ19	164 a	90 a	79 b	58 ab	2.0 ab	5.2 a
	ROZ45	140 b	86 a	66 c	63 a	2.4 a	4.5 ab
	ROZ46	132 c	84 a	66 c	55 ab	1.7 b	2.6 c
	Avg	140	66	73	54	2.0	3.5
JM	V-6	82 c	44 c	26 c	43 c	1.6 b	0.5 b
	ROZ17	84 c	49 c	36 b	45 c	1.7 b	0.5 b
	ROZ19	98 a	87 a	38 b	62 b	2.0 ab	1.1 ab
	ROZ45	96 a	93 a	43 a	59 a	2.3 a	1.4 a
	ROZ46	93 ab	68 b	41 a	52 b	1.8 b	0.9 ab
	Avg	91	68	37	50	1.9	0.9
RG	V-6	56 c	40 b	18 c	40 b	1.2 c	0.3 c
	ROZ17	70 b	41 b	26 b	46 ab	1.5 b	0.4 c
	ROZ19	83 a	88 a	31 a	54 a	1.7 b	0.8 b
	ROZ45	82 a	92 a	27 b	52 a	2.2 a	1.4 a
	ROZ46	81 a	81 a	32 a	50 a	1.6 b	0.6 bc
	Avg	74 c	66 a	27 c	48 b	1.6 b	0.7 b

[z]BD = Bet Dagan; JM = Jerusalem; RG = Ramat haGolan

[y]Mean separation in columns by Duncan's multiple range test, 1% level.

Table 3. Fatty acid composition of *Matthiola incana* seeds cultivated at three locations in Israel (4 replications).

	Fatty acid composition (%)					
Line	C16:0	C18:0	C18:1	C18:2	18:3	% oil
	Bet Dagan					
V6	9.7 a[z]	3.0 ab	18.4 b	11.9 b	56.3 a	21.1 c
ROZ17	9.5 a	2.5 c	21.1 a	15.6 a	50.7 c	22.5 b
ROZ19	8.6 b	2.6 bc	18.9 b	13.2 b	56.1 ab	24.7 a
ROZ45	8.8 b	3.1 a	17.7 b	12.8 b	57.1 a	25.3 a
ROZ46	8.9 b	3.1 a	19.3 ab	13.0 b	55.1 b	25.6 a
	Jerusalem					
V6	9.9 a	3.5 a	18.6 a	13.1 b	54.4 c	24.9 c
ROZ17	9.4 ab	2.7 c	16.4 b	14.2 a	56.8 b	25.7 bc
ROZ19	9.1 b	3.0	17.3 ab	14.1 a	55.9 b	28.9 a
ROZ45	9.0 b	3.2 ab	16.0 b	11.5 c	59.8 a	27.5 ab
ROZ46	9.1 b	3.3 ab	17.9 a	13.4 b	55.8 b	29.1 a
	Ramat haGolan					
V6	11.1 a	4.1 a	21.8 a	20.3 a	41.0 c	21.6 b
ROZ17	10.4 b	3.2 b	18.7 b	20.6 a	46.3 b	26.2 a
ROZ19	9.4 c	3.2 b	18.6 b	17.7 ab	50.4 a	28.2 a
ROZ45	9.2 c	3.3 b	18.2 b	14.9 b	53.6 a	26.0 a
ROZ46	9.1 c	3.5 b	20.0 b	15.3 b	51.4 a	28.8 a

[z]Mean separation in columns by Duncan's multiple range test, 0.01% level.

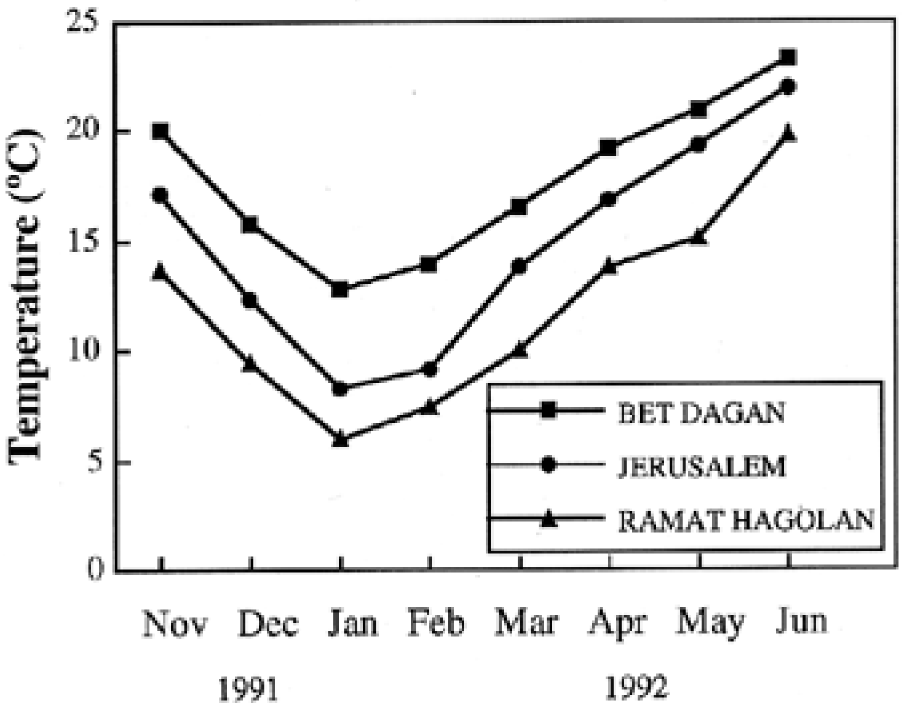


Fig. 1. Mean temperatures (°C) measured at the Bet Dagan, Jerusalem and haGolan Experiment Stations, during the 1991/1992 growing season.

Last update August 21, 1997 aw

Index | Search | Home

Melinis minutiflora Beauv.

Poaceae

Molasses grass, Stinkgrass

We have information from several sources:

Article from:
Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Last update September 26, 1996 by aw

Solanum muricatum Aiton.

Solanaceae

Kachun, Melon pear, Melon shrub, Native cucumber, Pear melon, *Pepino de la tierra, Pepino Dulce*, Pepino Melon

NewCROP has Pepino Dulce information at:

New Horticultural Crops in New Zealand—Errol W. Hewett

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

"New" Solanums—Charles Heiser and Gregory Anderson

Magness J.R. et al. 1971. Food and feed crops of the United States.

Outside links:

Pepino can be found in Lost Crops of the Incas from National Academy Press

PEPINO DULCE "FRUIT FACTS" (Fruit Facts are a series of publications of the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Pepino dulce information from the California Dept. of Food and Agriculture.

Melon, Winter

Casaba, Honeydew, Persian

Cucurbitaceae *Cucumis melo* L. (Inodorus group)

Source: Magness et al. 1971

These are melons grown on plants similar to cantaloupes, but fruits are without distinctive odor and late in ripening. The fruits are medium to large with generally smooth surface. In all cultural aspects they resemble cantaloupes except for longer growing season requirement. Included in the group are the Honey Ball, Honeydew, Casaba, Crenshaw, and Persian.

Season, seeding to maturity: About 4 months.

Production in U.S.: 6,700 tons.

Use: Fresh eating, salads.

Part of plant consumed: Internal pulp.

Last update February 18, 1999 by ch

Moonseed

Menispermum canadense L.

Other common names.—Canada moonseed, menispermum, yellow parilla, Texas sarsaparilla, yellow sarsaparilla, vine maple.

Habitat and range.—Moonseed is usually found along streams in woods climbing over bushes, its range extending from Canada to Georgia and Arkansas.

Description.—This woody climber reaches a length of from 6 to 12 feet, the round, rather slender stem bearing very broad slender-stalked leaves which are from 4 to 8 inches wide, roundish in shape, an] resembling the leaves of some of the maples. In July the loose clusters of small, yellowish or greenish-white flowers are produced, followed in September by bunches of black 1-seeded fruit, covered with a bloom and very much resembling grapes.

Part used.—The rootstock, collected in autumn.

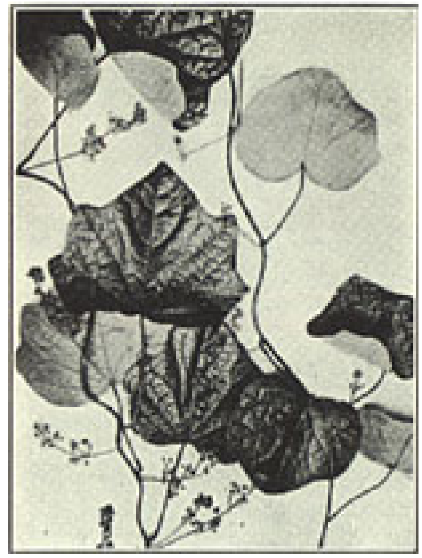


Figure 78.— Moonseed (*Menispermum canadense*)

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Mentha pulegium L.

Lamiaceae (Labiatae)

Pennyroyal

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971-1980.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside Links to *Mentha pulegium* information. information

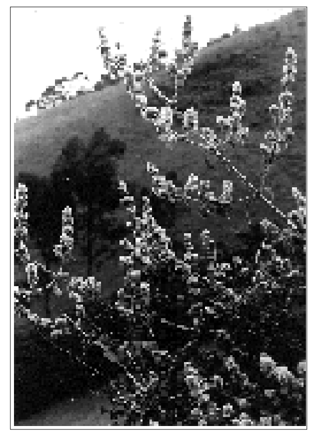
Mentha species(>500) accessions at the National Germplasm Repository, Corvallis, Oregon.

Last update Monday, January 5, 1998 by aw

Tipo, Poleo, Muña, Peperina

Labiatae or Lamiaceae *Minthostachys sp.*
Tipo, Poleo, Muña *M. mollis* (Kunth.), ***M.tomentosa*** (Benth.), ***M.setosa*** (Briq.) and other species.
Piperina of Argentina is *M. verticillata*.(Griseb.)
Source: Alkire B.H.,and A.O. Tucker and M.J. Marciarello. *Economic Botany* 48(1) pp.60-64. 1994

The "mint-like" aromatic herbs of the genus Minthostachys are limited to the Andean zones of South America, with perhaps 12 species distributed at various altitudes from Venzuela to Argentina. The plethora of integrating phenotypes typical of *Minthostachys spp.* adds uncertainty to species determination. The use of vegetative characters to separate species is confounding. Species are separated by counting and measurement of calyx ribs. "Taxonomically the genus is in need of revision." - Ray Harley, Kew Botanical Gardens. Pollen morphology has indicated that the genus is most closely linked to *Pycnanthemum* and *Bystropogon* of the Canary Islands.



Use: *M. mollis, tomentosa, setosa* and other species:. As a as refreshing beverage, as a condiment in food, and as medicine for colds and coughs. Leaves are combined with storage potatoes; which have a definite inhibitory effect on tuber sprouting and also serves as a potato insect anti-feedant.

In Argentina *M. verticillata* tea is a well-known and widely commercialized product, packaged in tea bags as "Peperina". This species was once comercially distilled for a l-carvone rich essential oil. A scanned image from a boxtop from an Argentine peperina-containing commercial tea is displayed below (*courtesy of Dolly Bell-LeLong*).

Part of plant consumed: Leaves and flowering stems.

Last update December 19, 1995 by bha

Synsepalum dulcificum Daniell

Sapotaceae

Miracle Fruit, Miracle Berry, Miraculous berry

NewCROP has outside links to Miracle Fruit info:

MIRACLE FRUIT "FRUIT FACTS" (Fruit Facts are a series of publications of the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Mithi Patti (*Scoparia dulcis* Linn.)

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Scientific Name: *Scoparia dulcis* Linn.
Family: Scrophulariaceae
Hindi Name: Mithi Patti

General Description: It is introduced in India from Tropical America. It grows as wasteland herb. The traditional healers have developed its many promising traditional medicinal uses.

Botanical Description: it is a small, much branched, glabrous, leafy annual herb or under shrub with erect or ascending branches; Leaves opposite and 3-notely whorled, rhomboid, elliptic or elliptic lanceolate, obtuse at apex, base tapering, margins serrate; Flowers many, in terminal panicles, pedicelate, pedicels slender, rigid; Calyx lobes 4, oblong; Corolla white, tube very short, Capsule globose; seeds minute, many.

Useful parts: All parts.

Medicinal Uses
Leaves are used in treatment of fever, cough, bronchitis and dental trouble.
Leaves and stems are used for diabetes.

Chemical Constituents: A triterpene and mannital have been isolated from roots and dulcitol from aerial parts.

Internet Resources

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Spanish plum, red mombin

(*Spondias purpurea*)

The author of this chapter is J. Axayacatl Cuevas (Department of Plant Science, Ethnobotanical Unit, UACH, Mexico).

Botanical name: *Spondias purpurea* L.

Family: Anacardiaceae

Common names. English: Spanish plum, red mombin; Nahuatl: ateyaxocotl; Spanish. jocose (Mexico [Oaxaca], Central America), ciruelo (Mexico [Jalisco, Yucatán])

Spondias purpurea was grown widely from Mexico to the northern region of South America when the Europeans arrived, as can be deduced from the descriptions of the first chroniclers (Oviedo, Sahagún). It spread through the Antilles and the rest of South America and was possibly taken from Mexico to the Philippines. The fresh fruit has a very pleasant taste and its consumption is increasing. It is a valuable but economical raw material for the preparation of soft drinks, preserves and syrups and is also eaten as a dried fruit. The current marginalization and scarcity of commercial plantations are largely due to a lack of attention on the part of producers, technical experts and agricultural extension workers, who are concentrating their efforts on other fruit-trees in greater demand on the foreign market.

The most widespread use of *S. purpurea* is as a fresh fruit for local consumption and for supplying city markets. In Mexico and Guatemala. it is used in other forms which are possibly of post-Hispanic origin. In one form, the fruit is boiled in brine for five to ten minutes and then dried in the sun, either on tables with a wire mesh or reeds for three days or on driers on mobile units for ten to 12 hours. By this process, the dried fruit is reduced to one-quarter of its fresh volume. Another way to prepare the fruit is to heat it in unsalted water and dry it in the sun, while a third process, used in Mexico to obtain *ciruelo negro*, consists of pricking the skin of the fruit, placing it in syrup (1 kg of sugar in a bottle of water) and letting it simmer until the sugar burns or becomes concentrated. *Ciruela cristillina* is a fourth method of preparing the fruit, similar to the previous one, only the fruit is gathered while it is ripening and is boiled for a shorter time.

Other uses of *Spondias* pulp include as an atole, mixed with maize flour and sugar, and in the preparation of wine, *chicha* (maize liquor) and soft drinks.

Analyses of the fresh fruit show that the percentage of moisture in the flesh ranges from 76 to 86 percent; it is very low in protein and fat and contains appreciable quantities of calcium, phosphorus, iron and ascorbic acid.

Its consumption is currently increasing throughout Mesoamerica. The bulk of production comes from isolated trees or hedges, while very little comes from well-ordered and maintained plantations, such as the ones seen around the city of Oaxaca. However, it is a very promising fruit-tree because it is accepted on the market; it is a hardy species with a high resistance to drought; it is easy to produce on poor soil; and its propagation is exclusively vegetative, which ensures an early harvest.

Botanical description

S. purpurea is a small tree, growing 4 to 8 m, with a broad crown, irregular trunk and fragile branches; its leaves are composed of five to 12 pairs of elliptical-acute leaflets, 2 to 4 cm in length and which fall before the flowering period. It has red flowers in 3 to 5 cm panicles, situated along the small branches; the fruit is an irregular oval drupe, somewhat gibbous, smooth and shiny, 4 to 5.5 cm long and a violet to yellow colour, with a woody kernel which contains the seeds. The flesh is sparse, creamy, yellowish and bitter-sweet in the cultivated plants and very acid in the wild plants. It contains malic acid, sugar, calcium malate and starch. The growth cycle has only been studied in Mexico, in Sinaloa and Puebla. In Sinaloa, the trees have foliage from June to October, leaves fall from October to December and the trees are without foliage from January to May. Flowering occurs in February and March and fruiting in June. In Puebla, the trees have leaves from March to October, leaf fall occurs from October to December and the trees remain leafless from January to April. Flowering takes place from December to January and the fruit ripens in April and May. Of great interest is the absence of seed formation in this species, an aspect that was first studied in the Philippines. In the "nut", which occupies the central part of the fruit, only remnants of aborted seeds are found. This is due to both poor pollen formation and the oosphere. Natural distribution is thus completely limited, but the ease with which stems and branches sprout, together with their fragility, allows a very limited natural propagation. Recognition and conservation of the numerous variants which this species displays is possibly due to the action of humans.

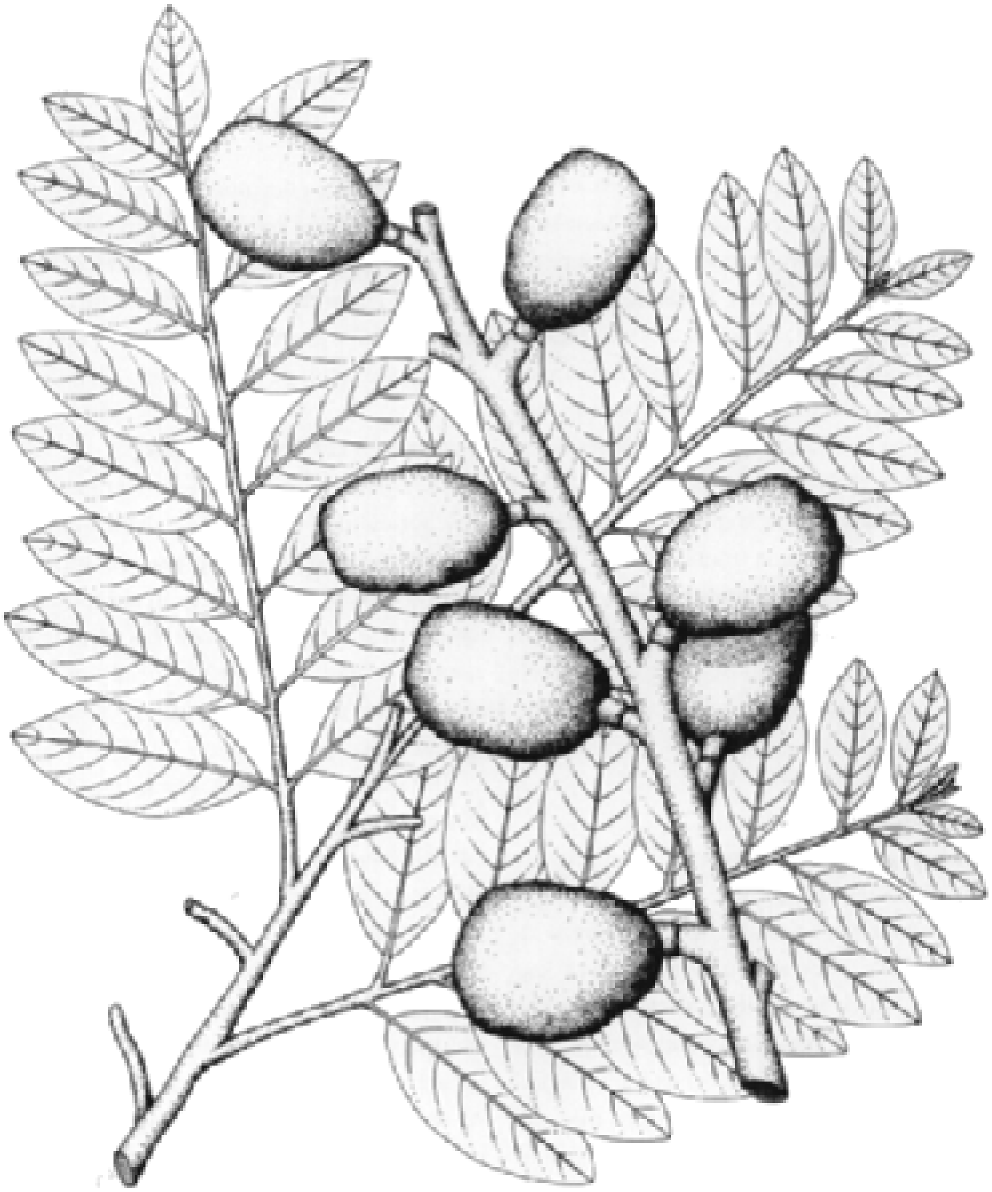

Figure 10. Spanish plum, red mombin (*Spondias purpurea*)

Ecology and phytogeography

The natural populations of *S. purpurea* grow from sea level to an altitude of 1 200 m in areas

with alternating seasons from Sinaloa and Jalisco in Mexico to Colombia. It is known that *S. purpurea* was taken from Nicaragua to Panama and South America in the form of cuttings with a viability of several weeks. It grows in regions of low humidity and remains leafless during the dry season. It has been introduced into similar tropical regions in Southeast Asia and also in subtropical areas (Florida).

Genetic diversity

Numerous clonal varieties of *S. purpurea* are known, but there has been no formal characterization of them. In Yucatán there are 20 varieties and, although some may be *S. Iutea*, this is perhaps the most notable varietal concentration in Mesoamerica. Ak-abal, with small, poor-quality fruit and smooth succulent roots, like those of the Brazilian species *S. tuberosa*, is used for pickles. The cultivated varieties may be divided into two groups:

Summer mombin. This fruits (in Central America) during the dry season from February to May, has ellipsoidal fruit that is 2.5 to 3 cm long with smooth, purple-red skin and yellow, smooth, sweet and slightly acid flesh. When green, these varieties look like olives. The varieties Tronador, Criollo, Nica and Morado grow between 0 and 800 m.

Winter mombin. This is of superior quality, with fruit that is 3.5 to 4.5 cm long, red or yellow, smooth or with protuberances, and has firm, sweet, slightly acid flesh. It ripens at the end of the rainy season (September to December). Most of these varieties grow between 800 and 1200 m and those known include Petapa, Corona and Cabeza de loro.

It has been suggested that these two groups should be considered as different species, but their distinctive characteristics are within the normal varietal range in the cultivated species. Wild populations, such as the iguana mombin in Costa Rica. have very attractive, red or purple fruit. with yellow flesh similar to certain grapes, although it is acidic and astringent. There are other wild varieties in Central America, some with common names. Being a species in which crossings must be very difficult, neither varietal richness nor related species, such as the jobo (*S. lutea*), are of great use in genetic improvement.

On the other hand, the study and evaluation of clonal variation may offer new material. In this connection. regions of particular interest are: the Pacific area of Nicaragua which has been famous for its mombin or Spanish plum since the days of colonial settlement; Yucatán, where numerous varieties exist; and southwestern Mexico and the neighbouring region of Guatemala. There are no collections of germplasm, but they should not be difficult to establish and maintain. In addition to *S. lutea*, there are two cultivated species: ambarella, Jew's plum or golden or Otatheite apple (*S. dulcis*) from Polynesia, which is grown sporadically in tropical America; and imbu mombin (S. *tuberosa*) from the dry region of northwestern Brazil, whose fruits are of excellent quality. These three species are propagated by seed.

Cultivation practices

Being a vegetatively propagated species, the sowing material consists of straight cuttings, more than 6 cm thick and at least 1.5 m long, with horizontal cuts. They are cut at the start of leaf production which generally coincides with the beginning of the rains. The cuttings are kept in the shade for a couple of weeks and are planted 8 x 8 m apart at a depth of 30 cm. As a rule, the only cultivation practice is pruning of the branches to cause numerous shoots to form along the main branches. Pruning can be done every year, since the flowers bud on the current year's branches. The experience of producers in Mexico is that pruning increases the size and weight of the fruit.

In Oaxaca, there are commercial plantations on which the trees are pruned at a height of 2 m; the cuttings are planted in double, inclined rows, with 3 m between the pairs of rows; when pruned, they look like European apple orchards.

There are no serious pests apart from the Mediterranean fruit fly (*Ceratitis capitata*) and Mexican fruit fly (*Anastrepha ludens*) which cause serious damage.

Harvesting on the pruned trees is an easy operation, performed by shaking the branches with poles or sticks; the fruit is gathered from the ground. Throughout the region where mombin is produced, the green fruit is eaten a great deal, as is the green fruit of the ambarela (*S. dulcis*).

Prospects for improvement

S. purpurea can be grown on marginal land of low agricultural value, on which the tree could be used for reforestation and produce extra profit for growers. Its production season is short, and late or early varieties that extend this period must be sought. Marketing, whether locally or in major towns, does not pose any major problems, as it is a widely accepted product.

The main limitation is attack from fruit flies, since control is expensive and beyond the range of small producers. An evaluation of cultivars that have some degree of resistance would be very advantageous, as would agronomic measures that tend to reduce infection by flies. Another theme to be investigated is the effect of defoliants on the acceleration of fruit formation.

So far, there has not been any industrialization of the fruit. Improving the primitive processes described earlier and research into others, as has been done in Florida with the artificial drying of slices of the flesh, may open up new possibilities for consumption.

Varieties of *S. purpurea* urgently need to be collected in one or more gene banks, which allow a quick evaluation of their genetic characteristics (resistance to insects, production period, response to pruning), and sowing material must be distributed among growers. In areas with sufficient space, it is recommended that *S. purpurea* be planted as a hedge, since its fruit production represents extra profit for the grower. Finally, transport and packaging problems must be studied to see how they can be Improved, since they are at a very primitive stage.

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New Fruits for Arid Climates

Yosef Mizrahi, Avinoam Nerd, and Yaron Sitrit

INTRODUCTION

In many countries around the world "developers" take the best agricultural lands for housing, and urbanization spreads rapidly. As a result, the agricultural industries are pushed into less productive lands in which the climate is not the most suitable for crops. A very good example is found in Israel. The best agricultural area is along the Mediterranean coast where the citrus industry flourished for almost a century and is the area where the famous 'Shamouti' (syn. Jaffa) orange was found and developed. Later, "Jaffa" became the trade name for the whole successful Israeli citrus industry. Today, most of this area is heavily populated and the agricultural industry is pushed into the Negev Desert where extreme temperatures exist, the soil is less fertile, and water, if available, is saline and/or very expensive. Labor is also less available and very expensive. The government by doing "more of the same" is encouraging the reestablishment of the citrus industry in the Negev and planting olives for oil (Negev of Growth Campaign).

Traditional crops in Israel appear to be at the end of their viable economic-life-cycle, but there is hope that new crops could establish a future profitable agricultural industry (Mizrahi and Nerd 1996). New crops could also ameliorate the increase in atmospheric CO_2 concentration (greenhouse effect) which increases temperature and drought, changing fertile lands into deserts (Mizrahi and Nerd 1996). The old traditional crops cannot cope with these expected changes. Over a decade ago Noel Vietmeyer (1986, 1990) raised the point that humans are "stupid" to neglect the huge treasure-house of biodiversity available in the thousands of wild plants and neglected crops that might solve many of our present and future agricultural problems. The aim of our program that started 16 years ago was to develop totally new fruit crops not known in the world markets, as new crops for desert areas (Nerd et al. 1990, 1993; Mizrahi and Nerd 1996, 1999). After many years of extensive R&D we had both failures and successes and we wish to share our experiences with others interested in new crops.

FRUIT TREES INTRODUCTION UNDER DIFFERENT DESERT ECOZONES

Since 1984 we have introduced and tested over 45 fruit tree species. Many of them are totally wild while others are neglected crops known only in their country of origin. All these species were tested in different ecozones around our Negev Desert, each differ from the other by average and extreme high and low temperatures and salinity of the irrigation water. In Israel, climatic and socio-economical considerations dictate that almost all crops are irrigated and in the Negev desert, most areas are irrigated with saline water. Salinity differs in the various ecozones not only by degree of salinity but also by ion composition. Whenever Na^+ is more abounded than Ca^{++} (Rengel 1992) and Cl^- is more abounded than SO_4^{--}, the damage of salinity is more pronounced and more species will die even under $4dS/m^2$ (Nerd et al. 1990; Mizrahi and Nerd 1996).

FAILURES WITH SOME AFRICAN SPECIES

As would be expected we have had many failures. Among our unsuccessful attempts is the yehib (*Cordeauxia edulis* Hemsl., Caesalpiniaceae), a wild shrub from the horn of Africa. This shrub produces a tasty edible nut even under extreme drought conditions when most plants will die. Unfortunately, we found yehib to be extremely sensitive to chilling temperatures, and plants have died at 4°C (Mizrahi and Nerd 1996). This unique bush deserves much more R&D efforts to save it from extinction (Miege and Miege 1979; National Research Council 1979).

Mongongo (*Ricinodendron rautanenii* Schniz, Euphobiaceae) is a nut-producing wild tree from the Kalahari Desert in southern Africa. It is highly nutritious and tasty nut but the yields are very low with no hope for the Israeli horticultural industry (Biesele et al. 1979; Fox and Norwood-Young 1982; Mizrahi and Nerd 1996). In all of the tested ecozones we only established fruiting mongongo trees in the Besor region with moderate temperatures and good quality irrigation water (Nerd et al. 1990).

A species which performed very well in most tested ecozones is the African plum (*Harpephyllum caffrum* Bernh. ex C. Krauss, Anacardiaceae). This wild tree of Southern Africa produces many small, tasty, aromatic, red fruits in bunches with different hues. However, there are problems that inhibit cultivation. First, the fruit is very small (few grams) and hence labor intensive and second the flesh is only 10% of the total weight. However it can be used for home gardens and city and park gardening with fruits that children and others will enjoy picking.

CACTI

Of the many plant families we have explored, the Cactaceae is the most important one for Israel, since water is the major limiting factor and becomes scarcer every day. In the future, the water authorities think that only recycled water will be used for agricultural production. The high water use efficiency of the cacti stems from their Crassulacean acid metabolism (CAM) pathway (Gibson and Nobel 1986; Nobel 1994; Mizrahi et al. 1997). Cacti have many uses as crops (Mizrahi et al. 1997). Our efforts have concentrated on fruit production of the unknown pitayas and not on the well-known prickly pear now called cactus pear [*Opuntia ficus-indica* (L.) Miller] that is already grown world-wide (Mizrahi et al. 1997, Mondragon Jacobo 1999, 2001).

Pitaya is a common name to many genera and species of cacti, all with elongated coloumnar stems (Ortiz 1999, 2001). Most of our work was recently reviewed (Mizrahi and Nerd 1999; Nerd et al. 2002) and here we would like to concentrate on updating the data and on the take-home-lesson and consequences from dealing with “real new crops.” These crops are not well known and there is great confusion about their botanical identity. We shall describe briefly each one of the species that have made their way into the European markets.

Vine Cacti

Yellow pitaya [*Selenicereus megalanthus* (Schum.) Britton & Rose], is a vine cactus that needs a trellis system for support. In Israel net-houses are required to avoid photo-inhibition and bleaching of its stems (Mizrahi and Nerd 1999; Nerd et al. 2002). Colombia was the first country to sell *S. megalanthus* in the world market under the name “yellow pitaya.” Until now, the incorrect names of *Hylocereus triangularis* and *Hylocereus undatus* have been used to describe this plant (Weiss et al. 1995). This plant can tolerate high temperatures more than the other vine cacti, yields spiny fruits where the spines abscise easily upon ripening and are unseen by consumers (Fig. 1). The fruits are smaller than the other vine cacti fruits but the taste is superior, hence, the higher prices obtained in the markets in comparison with other vine cacti. Most of the plantations in Colombia have been uprooted due to heavy infestation with fungi (Bibliowicz and Hernandez 1998). We found that desert environment is better than tropical, both from the phytosanitary point of view and the possibility to control and regulate plant production via irrigation, fertilization, and manipulation of shade regimes (Raveh et al. 1996; Mizrahi and Nerd 1999; Nerd et al. 2002).

Fig. 1. Fruit of the real yellow pitaya—*Selenicereus megalanthus*. Notice the tubercles on the fruits' peel, before ripening they contain large spines (1–2 cm), which abscise easily upon ripening.

The red pitaya [*Hylocereus undatus* (Haworth) Britton & Rose] is known in Latin America but the Asian name is dragon-fruit (Fig. 2). There are red flesh clones but we do not know where they are produced. Some red flesh pitayas are produced in Nicaragua and are considered *Hylocereus costaricensis* (Weber) Britton & Rose. In Israel we cultivate *Hylocereus polyrhizus* Weber. Guatemalan researchers refer to it as *Hylocereus undatus* (Mizrahi and Nerd 1999). Pigments differ among the clones and species, and have not been fully explored. For example the *Hylocereus* sp. clone 10487 has red color while the *H. polyrhizus* clones show glowing purple, a unique color, which has been chemically identified as hylocerenin and iso-hylocerenin (Wybraniec et al. 2001). The major problem which exists in these plants in desert areas is their sensitivity both to low and high temperatures (Mizrahi and Nerd 1999). Since variability in these characteristics exist among genotypes, and since there is no genetic barrier among species and even genera, breeding may solve these problems (Lichtenzveig et al. 2000; Tel-Zur et al. 2001). Other important problems with these fruits which might be solved with breeding, is the bland taste and lack of distinct flavor. Sellers of these fruits in Europe claim that the dragon fruit and other red pitayas, which exist today in the market, are bought for their beauty and used mainly for decoration (A. Ronen unpubl. information). Our first hybrids released lately to our growers, exhibit much better taste than the original clones. However there is a lack of effort for breeding tolerance to extreme desert conditions, because of what we consider to be "establishment antagonism." We are convinced that in addition to marketing issues genetic and physiological R&D efforts are required to convert these exotics to mainstream commodities in the world markets.

Fig. 2. Fruit of red pitaya (Dragon fruit in Asia) *Hylocereus undatus*. Note that the fruit contains scales that shrivel post harvest, and they are the main reason for loss of fruit value.

Columnar Cacti

Among the various columnar cacti we believe that the most promising one is *Cereus peruvianus* Britton and Rose, which might be the same species as the *Cereus jamacaru* (Nerd et al. 1993; Mizrahi and Nerd 1999; Gutman et al. 2001). The plant is columnar with many branches (Fig. 3). Columns may bear spines to various degrees and length, but the fruits are smooth and totally spineless. The fruits are medium in size, and vary in skin color from yellow to red with various hues. Flesh is white and aromatic with a delicate sour/sweet taste. Black seeds are embedded in the flesh, but are soft and edible reminiscent of kiwifruit seeds (Fig. 4). Israel was the first country to sell this fruit both in the domestic market and in Europe (Fig. 5). Efforts have been carried out in the US and Australia to introduce this unique fruit to their markets. This plant might have other industrial uses because of polysaccharides which may be extracted from its stems (Alvarez et al. 1992). Stem pruning is necessary to ensure efficient fruit harvest. Our results in domestication of this fruit was recently reviewed (Mizrahi and Nerd 1999; Nerd et al. 2002) and here we would like to discuss difficulties in marketing which might hamper introduction. In Israel there are only a few producers. One producer is marketing the fruit at the proper stage of ripeness, with each package containing a leaflet describing the fruit, how to use it fresh, its other uses, storage and nutritional information. However, others sell it in simple boxes with other fruits, at various stages of ripening, from unripe, to ripe and over-ripe, without explanatory leaflets, acts which damage the future of this newly developed fruit. In Europe columnar cactus fruit was accepted quite well but supermarket chains required 300 tonnes/year, while the quantities produced in Israel in 2001 were only 70 tonnes. Special efforts are required from the exporters to sell it in small quantities and if they are not determined to market this fruit it will not be sold. The Israeli establishment (as other establishments) is not interested in new crops. Despite these difficulties, we foresee a great future for this crop due to early and precocious yields (Fig. 6), beautiful appearance, excellent delicate taste, long shelf-life to enable export, and, above all, minimum demand for irrigation and water-stress tolerance.

Fig. 3. Five years old *Cereus peruvianus* plant, multi branched + fruits. The picture was taken at Sde Nitzan in the Western Israeli Negev Desert.

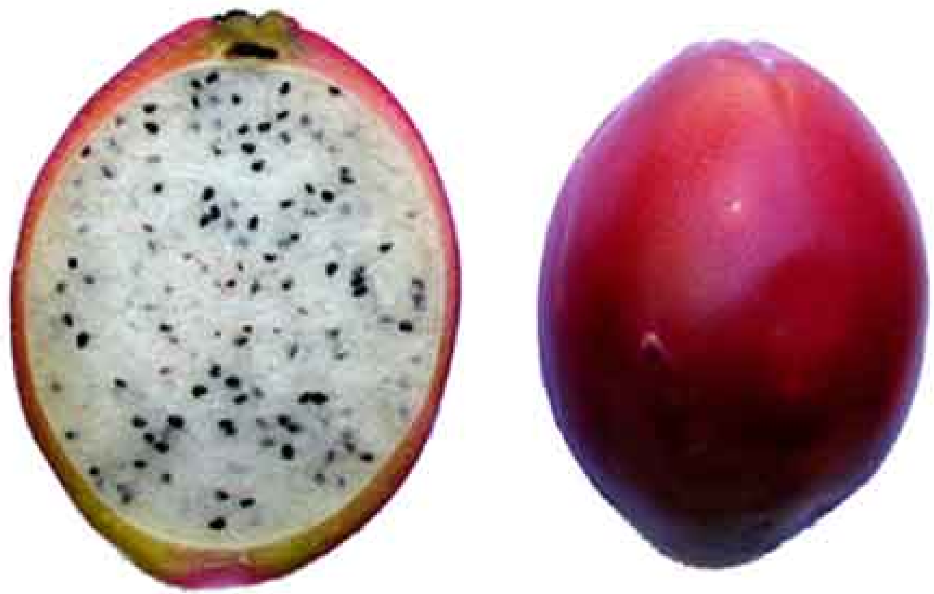

Fig. 4. *Cereus peruvianus* cut fruit. Note the smooth peel and the many black, soft edible seeds embedded in the pulp.

Fig. 5. Export box of *Cereus peruvianus* ripe fruits, ready to be shipped to Europe. The trade name Koubo is used by AGREXCO the main Israeli export company.

Fig. 6. Heavy load of fruits on 4 years old *Cereus peruvianus* plant. The picture was taken at Sde Nitzan in the Western Israeli Negev Desert.

OTHER FRUIT TREES SUITABLE FOR DESERT AREAS

Of the many fruit trees we have tested the following species are ready for the first trials to test their feasibility as new orchard crops under desert conditions. We have selected clones where we had information on tolerance to desert conditions, fruit yields, quality, and shelf life (Mizrahi and Nerd 1996). These fruits include white sapote (*Casimiroa edulis* Llave & Lex, Rutaceae) (Nerd et al 1992); black sapote (*Diospyros digyna* Jacq., Ebenaceae); desert apple ber or bor in India (*Ziziphus mauritiana* Lam., Rhamnaceae); marula from Southern Africa [*Sclerocarya birrea* (A. Rich) Hochst. sbsp. *caffra* (Sond.) Kokwaro, Anacardiaceae] (Weinert et al. 1990; Nerd and Mizrahi 2000); argan [*Argania spinosa* L. (Skeels), Sapotaceae], wild tree of Morocco, the best culinary oil is extracted from its seeds (Prendergast and Walker 1992; Nerd et al. 1994); and sapodilla [*Manilkara zapota* (L.) van Royen, Sapotaceae], from South East Asia, which is already a crop in many warm countries (Morton 1987). Some of these species (pitaya, white and black sapotes, and sapodilla) are also recommended for tropical zones such as Northern Queensland in Australia (Finocchiaro 2001). Unfortunately there is a lack of support to develop these and other new crops and farmers are afraid to take the risks. The daring farmers of Israel are already involved in production of various pitayas.

Another interesting fruit, which has not reached the R&D stage, is the monkey orange. It consists of three main species as follows: *Strychnos cocculoides* Backer; *S. spinosa* Lam.; and *S. pungens* Solereder, Loganiaceae, all native to Southern Africa (Wehmeyer 1966; Fox and Norwood-Young 1982; Taylor 1986). *Strychnos pungens* did not survive in any of our introduction orchards. *Strychnos cocculoides* which is considered the best of the three (in terms of eating quality), survived only in the Besor region (good quality water and moderate temperatures) and some trees started to bear fruits not of very high quality. It is too early to judge its performance. So far the best of the three under our conditions is *S. spinosa*. It survived in three of our introduction orchards and performed very well in the Besor area (Fig. 7). We have around 15 fruiting trees with high variability for growth, yields, fruit size, ripening season, and taste. Some of the seedlings bear astringent, bitter fruits, other bear very sour ones but two of the trees bear excellent tasty fruits. In organoleptic taste tests, people were requested to compare the monkey orange fruit with familiar fruits; the most common answers were, orange, banana, and apricot, and all possible combinations among them. The fruits emit a delicate aroma reminiscent of the spice clove. GC/MS analysis performed by Ephraim Lewinson of Newe Ya'ar, (ARO Israel) found eugenol, the essential oil found in clove (unpubl. results). Over 90% of the panel claimed that it was very tasty. Various products such as juices and dry fruit rolls are potential uses for this fruit. The fruit is large (400–1200 g), (Fig. 8), round, has a thick shell 4–7 mm, and contains 30%–45% juicy flesh with over 20% total soluble solids, and high acidity (over 200 μeq H^+/gFW).

Fig. 7. Six years old tree of monkey orange Strychnos spinosa bearing fruits. The picture was taken in the Besor Research Farm, in the Western Israeli Negev Desert.

Fig. 8. Open fruit of monkey orange Strychnos spinosa. Note the very thick peel.

We are aware of the difficulties in introducing a new product into a market which is full of other temperate and tropical fruits. The first questions we are asked is—who needs these strange fruits? Who is going to buy them? For how much? What is the volume that the market can receive? All these are legitimate questions, which are discouraging for the establishment to deal with. On the other hand it is quite clear that apples and citrus fruits will struggle to withstand the changing economic and climatic conditions (Vietmeyer 1990). Also it is known that among the affluent class in the Western societies there is an increasing demand for exotic fruits and vegetables and some such as kiwifruit have become mainstream products (Anon. 2000).

The health profile of these new fruits is unknown and needs to be explored. For example the non-proteinecious amino acid, taurine was found in Opuntia ficus-indica, in spite of the common belief that the main source of taurine in our diet, comes from animals especially sea-food (Stitzing et al. 1999). Taurine is an important ingredient in the so called "energy drinks" with proven positive activity on human well-being (Seidl et al. 2000). In spite of all these arguments, exotic new fruit trees have received strong antagonism from all possible established organizations, such as the officials in the Ministry of Agriculture, Associations of Fruit Growers, and the main Export Company AGREXCO. We conclude with a plea from a report which speaks for itself.

> *"Every production system and every mature organization is equipped with antibodies against deviations from routine. These antibodies work overtime to kill all interest in the new product and are very likely to succeed. It is an innate property of every established industrial organization, which is why most new products are created and brought to market by young organizations that have no standard products to occupy them. Established organizations (Israeli agriculture among them) that want to get into this business of introducing new products have to build themselves managerial mechanisms designed to act as a countervailing weight against the forces of routine."*

Yshai Sfarim (1989)

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Winter purslane

Cuban spinach

Portulacaceae *Montia perfoliate* Howell

Source: Magness et al. 1971

Winter purslane is a short-lived annual with opposite, somewhat fleshy leaves mostly rising from the root, generally ovate in shape and up to 3 inches long. The plant is mainly grown in winter in warm countries, and the leaves are used as salad and pot herbs. Exposure of edible parts is comparable to that of spinach.

Velvet bean

Leguminosae *Mucuna deeringiana* (Bort.) Merr.

Source: Magness et al. 1971

This is a strong-growing annual plant native to the tropics. Most of the several varieties grown in the United States are *M. deeringiana* although some kinds are of other *Mucuna* species or interspecies hybrids. The slender stems may grow to 30 feet in some kinds. They are mainly grown with a support crop, usually corn, on which they climb and are partially supported. The leaves are trifoliate, with large ovate leaflets. Pods are pubescent, up to 6 inches long, with 3 to 6 seeds per pod. Velvet beans are well adapted to sandy soils and require a long growing season to produce much pasturage. They are grown mainly in the Southeastern Coastal Plain for late summer pasturage and soil improvement. All parts of the plant are nutritious and palatable to livestock.

Last update June 27, 1996 bha

R.J. Dufault, M. Jackson, and S.K. Salvo. 1993. Sweetgrass: History, basketry, and constraints to industry growth. p. 442-445. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Sweetgrass: History, Basketry, and Constraints to Industry Growth

Robert J. Dufault, Mary Jackson, and Stephen K. Salvo

Sweetgrass is a native, perennial, warm-season grass found growing sparsely in the coastal dunes extending from North Carolina to Texas. The "treads" or long, narrow leaf blades of this grass have been harvested by direct descendents of enslaved Africans of antebellum South Carolina and used as the principle foundation material for constructing African coiled basketry in the Southeast, especially near Charleston (McKissick Museum 1988). Originally, these graceful products provided useful, practical objects or "work baskets" for agricultural and household use on the plantations; today, they have evolved as souvenirs treasured by tourists, and elegant objets d'art (Fig. 1).

Basketmakers are faced with changes and challenges that threaten the existence of their craft. The supply of sweetgrass is becoming more difficult to acquire because the natural habitats of sweetgrass have significantly diminished. Two primary factors have led to this situation. First, the urbanization of the area around Mt. Pleasant has led to the destruction of much of the natural sweetgrass plant communities. Second, the traditional gathering areas on the Barrier Islands off the coast of Charleston, have been developed as beach resorts or private communities with restricted access. Basketmakers now have to travel to Georgia and Florida to find adequate supplies.

Natural habitats of sweetgrass need to be preserved, protected, or relocated if this industry is to continue. The basketmaking community will need help from local governments to continue to sell baskets along the old Ocean Highway (Hwy 17) or relocate the stands to equally visible, safe locations. Alternatively, the ability to cultivate sweetgrass on inland soils in the Mt. Pleasant area would enable the production of readily available raw material. These practices would help to insure that the heritage of basketmaking will continue to flourish into the 21st century.

SWEETGRASS INDUSTRY

Mt. Pleasant, South Carolina, is located four miles north of Charleston on U.S. Hwy 17. Baskets are sold in a variety of places in the Charleston area. About 75 basket stands dot the old Ocean Highway in Mt. Pleasant. Baskets are also sold by the "basket ladies" in Charleston's Market area and even on major intersections within the historic areas of the city.

About 300 families are involved in sweetgrass basketry of which approximately 75% are full-time basketmakers and 25% are part-time (Mary Jackson pers. commun.). Twenty-five years ago, approximately 1,200 families were involved in basketmaking and this represents a 75% decline in the basketmaking community.

HISTORY

The variability of African baskets is as diverse as the 800 different ethnic groups that comprise the African people (Vlach 1978). Only certain African people however, especially those from Senegal, were brought to South Carolina as early as 1505 with the advent of the slave trade in the New World. By the end of slavery around 1808, Africans were abducted from areas down to Central Africa and Mozambique.

Rice was the main cash crop of South Carolina during the colonial period and the base of the State's economy until the 19th century. Slavers were paid premium prices for Africans from the West African Rice Kingdoms of the Windward Coast (Senegal to the Ivory Coast) and the mouth of the Congo River (Gabon, Zaire, and Angola) (Littlefield 1981). A man or women who made baskets was worth more than one who did not, age, strength, and other skills being equal (Chas. Gaz. Adv. 1791). Since colonial South Carolinians knew little of rice culture, the success of the American Rice Kingdom is credited to enslaved Africans (Joyner 1984).

The technique of basketmaking crossed the Atlantic in slave ships and took root in the new land. The art of making sweetgrass baskets is a three-century old African-American tradition that has been "passed-down" over the centuries from parent to offspring. Sweetgrass basketmaking is one of the earliest traditional rafts with a rich documented history from "carryover" from African enslavement and plantation days to the present (McKissick Museum 1988). Although the materials used are different in the United States, the form and function of the African counterparts of sweetgrass baskets are unchanged to this day (Mary Jackson pers. commun.).

Folk history recounts that enslaved men and women weaved African coiled baskets to fan rice in order to separate the grains from the chaff. After the Emancipation Proclamation in 1863, former slaves were dedicated to preserve the African traditions of their ancestors. A reaffirmation of this goal has been made by each generation of the descendants of enslaved Africans and sweetgrass basketry is a symbol of this devotion.

SWEETGRASS IDENTITY AND HABITAT

Sweetgrass (*Muhlenbergia filipes* Curtis, Poaceae) was first identified and described botanically by Moses Ashley Curtis in 1843 and later by Pinson (1971). There is still a dispute as to whether sweetgrass should be identified as a variety of *Muhlenbergia capillaris* or remain a distinct genus and species (Rosengarten 1987). There is a lack of concise, comprehensive descriptive information on this species (Pinson and Batson 1971.)

Sweetgrass grows in bands about 50 to 75 m from the mean high tide line in undulating sand dunes usually behind the first dune along the ocean from North Carolina to Texas. Occasionally, plants are found growing on well-drained, sandy uplands bordering brackish marshes and in open maritime forests (Pinson and Batson 1971). Sweetgrass grows on many of the barrier islands along South Carolina's coast, such as, Kiawah, Seabrook, Dewees, Bulls, Fripp, and Hilton Head.

BASKET CONSTRUCTION

Rosengarten (1987) has provided an excellent review of basketry technique. Coiled basketry involves sewing or stitching unlike other types of baskets that are woven. Each basket begins with a small knot of long-leaf pine needles (*Pinus palustris* Mill.) or the fine-threaded sweetgrass. Pine needles may be used throughout the basket to provide a russet color that contrasts well with the more yellow sweetgrass. Coarse, thicker gauge black rush (*Juncus roemerianus* L.), also known locally as "bulrush, rushel, or needlegrass", may be added to the inside of the baskets for strength. Black rush turns a rich tawny color when dried. Strips of palm leaf (*Sabal palmetto* Lodd.) are used to sew the rows of coils to each other. A hole for the palm strips is made with a bone (a spoon with the bowl removed and the end smoothed and polished), nail, or bagging needle. Shape of the baskets is created by building upon the foundation, one row at a time and then row upon row. The coils of material must constantly be fed with new grasses to maintain a constant foundation of uniform thickness. The strength of the basket depends on how firmly the stitches are pulled. Today, baskets of great variability are constructed by modifying the amounts of these materials to create subtle changes of tone and radical change of texture.

CONSTRAINTS TO INDUSTRY GROWTH

The development of South Carolina's barrier islands and beach fronts has increased the areas economic prosperity and tourism which has been helpful to the basketmakers. However, changes in land ownership, land use and lifestyles have destroyed many plant communities or restricted access to remaining local sweetgrass habitats. Expensive and long journeys to Georgia or Florida are now necessary to gather raw materials. Political help is needed to preserve and protect natural sweetgrass habitats from destruction. Research is needed to learn how to domesticate this wild plant and cultivate sweetgrass as a row crop.

JUSTIFICATION FOR PRESERVING SWEETGRASS BASKETRY

The traditional basket stands along the Ocean Highway are being unintentionally forced out of the community by construction of shopping malls and business parks with road frontage along the highway. These stands have been located on this highway for over 60 years. The display of African baskets has been a major source of income for many basketmakers as well as providing tourists an appreciation of the beauty, significance, and value of this ancient art form. The danger in displacement from traditional marketing areas is that basketmakers would have very few alternatives to sell their baskets in highly visible locations. This frustration may require them to seek other sources of income and cause a loss of basketmakers from the community.

The Mt. Pleasant basketmaking community has become known throughout the United States and abroad for their art. Today, the baskets have become a symbol of coastal South Carolina. The downtown area of Charleston has over 2,000 buildings registered with the Historic Society, yet basketmaking is truly the only "live" viable symbol or relic of the extinct plantation days of colonial times. After 300 years, this tradition, as well as historic buildings, are the trademarks of Charleston. Postcards and photographic illustrations commonly depict basketmakers and their art. African coiled basketry are objects of scholarly research and commonly are featured in newspaper and magazine articles in the United States and abroad. Sweetgrass baskets are displayed in art galleries, traveling exhibits, and have been displayed in the Smithsonian, Vatican, and Gibes Art Museum in Charleston and other museums.

In 1988, the Mt. Pleasant Basketmakers' Association was formed. The function of the Association is to organize the basketmakers into a cohesive group and to form a common voice to influence the management of their resources. The Association's purpose is to promote, preserve, and protect the tradition of sweetgrass basketmaking.

The first Sweetgrass Basket Conference was held on March 26, 1988 to discuss the basketmaking tradition, biological assessment and ecology of sweetgrass resources, impact of coastal development and public and private concerns in relation to the basket industry (McKissick Museum 1988). Through the activities of the Conference, many immediate pledges of public and private aid were offered.

In October, 1988, the Town Council of Mt. Pleasant resolved to make preservation of the basket stands a goal of the zoning process. In December, 1991, the Sweetgrass Preservation Society was formed by the Mayor of Charleston to help the basketmakers work on strategies to help protect and preserve their craft and tradition.

The art of sweetgrass basketmaking has evolved from a practical craft, to a curio, to a genuinely valuable artform. The sweetgrass basketmaking tradition is a crucial element of the African cultural tradition. The descendents of enslaved Africans possess an intimate, loyal, and loving bond of their ancestry and heritage in colonial South Carolina and Africa. Sweetgrass basketmaking is the "living" symbol of this passion.

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Fig. 1. Sweetgrass plant and baskets.

Last update September 15, 1997 aw

Mullein

Verbascum thapsus L.

Figure 79.—Mullein (*Verbascum thapsus*)

Other common names.—Common mullein, great mullein, mullein dock, velvet dock, Aaron's-rod. Adam's-flannel, old-man's-flannel, blanket leaf, bullock's lungwort, cow's lungwort, clown's lungwort, candlewick, feltwort, flannel-leaf, hare's-beard, velvet plant.

Habitat and range.—Mullein is a weed found in fields, pastures, along roadsides, and in waste places, its range extending from Maine to Minnesota and southward. It is also spreading in the Western States.

Description.—This plant is easily recognized by its tall, straight stem, its large felty or flannellike leaves, and its long, dense spike of yellow flowers. During the first year it produces only a rosette of downy leaves followed from June to August of the second year by the long flowering stalk. The densely hairy, erect stem sometimes reaches a height of 7 feet. The thick, felty leaves are from 4 to 6 inches in length and, with the exception of the basal ones, are stemless.

Part used.—The flowers and leaves, the former collected when fully opened.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Mushrooms

Beefsteak fungus, Beef tongue, Black tree fungus, Brown-capped mushroom, Button mushroom, Cep, *Cèpe, Champignon d'Paris*, Chanterelle, Chinese black mushroom, Cloud-ear fungus, Common mushroom, Common white mushroom, Cremini mushroom, English mushroom, *Enoki*, Enokitake, Fairy-ring mushroom, False *mousseron*, Field mushroom, Forest mushroom, *Girolle*, Golden chanterelle, Honey mushroom, Italian brown mushroom, Japanese brown mushroom, Jew's-ear, Liver fistulina, Matsutake, Meadow mushroom, Morel, *Mousseron, Mousseron d'automne*, Oak tongue, Oyster mushroom, Paris mushroom, *Pfifferling*, Pinecone mushroom, Pink-bottom, *Porcini*, Portabello, Puffball, Rodman's mushroom, Roma, Shiitake, *Steinpilz*, Straw mushroom, Tree ear, Tree mushroom, Vegetable beefsteak, Vegetable meat, Wild mushroom, Winter mushroom, Wood ear

We have information from several sources:

Specialty Mushrooms—Daniel J. Royse

Response of Australian Strains of the Mushroom *Lepista nuda* to Temperature and Substrate—Karen Stott and Andrew Broderick

New Crops for Canadian Agriculture—Ernest Small

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

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Douglas, J.A. 1993. New crop development in New Zealand. p. 51-57. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

New Crop Development in New Zealand

James A. Douglas

New Zealand lies between the 33° to 53° south latitudes in the South Pacific about 1,600 km east of Australia. It consists of two main islands similar in size to Japan or the British Isles. The climate is temperate and dominated by a westerly wind flow within an oceanic environment that gives a weather pattern which is changeable over short periods. In the southern main island a mountain chain exceeding 3,000 m in height modifies the weather pattern. The country as a whole is subject to extremes of wind and rain with annual rainfall varying from below 400 mm to over 12,000 mm in the Southern alps. Summer droughts are common in many areas and all regions of the country experience frost except the northern part of the North Island.

New Zealand has been settled by Europeans for 170 years with the total population now 3.3 million. About 18 million hectares are occupied with pastoral farming being the major form of land use. In 1988, New Zealand had 65 million sheep, 8 million beef and dairy cattle, 1.3 million goats, and 0.6 million farmed deer. Primary products from these stock, forestry products, fruit and vegetables, and fish make up 64% of the New Zealand export trade of $NZ15 billion ($NZ = 0.59 US$, 1991). The important point about this trade is that, with the exception of fish, it is based on animals and plants which have been introduced into New Zealand over the past 150 years. The pastoral industry is based on the European pasture species perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.), the forestry industry on the Monterey pine (*Pinus radiata* D. Don) from coastal California, and the fruit industry on the Eurasian apple (*Malus* x *domestica* Borkh.) and the kiwifruit [*Actinidia deliciosa* (A. Chev.) C.F. Liang & A.R. Ferg.] from China.

NEW CROP PROGRAM

The wide range of climatic variation in New Zealand from low to high rainfall, cool temperate to marginally subtropical gives a capacity to grow a very wide range of crops. The difficulty has been to narrow down the number of potential crops from those which are environmentally feasible to those which are profitable. To do this, the focus has been moved from examining what crops will grow in New Zealand to using market intelligence to identify crops with defined international or niche market opportunities and then working back to the feasibility of production in New Zealand. Published information about target markets has been used to identify growth areas within markets but often this information is too generalized to identify specific crops. Consequently, these desk studies have been followed up by commissioned within market investigations to gather the detailed information required to identify crops which have established markets but which are not currently grown in New Zealand. Available literature has been collected on each crop to characterize their environmental requirements and assess the likely adaptation to New Zealand conditions. Target crops are sourced, plant material imported, and grown in preliminary trials to assess their local environmental adaptation and their ability to produce the product required by the market place. Crop samples are sent to the target markets to assess the quality standard and market acceptability. Crops which exhibit potential proceed to more sophisticated trials with a greater selection of cultivars to determine their specific environmental, agronomic, and postharvest requirements to optimize yield and quality parameters.

The new crops program is carried out at a number of research stations which span the major island environments (Fig. 1). Climatic recordings from these research stations or close by, listed in Table 1, indicate the temperate nature of the New Zealand environment. In summer, temperatures above 30°C are uncommon and in winter, snow is normally only a one or two day phenomena in the southern regions. There are six programs: new export vegetable crops; European and Asian medicinal herbs; culinary herbs and essential oils; edible fungi; fruit; nuts; and ornamentals.

NEW EXPORT VEGETABLES

Research on new export vegetables has concentrated on investigating the requirements of the Japanese market. Already, New Zealand exports significant volumes of squash, asparagus, and onions to Japan. Traditional Japanese vegetables, which are not widely known outside Japan, have strong internal demand. The possibility of growing such vegetables in New Zealand and exporting them to Japan provide the basis of this program. New Zealand has many climatic features similar to Japan and is environmentally suitable to produce Japanese vegetables. The major constraint is the need to choose vegetables which have sufficient shelf life so that they can be freighted to Japan in good condition.

Subsequent to an examination of Japanese market information, two crops, wasabi [*Wasabia japonica* (Miq.) Matsumara] and myoga ginger (*Zingiber mioga* Roscoe), were identified as having strong market potential. Research began on wasabi in 1982 and myoga in 1983.

Wasabi

Wasabi or Japanese horseradish is a native perennial crucifer of Japan which is used as a traditional condiment of Japanese food. It requires specific conditions of light and water to thrive. In Japan, the highest quality fresh product is grown on tree shaded, terraced gravel beds covered by a thin layer of cool running water from mountain streams or on artificially shaded mounded gravel ridges formed in larger river beds (Hodge 1974; Follett 1986). Lower quality wasabi for processing is grown in soil.

Wasabi plants grow poorly in New Zealand in full sunlight and artificial shading is required to keep the light levels below 700 µmol m^{-2} s^{-1} otherwise the plant is liable to wilt. Japanese recommendations of using 50% shade cloth were inadequate under New Zealand conditions and a further 30% shade cloth was required during the summer. Further research on the shade requirement of wasabi is needed.

The initial New Zealand trials on wasabi were established in large concrete troughs filled with rock and gravel similar to the tatami ishi wasabi beds of Shizuoka, Japan. Spring water of 13° to 14°C was flowed over the beds at about 160 liters/min. Unrooted cuttings were planted at 25 cm centers and the crop grown for two years. Sequential harvests from 15 months indicated that there was a need to leave the crop at least 18 months before harvest to achieve a reasonable production of stems over 50 g (Table 2).

Wasabi has a number of major pests and diseases and is known to suffer from various mosaic viruses which can cause rapid crop decline if successive crops are grown from infected sideshoot cuttings. Regular spraying is required to control aphids and white cabbage butterfly caterpillars. Leaf diseases such as white rust (*Albugo* sp.) are also controlled by foliar sprays but the more difficult diseases to control include the stem and root fungal diseases, *Phoma* and *Botrytis* and bacterial softrot, *Erwinia*. Control of these diseases is largely unresolved in the natural running water systems.

Considerable progress has been made in New Zealand in the past 5 years on how to grow wasabi to produce a marketable crop, but it is only the beginning. A greater understanding of the physiology of the crop in relation to its environmental requirements, improved cultivars, and better disease control should all allow higher yields and more efficient production methods to be developed. Research in these areas is underway.

Myoga Ginger

Myoga ginger (*Zingiber mioga* Roscoe), a cold tolerant member of the ginger family (Zingiberaceae), is a native perennial of Japan grown as a traditional Japanese vegetable for its spring shoots or its summer/autumn flower buds. The production of flower buds is highly seasonal and consequently there is an opportunity for a southern hemisphere producer such as New Zealand to supply myoga to Japan when their supplies are low.

Preliminary research on myoga was conducted in New Zealand by Palmer (1984) and following an investigation of Japanese production systems (Follett 1986) further plants were introduced. The plant is established vegetatively from rhizome sections with faster and more even plant emergence from coolstored rhizomes (Follett 1991). The plant is frost sensitive and dies down in winter but the dormant rhizomes have proved to be quite winter hardy (Palmer 1984). Myoga is vigorous and largely disease and pest free when grown on free draining soils, although rhizome rotting from *Fusarium* and *Pythium* species has been noted on poorer drained soils. Under New Zealand conditions, myoga topgrowth sunburns and becomes chlorotic without shading and consequently trials have been established under 50% shade cloth. A comparison is presently being made between artificial shade and natural shade given by spaced Paulownia (*Paulownia elongata* S.Y. Hu) trees.

Myoga production beds established with 30 cm between rhizomes and 1 m between rows have yielded 6.75 t/ha of flower buds in the second year. This is comparable to Japanese production levels. The flower buds develop from underground stems on the edge of the plant mass and to achieve top quality produce, the buds should be picked before they emerge and turn green. To facilitate this, a 10 cm layer of sawdust was applied so that the buds could be located by fossicking and picked. Picking was carried out every 2 to 3 days over a 2 month period.

Myoga is a very new crop in New Zealand with little grown commercially. There remains considerable research to be undertaken in defining its agronomic management but research results to date and the successful test marketing of New Zealand grown myoga indicate that it is likely to be a successful new crop for New Zealand.

Medicinal Herbs There is a large and expanding international market for medicinal herbs and plants for the manufacture of pharmaceuticals (Principe 1989). New Zealand has no significant production of these products although in the late 1970s commercial extraction of solasodine from the native *Solanum* species (*S. aviculare* Forst., *S. laciniatum* Ait.) was begun but later abandoned (Mann 1978; Mann et al. 1985). Nevertheless, the New Zealand environment provides good conditions for the growth of a wide range of medicinal herbs and in many instances they are familiar as weeds. Examples include dandelion (*Taraxacum officinale* G. Weber), St John's wort (*Hypericum perforatum* L.), horehound (*Marrubium vulgare* L.), burdock (*Arctium lappa* L.), Variegated thistle [*Silybum marianum* (L.) Gaertner], briar rose (*Rosa rugosa* Thunb.), and hawthorn (*Crataegus monogyna* Jacq.).

The current research program is focussed on understanding the agronomic requirements of seven medicinal herbs: coneflower [*Echinacea purpurea* (L.) Moench], valerian (*Valeriana officinalis* L.), *Arnica montana* L., dandelion, feverfew (*Chrysanthemum parthenium* Pers.), goldenseal (*Hydrastis canadensis* L.), and ginseng (*Panax ginseng* C.A. Mey., *P. quinquefolius* L.). Test marketing of samples from preliminary research on valerian, dandelion, rosehips, and chamomile [*Chamomilla recutita* (L.) Rauschert] has already shown that these crops can be produced to international market standards. Collections of a wide range of European and Asian medicinal herbs are being assembled for preliminary evaluation of both their growth potential and quality assessment before proceeding to more sophisticated agronomic programs. A Plant Extracts Research Unit provides the quality assessment of the medicinal herbs and also produces plant extracts for examination of their biological activity. This research program is in its infancy and although few results are available, the initial indication is that a wide range of medicinal herbs should be able to be grown successfully in New Zealand.

Culinary Herbs

A wide range of culinary herbs are grown by home gardeners and herb enthusiasts in New Zealand and the more common ones are supplied fresh to local markets with a small export industry based on fresh herbs. There is however no significant industry growing herbs to supply the international dried herb market. Preliminary research has already shown that lemon balm (*Melissa officinalis* L.), lemon verbena [*Aloysia triphylla* (L'Her.) Britton], sage (*Salvia officinalis* L.), and thyme (*Thymus vulgaris* L.) have all produced good quality herbage which meets international market standards. Research has been planned on these crops as well as oregano (*Origanum vulgare* L.), peppermint (*Mentha* x*piperita* L.), and spearmint (*M. spicata* L.), to examine the environmental and agronomic requirements to produce high quality produce. It is expected that as a greater understanding of each crop is developed more emphasis will be placed on growing these crops organically.

Essential Oils

New Zealand has the potential to grow a wide range of essential oil crops but no major industry has yet developed. Considerable research has been conducted describing the essential oil content of New Zealand native species and a small industry extracts manool from the native pink pine [*Halocarpus biformis* (Hook.) Quin] (Brooker et al. 1988). Research on peppermint begun in 1968, led to some commercial planting but this industry did not persist due to the difficulties with mint rust (*Puccinea menthae* pers. commun.) (Lammerink and Manning 1971, 1973).

The current research program seeks to systematically define the oil yield, composition analysis, and international quality assessments of a number of species (Table 3). The results have been very encouraging from this research and commercial extraction of essential oil and sclareol from clary sage is currently under investigation. Agronomic trials have been established to examine the influence of cultivars, environment, weed control, time of harvest, and distillation on oil yield and quality.

Edible Fungi

New Zealand has an industry based on the cultivation of the button mushroom [*Agaricus bisporus* (Lange) Sing.] and a growing interest in the cultivation of shiitake [*Lentinula edodes* (Berk.) Sing.]. In the past, a small industry has been based on the collection of the jelly fungus *Auricularia polytricha* (Mont.) Sacc. to supply the Chinese market (Brooker et al. 1988).

The current research program is directed at developing techniques to establish and produce the sought after mycorrhizal fungi, black truffle (*Tuber melanosporum* Vitt.), white truffle (*T. magnatum* Pico.), matsutake [*Tricholoma matsutake* (S. Ito & Imai) Sing.], and cep (*Boletus edulis* Bull.). Research has successfully devised techniques to inoculate black truffle onto oaks and hazels and although the fungus is evident in the field no truffle production has yet occurred (Hall and Brown 1989).

Fruit, Nuts, and Ornamentals

Research on new fruits is directed at identifying appropriate cherimoya (*Annona cherimola* Mill.) cultivars for the northern regions of New Zealand. There are now over 60 named cherimoya cultivars in New Zealand and evaluation continues to seek a fruit which has the attributes of high yield, smooth skin, low seed number, good flavor, and a reasonable shelf life (Anderson and Richardson 1990). At the present time, there is no cherimoya industry in New Zealand.

There is a small and developing industry on macadamia (*Macadamia integrifolia* Maiden & Betche, *M. tetraphylla* L.A.S. Johnson) nuts in New Zealand but low yields limit the commercial success (Richardson and Dawson 1991). Research is continuing on evaluation of cultivars from mainly Australian and Hawaiian sources and investigating the effect of pollination and nutrition on crop yields to highlight possible ways to increase yields.

Preliminary research has begun to better define pollination of chestnuts (*Castanea sativa* Mill., *C. crenata* Siebold & Zucc.) and identification and control of fungal pathogens which spoil stored nuts. Small commercial plantings of chestnut have taken place based mainly on superior selected trees from local seedlings and there is a need for further cultivar evaluation.

Biogeographic principles are being used to pinpoint sources of appropriate plant material for new plant introductions into New Zealand where there are perceived market potentials not currently being addressed. Particular emphasis is being directed towards sourcing plants from the enormous germplasm resource of South America. Species collected are fed into the herb, essential oil, fruit, and ornamental programs. New ornamentals obtained in South America such as some *Begonia*, *Ennealophus*, *Fuchsia*, and *Tibouchina* species which are new to New Zealand are evaluated for growth habit, flowering behavior, and postharvest shelf life to estimate their potential as cut flowers or potted plants.

CONCLUSION

The emphasis in this research program is to identify and develop new export trade opportunities for New Zealand. The focus is on what the marketplace demands both in terms of type and quality of product. To reach this endpoint the new crops program is built around an approach of identifying the market opportunity, evaluating the adaptability and productivity of the new crop, and test marketing samples of the crop to be assured the product reaches market specifications. In this way, the New Zealand new crops program has a clear focus and clearly defined goals. The program is new and open-ended in relation to identifying new opportunities and although many of the crops under investigation have not been previously grown in New Zealand, we believe the approach will see many of them become established industries in the future.

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Table 1. Climatic observations relevant to each research station shown on Fig. 1.

Research station	Rainfall (mm)	Mean air temp. (°C)	Avg. daily range (°C)	Mean Jan. air temp. (°C)	Mean July air temp. (°C)	No. degree days above 10°C	No. air frost free days
Redbank	360	10.1	13.4	16.5	2.5	889	112
Invermay	691	10.2	10.7	14.7	5.0	791	195
Lincoln	666	11.4	10.5	16.5	5.8	1067	206

Hastings	764	13.9	10.5	19.1	8.4	1317	189
Ruakura	1201	13.3	11.2	17.8	8.3	1376	228
Kerikeri	1682	15.1	10.1	18.9	10.8	1912	603

Table 2. The effect of crop age on the stem yield of wasabi.

				Stem yield (t/ha)		
Harvest time (mo.)	Mean stem wt (g)	Total stem wt/plant (g)	Stems/plant >50 g	<20 g	20-50 g	>50 g
15	14	192	0.44	8	11	3
18	20	266	1.38	7	8	10
22	22	296	1.41	5	8	7

Table 3. Essential oil crops under evaluation.

Scientific name	Common name	Favorable yield estimates of essential oils (liters/ha)	International market assessment on essential oils
Artemisia dracunculus L.	French tarragon	40	
Carum carvi L.	Carraway seed	100	
Coriandrum sativum L.	Coriander seed	16	yes
Hyssopus officinalis L.	Hyssop	---	yes
Lavendula angustifolia Mill.	Lavender	30	
Lavendula x*intermedia* Emeric ex Loisel.	Lavandin	50	
Lavendula latifolia Medik.	Spike lavender	35	yes
Mentha x*piperita* L.	Peppermint	50	
Mentha spicata L.	Spearmint	---	
Origanum vulgare L.	Oregano	110	
Rosa damascena Mill.	Rose	---	
Salvia officinalis L.	Sage	60	yes
Salvia sclarea L.	Clary sage	50	yes
Thymus vulgaris L.	Thyme	40	yes

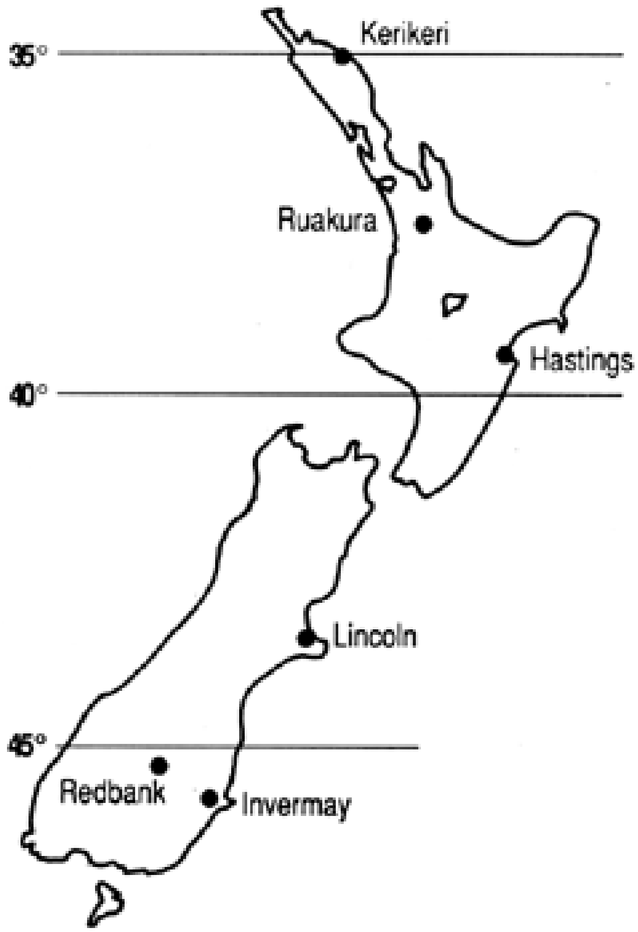

Fig. 1. Location of research stations involved in the New Zealand new crop program.

Last update September 5, 1997 aw

Myrrh

Sweet cicely, Sweet chervil

Umbelliferae *Myrrhis odorata* (L.) Scop.

Source: Magness et al. 1971

The myrrh plant is a pubescent perennial, up to 3 feet in height, with thin, soft, pinnate leaves. Leaflets are lanceolate. Leaves, tender stems, and roots are sweet scented. The plants persist for years. Formerly myrrh was used for flavoring salads. Now apparently little grown, except as an ornamental.

Last update February 18, 1999 by ch

Solanum quitoense Lam.

Solanaceae

Naranjilla, *Lulo*

We have information from several sources:

Naranjilla—Julia Morton, Fruits of Warm Climates

The Naranjilla, the Cocona and Their Hybrid—Charles B. Heiser

"New" Solanums—Charles Heiser and Gregory Anderson

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside links:

Naranjilla can be found in Lost Crops of the Incas from National Academy Press

Narrow Dock

Rumex crispus L.

Figure 80.—Narrow dock (*Rumex crispus*)

Other common names.—Yellow dock rumex, curled dock, sour dock.

Habitat and range.—This troublesome weed is now found throughout the United States, in cultivated as well as in waste ground, among rubbish heaps, and along roadsides.

Description.—Narrow dock has a deep spindle-shaped root from which arises an erect, angular, and furrowed stem, attaining a height of from 2 to 4 feet. The stem is branched near the top and is leafy, bearing numerous, long, dense clusters formed by drooping groups of inconspicuous, green flowers arranged in circles around the stem. These are followed by the fruits, which are in the form of small triangular nuts like buckwheat grains, surrounded by three very small veiny leaves. As the clusters ripen they become rusty brown. The lower leaves of the yellow dock are blunt, from 6 to 8 inches in length, with long stalks, while the upper leaves are narrower, only 3 to 6 inches in length, short stemmed or stemless. The root is large and fleshy, usually from 8 to 12 inches long, tapering or spindle shaped, with few or no rootless.

Part used.—The root, collected late in the summer or autumn after the fruiting tops have turned brown. They are washed, either left entire or split lengthwise into halves or quarters, and carefully dried.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Pyrus communis L.

Rosaceae

Anjou, Bartlett, Bosc, Clapp, Comice, Common pear, Nellis, Perry, Pome-fruit, Seckel, Summer pear, Winter Nellis, Winter pear

Pyrus pyrifolia (Burm. F.) Nakai [*P. serotina* Rehd.]

Rosaceae

Asian pear, Nashi

We have information from several sources:

Asian Pears—James A. Beutel

Fire Blight Susceptibility in a Young Asian Pear Planting (Abstract)—Caula A. Beyl

Growing Pears HO-122 Purdue University cooperative Extension Service

Training and Pruning Fruit Trees HO-49 Purdue University Cooperative Extension Service

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside sources:

Pear accessions available from the National Germplasm Repository, Corvallis, Oregon.

Pears - Pyrus communis L. (European pear) Pyrus serotina L. , P. pyrifolia (Burm. f.) Nak. (Asian, Japanese or Oriental pear, Nashi, or Pear AppleFrom University of Georgia.

Historic Images from The Pears of New York, written by U. P. Hedrick and published by the New York Agricultural Experiment Station in 1921.

Nasturtium, Garden

Indian cress

Tropaeolaceae *Tropaeolum majus* L.

Source: Magness et al. 1971

The plant is a somewhat succulent, climbing annual, with nearly round smooth leaves, 3 to 5 inches in diameter. The pods are near globular, ridged, about 0.33 inch in diameter. Nasturtiums are widely grown as ornamentals, but the peppery flavored leaves are sometimes used in salads, like cress. The young pods are made into pickles. Plants will develop pods about 4 months after seeding. While one of the most common garden flowers, nasturtium leaves and pods are used as condiments rather rarely, and appear not to be commercially grown for this purpose.

Last update February 18, 1999 by ch

Tobacco

Solanaceae *Nicotiana tabacum* L.

Source: Magness et al. 1971

The tobacco plant is a thick-stemmed annual bearing large leaves with short petioles or leaf stems. Leaf blades are often more than 20 inches long and half as wide. They rise in a spiral along the stem. Stems grow 4 to 6 feet tall and terminate in a cluster of flowers if not topped. Except for seed production, however, plant terminals are usually removed when flowering begins in order to increase size and thickness of leaves - the marketable portion.

Plants are usually started in beds under cloth cover in early spring and moved to the field after all hazard of frost is past. Growth in the field from setting to harvest covers 3 to 5 months. Harvesting may consist of removing most mature leaves by hand at about weekly intervals or cutting the whole stem. The former method is more generally used as it gives higher leaf yield and better quality. Leaves are then dried by one of several processes. In flue-cured tobacco, heat is applied in such a way that no smoke reaches the leaf hung in racks. In fire-curing, open fires are used and the smoke results in a darker colored, distinctlv flavored leaf. In air-cured tobacco no heat is added except as necessary to prevent mold during humid periods. Kinds of curing depends on type of tobacco grown and ultimate use.

Cigar wrapper tobacco, grown mainly in Connecticut, is produced under partial shade - resulting in thinner leaves and less damage to the leaves.

In the final products from tobacco (cigarettes, pipe tobacco, cigars, chewing tobacco, and snuff) the leaf midribs and larger veins are largely removed. They may be processed to obtain nicotine insecticides or used as mulching material. They are not used as feed.

Tobacco was grown on 967,000 acres in the United States - average acreage for 1966-67. Almost 66% of this was flue-cured and nearly 33% aircured. Less than 3 percent was fire cured. Around 50,000 acres was devoted to cigar tobacco.

Last update June 27, 1996 bha

Peach and Nectarine

Rosaceae *Prunus persica* (L.) Batsch

Source: Magness et al. 1971

Peaches and nectarines are relatively large fruits with large, deeply ridged stones. Fruit 2 to 3.5 inches diameter. Peach fruits are pubescent throughout the growing season, and are usually brushed by machine prior to marketing to remove most of the pubescence. Nectarines have a smooth, plum-like peel. Nectarines have apparently originated from peaches by mutation. Trees of the two kinds are indistinguishable and are relatively small, usually held to under 15 feet by pruning. Both peaches and nectarines may be freestone - pit relatively free of the flesh - or clingstone - pit adheres to flesh. Many varieties, especially of peaches, are grown in the U.S., varying in season of ripening and climatic adaptation.

Peaches:

Season, bloom to harvest: 75-150 days, mostly 100-120 days.

Production in U.S.: About 1.800.000 tons.

Use: Fresh market, canned, dried, marmalade, baby food.

Part of fruit consumed: Mainly flesh only. Peel included in dried fruit

Nectarines:

Season, bloom to harvest: Same as peach.

Production in U.S.: About 70,000 tons.

Use: Mainly fresh eating.

Part of fruit consumed: All except stone.

(Pictures: J. Janick) Last update February 18, 1999 by ch

Needle-and-thread grass

Gramineae *Stipa comata* Trin. and Rupr.

Source: Magness et al. 1971

This is a native bunchgrass widely distributed over the Western States and common on dry, sandy, gravelly soils of the Northern Plains. Seed stalks may reach to 4 feet. Leaves are up to 12 inches long and 0.125 inch wide. Growth starts early in spring and continues through the summer when moisture is available. The seeds are sharp-pointed and have long, twisted thread-like awns. The shape of the seed and awn account for the name. The grass is palatable and readily grazed except when in seed. This period begins in June, and the seed is shed in July. During this period the sharp seeds penetrate mouth parts and hides of stock. Although the grass is widely adapted and has many useful characteristics, it is little used for reseeding because of injury to stock while in seed.

Last update February 18, 1999 by ch

Needlegrasses

Stipas

Gramineae, Poaceae *Stipa* sp.

Source: Magness et al. 1971

Some 30 species of *Stipa* are indigenous to the Western States. They are long-lived bunchgrasses. Each spikelet has a single flower which terminates in a prominent awn, accounting for the name needlegresses. These grasses are abundant, widely distributed, cure well on the ground, and rank high for forage. The needle-like awns, however, cause injury to animals, especially sheep, and greatly detract from their otherwise value. The two most valuable species are Needle-and-thread grass and Green needlegrass.

Last update February 18, 1999 by ch

Nephelium lappaceum L.

Sapindaceae

Ramboetan, Rambotan, Ramboutan, Rambustan, Rambutan, Ramtum

We have information from several sources:

Rambutan—Julia Morton, Fruits of warm climates

FactSHEET contributed by: Francis T. Zee

Rambutan and Pili Nuts: Potential Crops for Hawaii—Francis T. Zee

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Nephelium mutabile Blume

Sapindaceae

Pulasan

We have information from several sources:

Pulasan—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Wednesday, March 3, 1999 by ch

Saccharum officinarum L.

Poaceae

Sugarcane, Noblecane, white salt

We have information from several sources:

Article from:
Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Article from:
Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links

Sugarcane—FAO/IPGRI Technical Guidelines for the Safe Movement of Sugarcane Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Picea abies (L.) karst.

Pinaceae

Spruce

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Outside Links:

Technical Guidelines for genetic conservation of Norway spruce—(*Picea abies* (L.) karst.)—Link to the publication on the International Plant Genetic Resources Institute web site

Oxalis tuberosus Molina

Oxalidaceae

Bitter oca, Oca, Occa, Oka, Sweet oca, Ulluco

We have information from several sources:

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Andean Tuber Crops: Worldwide Potential—Calvin R. Sperling and Steven R. King

New Horticultural Crops in New Zealand—Errol W. Hewett

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside Links:

Oca can be found in Lost Crops of the Incas from National Academy Press

Oca—Descriptores de Oca—Link to the publication on the International Plant Genetic Resources Institute web site

Olea europeae L.

Oleaceae

Black olive, Green olive, King-of-trees, Manzanillo, Mission, Olive, Pickling olive, Queen, Ripe olive, Sevillano

We have information from several sources:

Mediterranean Fruits—Joan Tous and Louise Ferguson

Food and Feed Crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside links:

Olive—from Mark Reiger, Dept of Horticulture, University of Georgia.

Olive Information from the University of California Fruit & Nut Research and Information Center

Olive Fruit Facts from the California Rare Fruit Growers Inc.

Herbal - Botanical Information on Olive From Grieve's Modern Herbal.

Olive oil

Oleaceae *Olea europaea* L.

Source: Magness et al. 1971

See Olive, for tree and fruit characteristics.

Olive oil is obtained from the fleshy portion of the fruit, which contains from 14 to as high as 40 percent of non-drying oil, depending on variety and growing conditions. World production of oil totals around 1,000,000 tons annually, mainly in Mediterranean countries. For best oil, fruit is harvested just before full maturity. The fruit is crushed then pressed in various ways, depending on available facilities. Solvents are generally used for final extraction of the press cake, to obtain maximum oil yield. The oil is used as salad and cooking oil. Low-grade oils are used mainly for making soap. In the U.S., only about 5,000 tons are crushed for oil annually. Annual imports of olive oil average near 50 million pounds.

Last update February 18, 1999 by ch

Ullucus tuberosus Caldas

Bassellaceae

Olluco, Ulluco

We have information from several sources:

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Andean Tuber Crops: Worldwide Potential—Calvin R. Sperling and Steven R. King

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Outside links

Ulluco can be found in Lost Crops of the Incas from National Academy Press

Orange, Trifoliate

Rutaceae *Poncirus trifoliata* (L.) Raf.

Source: Magness et al. 1971

The genus *Poncirus* is closely related to citrus, but the small, thorny trees are deciduous. Trees are hardier than citrus, in mid-winter enduring temperatures to near 0F. Fruits are globose, up to 1.5 inches in diameter, and very acid and bitter. *Poncirus* will hybridize with citrus, and such hybrids bave been made in efforts to increase hardiness in edible citrus fruits. *Poneirus* seedlings are used as root stocks for citrus, particularly for Mandarin oranges. Hybrids of *Poncirus* with sweet orange, called citranges, are now widely used as stocks.

Poncirus is grown as an ornamental dooryard tree in areas too cold for citrus, and occasional trees may be maintained by nurserymen as seed sources. Fruit appears valueless in the U.S., but may be used for flavoring or marmalade in other countries.

Season, bloom to maturity: 8 to 10 months.

Production in U.S.: No data. None commercial.

Use: Fruit not utilized in U.S.

Part of fruit consumed: None

Last update February 18, 1999 by ch

Ornithogalum spp.

Liliaceae

We have information from several sources:

New Hybrid Ornithogalums and Orchids—Robert J. Griesbach, F. Meyer, and H. Koopowitz

New Floral Crops in the United States—Mark S. Roh and Roger H. Lawson

last update October 16, 1997 by aw

Oryza sativa L.

including *Oryza glaberrima* Steud.

Poaceae, or Graminae

Arborio, *Basmati*, Brown rice, Carolina rice, Dry rice, *Gohan*, Hill rice, Instant rice, Jasmine rice, Long-grained rice, Medium-grained rice, *Meshi*, Polished rice, Rice, Short-grained rice, White rice

NewCROP has rice information at:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Herbicide-tolerant Germplasm in Rice—R.H. Dilday, P. Nastasi, R.J. Smitk Jr., and K. Khodayari

Contribution of Ancestral Lines in the Development of New Cultivars of Rice (Abstract)—Robert H. Dilday

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

Magness J.R. et al. 1971. Food and feed crops of the United States.

And outside links to more rice info:

Lost Crops of Africa: Volume I: Grains
African rice*Oryza glaberrima*
Wild rices

Rice - *Oryza sativa*. As a forage grass from the FAO Tropical Feeds Database.

Rice - *Oryza sativa*. As a Grain from the FAO Tropical Feeds Database.

Rice - *Oryza sativa*. As straw from the FAO Tropical Feeds Database.

Disease Index for Ricefrom Texas A & M University.

INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI) Manila, Philippines

Smilograss

Gramineae, Poaceae *Oryzopsis miliacea* (L.) Benth. and Hook. ex Aschers. & Schweinf.

Source: Magness et al. 1971

This is a cool season bunchgrass introduced from the Mediterranean Region. It is used for range reseeding in Central and Southern California. It is drought resistant. The stout stems reach to 5 feet. Smilograss is moderately palatable and longlived but difficult of establishment.

Last update June 28, 1996 bha

Phyllanthus acidus Skeels

Phyllanthus distichus Muell.Arg.

Cicca acida Merr.

Cicca disticha L.

Euphorbiaceae

Chermai, Gooseberry tree, Grosella, Indian gooseberry, Malay gooseberry, Otaheite Gooseberry

We have information from several sources:

Otaheite Gooseberry—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Phyllanthus Species: Sources of New Antivital Compounds—David W. Unander, P.S. Venkateswaran, Irving Millman, and Baruch S. Blumberg

Sourwood

Oxydendrum arboreum (L.) DC.

Other common names.—Sorrel tree, sour gum, elk tree.

Figure 100.—Sourwood (*Oxydendrum arboreum*)

Habitat and range.—Sourwood is found in woods, Pennsylvania to Indiana and Alabama and Florida.

Description.—This is a smooth-barked tree reaching a maximum height of 60 feet with a trunk 15 inches in diameter. The pointed oblong or elliptic, finely and sharply toothed leaves are from 4 to 6 inches long and 1 to 3 inches wide. The small, white, waxlike flowers, produced in June and July, are borne in long, slender, 1-sided, clustered racemes. The reddish-brown wood is hard and heavy.

Part used.—The leaves.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Pachyrhizus erosus DC.

Leguminosae

Yam Bean

We have information from several sources:

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Yam Bean—*Pachyrhizus* DC.—Link to the publication on the International Plant Genetic Resources Institute web site

Palm oil

Palmaceae *Elaeis guineensis* Jacq.

Source: Magness et al. 1971

The source of palm oil is the fleshy fruit of a tropical, spineless palm tree, native to western Africa but extensively cultivated in other tropical countries. The fruits are borne in large bunches, each of which may carry up to 20 pounds of fruit. The red fruits are oval, 1 to 2 inches long and an inch or more in diameter. The flesh contains 30 to 70 percent of nondrying oil. The seed also contains oil, the palm kernel oil of commerce.

Various methods are used to extract the oil from the pulp, including pressing or centrifuging or macerating the pulp and boiling in water, the oil floating and skimmed off. The oil is used in margarine and vegetable shortening as well as in soap manufacture in industry.

The kernel oil is extracted by crushing and pressing, or with solvents. The oil is similar to coconut oil, and is used mainly in margarine and soap.

Several other species of palm, some indigenous to South America, also yield pulp and kernel oils that are generally similar to African palm oil, but production of these oils is much less extensive. About 200 million pounds of palm oil were imported into the United States in 1966, more than half of which was kernel oil.

Last update February 18, 1999 by ch

Vine-mesquite

Gramineae, Poaceae *Panicum obtusum* HBK

Source: Magness et al. 1971

This is a sod-forming grass, native from Missouri west to Colorado and south into Mexico, useful both for grazing and erosion control. Stems are up to 2 feet tall, and leaves are 4 to 6 inches long and 0.5 inch wide. Vine-mesquite grows in areas of low rainfall, producing a moderate amount of forage relished by livestock while green. Plants form stolons, which may grow to 15 feet in a season. Stands can be established by seeding or sod pieces.

Last update June 27, 1996 bha

Torpedograss

Gramineae, Poaceae *Panicum repens* L.

Source: Magness et al. 1971

Torpedograss is native along the Gulf Coast from Florida to Texas. It is a sod-forming grass with creeping rhizomes and upright stems reaching 2 to 3 feet in height. Leaves are flat or folded. It thrives on coarse sands and wet muck soils and grows so aggressively that it may become a serious weed. Palatability is good but it is less nutritious than many grasses. It is used to a limited extent for pasture and erosion control along the Gulf Coast.

Last update June 27, 1996 bha

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Panicum virgatum L.

Poaceae

Switchgrass

We have information from several sources:

Developing Switchgrass as a Bioenergy Crop—S. McLaughlin, J. Bouton, D. Bransby, B. Conger, W. Ocumpaugh, D. Parrish, C. Taliaferro, K. Vogel, and S. Wullschleger

Farmers' Motivations for Adoption of Switchgrass—Patricia C. Hipple and Michael D. Duffy

Costs of Producing Switchgrass for Biomass in Southern Iowa—Michael D. Duffy and Virginie Y. Nanhou

Biomass Yield Stability of Switchgrass Cultivars—Roger G. Fuentes and Charles M. Taliaferro

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Pastinaca sativa L.

Umbelliferae, Apiaceae

Parsnip, Wild parsnip

We have information from several sources:

Midwest Vegetable Production Guide for Commercial Growers 2000

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Parthenium hysterophorus: Traditional Medicinal Uses

Pankaj Oudhia
Society for Parthenium Management (SOPAM)
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www.celestine-india.com/pankajoudhia

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Parthenium hysterophorus L. [syn. *Tanacetum parthenium* (L.) Sch. Bip.; *Chrysanthemum parthenium* (L.) Bernh.; *Matricaria parthenium* L, *M. parthenoides* Hort., *M. carpensis* Hort., *M. eximia* Hort., *M. odorata* Lam; *Pyrethrum parthenium* Smith] Compositae, is known as congress weed, carrot weed, star weed, feverfew, white top, chatak chandani, bitter weed, ramphool, garghas. It is believed to have entered India accidentally in the mid 1950s, and is now considered is one of the most feared noxious weed species (Rao 1956). Adverse effects of on humans and on animal health have been well documented. It is known to cause asthma, bronchits, dermatitis, and hay fever in man and livestock. The chemical analysis has indicated that all the plants parts including trichomes and pollen contain toxins called sesquiterpene lactones. The major components of toxic being parthenin and other phenolic acids such as caffeic acid, vanillic acid, ansic acid, p-anisic acid, chlorogenic acid, and parahydroxy benzoic acid are lethal to human beings and animals (Mahadevappa 1997; Oudhia 1998). Despite the fact that *Parthenium* is considered a toxic plant industrial uses are reported in the literatures (Sastri and Kavathekar 1990). A related species, *Parthenium argentatum* Gray (guayule) yields rubber which can substitute for *Hevea* rubber.

The word *parthenium* is derived from the Latin *parthenice* suggesting medicinal uses (Bailey 1960). John Lindley (1838) in *Flora Medica* describes the plant as follows: "*The whole plant is bitter and strong-scented, reckoned tonic, stimulating and anti-hysteric. It was once a popular remedy in ague. Its odour is said to be peculiarly disagree to bees and that insects may be easily kept at a distance by carrying a handful of the flower heads.*" In Homoeopathy system, allergies caused by *Parthenium* can be treated by a drug prepared from *Parthenium*. In Finland an infusion of Partenium is used in for consumption.

In the *Dictionary of Economic Plants in India Parthenium hysterophourus* is described as a weed found in Poona and is reported to be used as tonic, febrifuge, and emmenagogue. Root decoction is useful in dysentery (Singh et al. 1996). Mew et al. (1982) demonstrated that sublethal doses of parthenin exhibited antitumor activity in mice and that the drug could either cure mice completely or increase their survival time after they had been injected with cancer cells. Parthenium is also reported as promising remedy against hepatic amoebiasis (Sharma and Bhutani,1988). South American Indian uses a decoction of roots to cure amoebic dysentery (Uphof 1959) whereas parthenin, a toxin of *Parthenium*, is found pharmacologically active against neuralgia and certain types of rheumatism). In *Compendium of Indian Medicinal Plants* by Rastogi and Mehrotra (1991) parthenin induced dose-dependent damage to human leucocyte chromosomes in vitro and micronuclei formation in polychromatic erythrocytes of mice is reported (Dominguez and Sierra, 1970).

Parthenium is used as folk remedy in the Caribbean and Central America (Nabie et al. 1996). It is applied externally on skin disorders and decoction of the plant is often taken internally as a remedy for a wide variety of ailments (Dominguez and Sierra 1970; Morton 1981). In Jamaica the decoction is used as a flea-repellent both for dogs and other animals (Morton 1981).

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Vasey grass

Gramineae, Poaceae *Paspalum urvillei* Steud.

Source: Magness et al. 1971

This is a warm season bunchgrass quite similar to Dallisgrass and introduced from South America before 1880. It is now common in the humid southeast, especially the Gulf Coast. It thrives both on wet sites and on well-drained soils. The erect stems may reach to 6 feet, with leaf blades up to 15 inches long and half an inch wide. Vasey grass is seldom planted but where growing is utilized for pasture and hay. It is easily overpastured. As hay, palatability is good and yields heavy with up to 4 cuttings per year possible.

Last update June 27, 1996 bha

Krugman, S.L. 1990. Woody fiber crops. p. 275-277. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR.

Woody Fiber Crops

Stanley L. Krugman

INTRODUCTION

Unlike modern agriculture, forestry in the United States is not dependent on exotic germplasm. Some exotic woody germplasm is planted in forestry but such germplasm represents only a small percentage of the current planting program. In terms of modern forestry the United States is rich in woody plants with more than 2,000 different native species having potential use. Currently, less than a few hundred of these native species are actually utilized for their fiber while a great many more are harvested as a fuel source, for protection plantings, and for use as ornamentals. In the last 25 years, an array of these native woody plants has been investigated to a limited degree to determine their genetic variation.

With the increasing demand for more traditional wood products, including paper and fuelwood, there is a need and considerable opportunity in some parts of the United States to grow and utilize fast-growing, short-rotation woody trees. Various species and hybrids of poplars (*Populus* spp.) and several other native hardwoods have played this role. However, poplars are highly specific as to their site and growing requirements which restrict their potential use to selected areas. The same is true for the other hardwoods, such as American sycamore (*Platanus occidentalis* L.) and green ash (*Fraxinus pennsylvanica* Marsh.). Since the late 1960s, a number of additional woody species has been selected and tested under accelerated growing conditions. For this discussion, I will restrict my comments to two genera, Eucalyptus (*Eucalyptus* L.'Herit) and Royal paulownia (*Paulownia* Sieb. and Zucc.). Both are exotics, having been introduced in the United States during the 1800s. Both are fast growing hardwoods with many useful qualities. The full potential of these genera are not fully understood nor appreciated, yet there is considerable information that suggests that with a focused effort, both genera would make a useful contribution.

Eucalypts are restricted in range because all members of this genus are susceptible to low temperatures. Yet, with careful selection of species and proper seed source, there are genotypes that can be of considerable value and use. *Paulownia* has had relatively poor acceptance because it is considered difficult to grow and often has poor form. There is virtually no industrial experience with this genus in the United States because of relatively low volumes now available. Yet in Asia, especially in Japan and the People's Republic of China, it is widely used in fine furniture. It is widely grown in its native land of China for its timber value, and as a windbreak tree.

EUCALYPTUS SPP.

Members of this genus are among the most planted forest trees in the world. The genus comprises approximately 530 species and 140 varieties with new species and varieties still being described. It was introduced initially into California and the Hawaiian Islands about 1853. Eucalypts are today planted as ornamentals, as part of shelterbelts, and for fiber and fuelwood in California, Hawaii Arizona, Florida, and New Mexico. They have been planted in a number of southern states with very little success. Since members of this genus have been grown in the United States for over 100 years, why should it be considered a new crop? It is only in the last 25 years that serious studies have been undertaken to understand and identify the extent of the generic variation within this genus. The potential of this genus has not been fully exploited in the United States.

Early introductions were essentially random. Although a number of plantings took place in California during the late 1800s, most of the species and seed sources were eventually found to be unsuitable for timber products. Still, the various species found a use as a windbreak tree or as an ornamental. By the 1960s, more than 150 species were being grown in California alone as ornamentals because of their decorative flowers and pleasing form and shape.

A Eucalypts species introduction and testing center was established in south Florida in 1899 by what is now the USDA Forest Service. The goal of this center was to identify an array of new, fast-growing hardwood species. A few years later, a similar center was established in southern California. Both centers lasted approximately 10 years; but sudden low winter temperatures in both California and the southern United States abruptly ended the wide use of *Eucalyptus* at that rime. Since then, a large series of new species introductions have been carried out, usually with limited success. The collections were often poorly identified and seed source sampling was inadequate.

Investigations of the last 25 years have clearly demonstrated considerable genetic variation within this genus. Although no truly cold-hardy species have been identified, it is still possible to select for a degree of low temperature tolerance in certain species and seed sources. In field studies in California, a number of high-elevation seed sources from Australia withstood, in 1973, a cold wave occurring in late December and January when the temperatures went below freezing on 10 consecutive nights with a low of -7°C. In Florida, selected seed sources have tolerated temperatures as low as -12°C. With the proper genetic and management studies, it should be possible and feasible to match species and seed source to the appropriate growing conditions. In recent years, this has led to reports of fiber yields of 15 to 25 dry tons per hectare. For example, *Eucalyptus amplifolia* Naud. has been coppiced cultured through four rotations in northern Florida with annual yields reaching 23 dry tons per hectare. Somewhat similar high yields have been reported for *Eucalyptus saligna* Sm. in Hawaii. In each case, the key was the careful identification and selection of genetic material (species and seed sources) appropriate for given site conditions and the application of compatible management techniques. It is apparent from a number of current field tests that the full potential of this genus has not been exploited and many more seed source (provenance) investigations need to be initiated within a narrow range of growing conditions. While it is very unlikely that true cold-hardy Eucalypts will be found, there are many situations in which this genus will be useful. At this time, only approximately half of the species have been tested to any degree in the United States. There are some subgroups of the Eucalypts in which virtually little is known, even in Australia where it is native. What is needed is a better coordinated effort and a better understanding of the considerable variation in this genus.

PAULOWNIA

Although *Paulownia tomentosa* (Thunb.) Sieb. & Zucc. was introduced into the United States in about 1845, virtually little is known about other species of this genus in the United States, nor the extent of genetic variation in *Paulownia tomentosa*, the most northern species in Asia. Since its first introduction, mainly in the southern United States, *Paulownia tomentosa* is now found growing wild in many parts of the United States, including the western U.S. and even in the northeast as well as in the south. In China, its source of origin, yields of 36 to 53 cubic meters per hectare have been reported. It should be noted that this species is not grown for its biomass alone, but for its use as a quality furniture wood.

Many report this species as a weed tree for its poor form and rather large shade leaves. This is not surprising since there has been very little genetic selection of seed source for its adaptability to given sites, nor selection for form or growth rate. In the last 15 years, studies have been initiated to select from *Paulownia tomentosa* populations within the United States for improved growth and form. Still, current efforts to produce *Paulownia* spp. commercially have not been completely successful. In addition to a lack of appropriate plant material (seeds), optimum management techniques have not been applied.

While reviewing forest genetics activities in the People's Republic of China, both natural and planted stands of *Paulownia* spp. were studied. Currently, seven species and six varieties are commonly recognized. However, the Chinese list nine species of *Paulownia*. Many of the species tend to be subtropical and are not suitable for the continental United States. In 1986, four provenances each of *Paulownia elongate* (S.Y. Hu), *P. fargessii* (Franch), *P. fortunei* (Seem) Hemsl. and *P. tomentosa* collected in China were planted near Birmingham, Alabama; Tillman, South Carolina; Morganton, North Carolina; and the Garrett-Allegheny County area of Maryland. These species and provenances were selected as being good candidates for the southern and southeastern United States. On the whole, seedling survival after 2 years has been good with height growth ranging from 0.5 to 8 meters. It is too early to make any conclusion but it does appear that other *Paulownia* species can be grown in the United States. At 5 years, we will have an opportunity to evaluate form as well as height growth. As a comparison, *P. elongate* in a park in Peking had a height of 10.6 meters at age 6 while a roadside tree of *P. fortunei* near Kweilin, Kuangsi, had a height of 20.8 meters at age 11.

From the experience in China, *Paulownia* spp. prefer warm climates with 24°C to 30°C being the most favorable. *P. tomentosa* can withstand temperatures as low as -20°C, and *P. elongata* -15°C. Both *P. fortunei* and *P. fargessii* appear to be less cold hardy than *P. elongate*. Cold hardiness will need to be further determined under a number of growing conditions. Additional studies will be needed to determine appropriate management techniques for this genus. Yet, its rapid growth, attractive flower, and excellent wood quality make it a genus that needs to be considered for further use in the United States.

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Last update March 7, 1997 by aw

Pigeon Pea, Gandules

Cajanus cajan (L.) Millsp.

Congo pea, No-eye pea, Red gram, Arhur, Grandul, Dhal, Toor, Grinds pea, Puerto Rico pea, Urhur

Leguminosae, Fabaceae

Source: Magness et al. 1971

These pea-like legumes are erect, short-lived perennial plants 3 to 10 feet high. much propagated as annuals in the tropics for the edible seeds and pods. They are important food plants in the West Indies, but are not grown commercially in continental U. S. In exposure of edible parts they are comparable to garden peas.

Last update February 18, 1999 by ch

Pea, Southern

Cowpea, Black-eye pea, Callivance, Cherry bean, Frijol, China pea, Indian pea, Cornfield pea, Crowder pea

Leguminosae, Fabaceae *Vigna sinensis* (Torner) Savi

Source: Magness et al. 1971

This so-called pea is more closely related to the beans (*Phaseolus*) than to the peas (*Pisum*). it is an important food and stock-feed crop in the Southern States. Several slightly differing types are grown, as blackeye, brown eye, cream and cream crowder, differing in the flower color and color markings on the seeds. The plant needs warm weather, and is injured by any frost. It is bushy, or procumbent, twining but not climbing. Pods are 3 to 12 inches long and slender. Seeds are small, 1/6-1/4 inch in length. For food, they are harvested either at the green-shell state, while pods are still green, or as dry-shells, when ripe. Harvesting is usually by mowing and threshing in a viner, as with green peas. The pods may also be hand picked. For stock feed, the whole plant is harvested as hay, or pastured.

Season, bloom to harvest: Green-shell stage, 15 to 20 days. Dry-shell, 30 or more days.

Production in U.S.: 37,000 tons shelled dry; no data on green shell; 300,000 acres as feed and pasturage.

Use: Commercially, green-shell canned or frozen; dry-shell marketed dry.

Part of plant consumed: Seed only for food; whole plant for feed. Immature pods and seed may be used as snap beans.

Last update February 18, 1999 by ch

Pea, Winged

Leguminosae, Fabaceae *Tetragonolobus purpureus* Moench

Source: Magness et al. 1971

The plant is an annual trailer, with broad, ovate bean-like leaves. Pods are 2 to 3 inches long, somewhat rectangular in cross section, fleshy when immature. Winged pea is grown for the edible pods, and for the seeds, which are roasted as a substitute for coffee. Exposure is similar to that of snap or field beans. There are no data on production in the U.S., but it is very slight.

Last update February 18, 1999 by ch

Prunus persica L.

Rosaceae

Bonanza peach, Clingstone peach, Freestone peach, Peach, Red Haven peach, Rio Oso Gem peach

We have information from several sources:

Red Ceylon Peach—Julia Morton, Fruits of warm climates

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside links:

Commodity Sheet FVSU-001 Peaches from Fort Valley State University

Peach—from Mark Reiger, Dept of Horticulture, University of Georgia.

Cling Peach Information from the University of California Fruit & Nut Research and Information Center

Peanut oil

Leguminosae *Arachis hypogaea* L.

Source: Magness et al. 1971

See Peanut for plant characteristics. Among edible vegetables oils, peanut oil is exceeded in world production only by soybean. World production of peanut oil, 1964-66, averaged 3,166,000 tons. In extracting the oil in the U.S., the cleaned nuts are passed through hullers or shellers to separate the kernels. The kernels, which contain 48 to 56 percent of oil, are then crushed, heated and pressed hot in hydraulic presses. The oil is used in the manufacture of margarines and shortenings, and as a salad and cooking oil. The press cake is used for cattle food.

Shelled peanuts crushed for oil annually in the U.S. averaged near 377 million pounds, 1964-66. Oil production averaged near 157 million pounds for the 3 years.

Sealy, R.L. and S. Bostic. 1993. Cliff brake fern: A native Texas fern with landscaping potential. p. 612-613. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Cliff Brake Fern: A Native Texas Fern with Landscaping Potential

Ramsey L. Sealy and Steve Bostic

Cliff Brake Fern [*Pellaea ovata* (Desv.) Weath.] is a native Texas fern that is found in nature on dry ledges and slopes of limestone outcroppings, calcareous rocks, or granite. It is frequently found on cliffs or at their bases; but also grows well in open rocky woodlands (Correll and Johnston 1979). Because of its tolerance to high temperatures, bright light, and alkaline conditions, cliff break fern might be well adapted to being incorporated into the xeriscape. Cliff break fern thrives in rich, well-drained soil (Hoshizaki 1975), and should be adaptable to many landscape situations.

Cliff Brake Fern has an attractive color, ranging from dark green to grayish-green (Jones 1987) and it has an interesting fine, open texture due to its peculiar rachis and costa structure (Lellinger 1985). Cliff break fern and other *Pellaea* spp. have been grown on trellises and in hanging baskets in greenhouses in the Northeast (Foster 1964), but its use in southern landscapes has been ignored. Because of the plant's apparent wide ecological adaptability and its ornamental qualities, *P. ovata* deserves consideration for use in the landscape and, in particular, in the xeriscape.

DESCRIPTION OF THE PLANT

P. ovata is a member of the Polypodiaceae, subfamily Gymnogrammeoidae, and tribe Cheilantheae (Tryon and Tryon 1973). Within the genus *Pellaea*, *P. ovata* is in the section Pellaea (Tryon and Tryon 1982).

P. ovata has slender rhizomes. Its leaves (fronds) may grow to 1 m or more in length and are divaricately bipinnate to tripinnate (Correll and Johnston 1979). There are 3 to 20 stalked pinnules on each pinna; the leaflets are 2 cm long and 1.5 cm wide and are ovate to oblong in shape with cordate to truncate bases (Correll and Johnston 1979) (Fig. 1). The petioles and rachises are pale tan-colored; the stalk is hard, dark, and polished (Hoshizaki 1975). The rachises and rachillae zigzag, often quite dramatically (Bailey and Bailey 1976). The zigzag pattern may all be in one plane or in several planes. Sori are borne in a marginal band along the blades and are covered by the reflexed margins of the pinnules (Bailey and Bailey 1976). The range of *P. ovata* is similar to that of several other American species of Pellaea, extending from the southwestern United States south to Argentina (Tryon and Tryon 1982).

The entire genus is adapted to relatively xeric conditions. The partially underground stems are covered with scales and have the capacity to survive light ground fires (Tryon and Tryon 1982). Further, the apogamous gametophytes do not require free water for fertilization (Tryon and Tryon 1982). New plants can be established during short moist periods because of rapid spore germination and sporophyte initiation (Tryon and Tryon 1982). *P. ovata* can tolerate and even thrive in moderate shade (as in open woodlands), but it may grow slowly under dense shade (Clute 1938). It is equally well adapted to full sun conditions (Hoshizaki 1975). *P. ovata* is native to areas with both very thin alkaline soils and areas with rich woodland soils (Clute 1938). *P. ovata* tolerates extremely hot summers (highs at 40°C or more) and can withstand at least brief periods of below freezing temperatures (periods of -17°C are reported with survival) (Hoshizaki 1975).

UTILITY IN THE LANDSCAPE

Several attributes recommend *P. ovata* as a xeriscape plant. These include its drought resistance and its tolerance of both alkaline soils and high temperatures. Cliff brake fern responds well to regular irrigation, but can thrive with neglect and occasional watering. We have observed that with even prolonged wilting, mature fronds of *P. ovata* revive with watering. Overwatering can kill cliff brake fern, and so it should not be placed with plants that have high water needs (Hoshizaki 1975). Since the fern is tolerant of both full sun and moderate shade, it can be used throughout the landscape in most light environments, except dense shade. Because it also grows well in rich woodland soils, *P. ovata* should be adaptable to many landscape schemes besides a xeriscape one. Some morphological characteristics make cliff break fern an interesting addition to the landscape (Fig. 2). The generic name *Pellaea* comes from a Greek word meaning "dusky" (Bailey and Bailey 1976), and the pinnules of *P. ovata* are somewhat to very glaucous. The small size of the leaflets (pinnules) and the open, zigzag character of the rachis allows *P. ovata* to lend an interesting open, light texture to the landscape. Cliff break fern can be effectively used in the landscape as a specimen plant, both potted or in the soil, and as part of a border, either by itself or in a mixed border.

Further popularization of *P. ovata* as a landscape plant will require determination of the limits of the fern's cold (freeze) tolerance, the extent of both drought and water-logging tolerance, information on the effect of different levels of shade on Cliff Break Fern's growth and survivability, and knowledge of the long-term adaptability of this new plant to the home landscape.

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Fig. 1. A specimen of *Pellaea ovata*.

Fig. 2. Use of *Pellaea ovata* in the landscape.

Last update September 17, 1997 aw

Pepper

Black, White, Pimienta

Piperaceae *Piper nigrum* L.

Source: Magness et al. 1971

Black pepper is the dried, unripe berry fruit of a perennial, tropical, woody vine. It may climb to 20 feet. The leaves are rather thick, broadly ovate-oblong or nearly round, and evergreen. The fruit is a small, globular drupe or berry, red in color. Powdered black pepper is the ground, entire fruit. White pepper is prepared by removing the outer skin of the fruit and grinding. It is less pungent than the black. Pepper is widely used in many forms of cookery. Desire for it was a strong motivation for searching for sea routes to India. Main commercial sources are now southern Asia and tropical Africa.

Last update February 18, 1999 by ch

Pepper, Long

Piperaceae *Piper longum* L., *P. chaled* Hunter

Source: Magness et al. 1971

These two species are similar in growth habit and culture to black pepper.
The spikes are gathered when they begin to color red or yellow, and dried rapidly. They may be used directly in pickling and are also ground and used in preserves or curries. They are grown mainly in South Asia, and some are exported to Europe.

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Development of *Phalaenopsis* Orchids for the Mass-Market

R.J. Griesbach

INTRODUCTION

It is widely recognized that potted *Phalaenopsis* production has increased tremendously in last few years. The specific statistics for *Phalaenopsis* are not available, for the US Department of Agriculture only keep records on total orchid production and sales. However, over 75% of all orchids sold are *Phalaenopsis* (American Orchid Society, pers. commun.). In 2000, wholesale orchid sales were approximately $100,000,000 (Fig. 1). The only crop with a higher value was poinsettia. During the last five years orchids sales has been increasing, unlike all the other ornamental crops (Fig. 2).

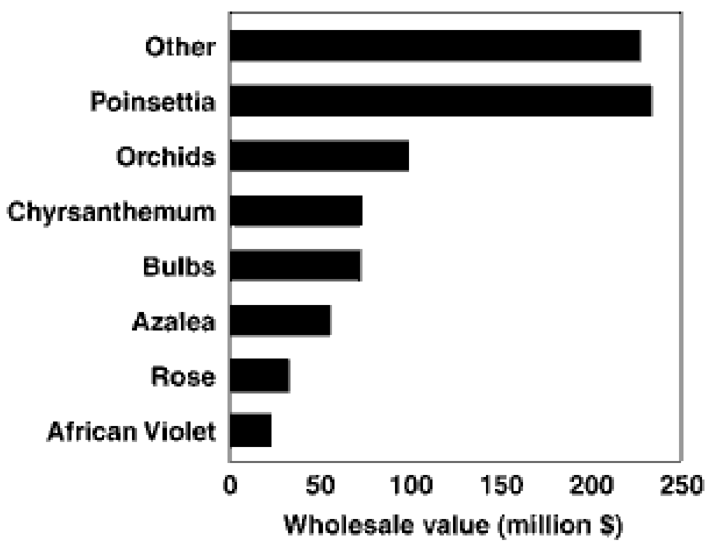

Fig. 1. Wholesale value of flowering potted plants within the United States for 2000 (USDA Agricultural Statistics).

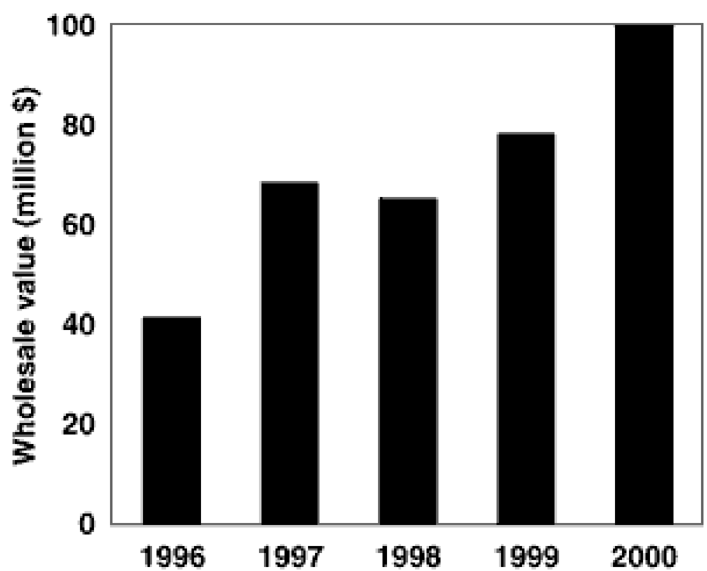

Fig. 2. Wholesale value of orchids within the United States for the last five years (USDA Agricultural Statistics).

Large scale, potted *Phalaenopsis* production is occurring in the Netherlands, Germany, China, Taiwan, United States, and Japan. In one cooperative venture, cultivar development is taking place in the Unites States; selected clones are being placed into tissue culture in Japan; mass proliferation of the tissue cultures is occurring in China; and the tissue cultured plants are being grown to maturity in the Netherlands. In 1957, James Shoemaker stated that "*orchid growing has not fully achieved the transition from a hobby to an industry*." Today, orchid growing is more than just an industry, it is an international business.

VICTORIAN BEGINNINGS

The development of hybrids reflects the preference of the consumer. As consumers' taste change, so does the type of hybrids produced and grown. During the Victorian period from 1830 to 1900, many homes had "parlor plants" (Martin 1988). During this period, the design of homes changed from a large single room to several smaller multiple-function rooms. Plants were grown in either the front or back rooms or parlors. The front parlor usually lacked heat and was extremely cold during the winter; while, the back parlor was typically overheated during the day and not heated at night. Many of the modern potted plants which we consider "new" were common house plants at this time. Several orchid species in the *Cattleya* Ldl. and *Dendrobium* Ldl. alliances were also common parlor plants.

The conditions in the Victorian home were not well suited to growing *Phalaenopsis* Bl. These orchids were considered a challenge to grow. James Veitch in his *Manual of Orchidaceous Plants* (1894) stated that "*the introduction of species of Phalaenopsis … has been one of the most difficult cultural problems horticulturists have been called upon to solve*." Because of the environmental conditions within the home, *Phalaenopsis* were predominantly grown in a conservatory or greenhouse.

Many homes in Europe at this time had greenhouses. In 1870, 50% of the middle and better class homes in London had attached greenhouses (Martin 1988). However in the United States, greenhouses were extremely expensive and rarely found. Because of this difference, *Phalaenopsis* were not as widely grown in the United States during the Victorian period.

The popularity of *Phalaenopsis* naturally led to the creation of many artificial hybrids. The first hybrid (P. Intermedia) was created in 1875 when John Seden at Veitch and Son's Nursery in England crossed *P. amabilis* (L.) Bl. with *P. equestris* Rchb. (Veitch 1886). The seed was sown at the base of the mother plant and only a single seedling survived which flowered a decade later in 1886. By 1900, an additional 13 primary hybrids were created and flowered. John Seden was responsible for creating all but one of these hybrids. The emphasis in hybridization at this time was to create exotic parlor plants.

The potential of artificial hybridization for creating new types was widely recognized, but the technical expertise required to germinate the seed and to raise the seedlings to maturity precluded its wide spread application. Only a few individuals were successful until 1909 (White 1942). In 1909, Hans Burgeff from Germany and Noel Bernard from France independently reported that orchid seeds germinated only in the presence of a symbiotic fungus. This discovery was used by Joseph Charlesworth and James Ramsbottom at the Charlesworth Company in England to develop a practical procedure to "symbiotically" germinate orchid seeds. In this procedure, a peat and sand mixture was sterilizing and then inoculated with the symbiotic fungus. After the fungus has penetrated the compost, the seed was sown on top. This symbiotic germination technology made it easier to produce hybrids, but large scale, commercial production of hybrids was still not possible. Many of the seeds in a capsule germinated, but few survived the process due to excessive fungal infection.

ORCHID TECHNOLOGY

Non-symbiotic Germination

Symbiotic germination methods were only used for a short time before being replaced by non-symbiotic germination procedures. In 1922, Lewis Knudson at Cornell University reported that the fungus was not required for germination if the seed was sown on agar containing appropriate salts and sugars. His Knudson C medium is still being used to germinate the seed of some species. With non-symbiotic germination technology, thousands of seedlings could be raised to maturity from a single seed capsule.

Besides the obvious potential in breeding, this technology was also extremely important for vegetative propagation. Unlike *Cattleya*, *Phalaenopsis* plants were difficult to import because they lacked water storage pseudobulbs. Many of the plants died in transit. Those plants which did survive were difficult to vegetatively propagate. The most desirable species (i.e. *P. amabilis*) produced a single stem that would produce only a few 'off-sets'. Non-symbiotic germination technology made it possible to produce very large quantities of plants.

By the time these new seed germination procedures were developed, the parlor plant craze had ended. Consumer preference shifted from potted plants to cut-flowers. Therefore, the emphasis in breeding focused on developing hybrids for this new market. Improved germplasm collected by Regnier in the Philippine Islands served as the genetic foundation for the cut-flower hybrids. Two improved forms of *P. amabilis* were collected. The *grandiflora* form of *P. amabilis* produced flowers that had fuller, rounder form with wider petals than the typical species. The *rimestandiana* form produced flowers that had the typical form and size but had tremendous substance. The *rimestandiana* forms that were used in breeding were later found to be tetraploid (Maurice Lecoufle pers. commun.). These two forms were originally recognized as distinct species.

Breeding Advances

The first major advance in breeding was made in 1920 by Dr. Jean Gratiot from France when he registered P. Gilles Gratiot. This hybrid, the result of a cross between the typical form of *P. amabilis* and the *rimestandiana* form, had extremely heavy substance. The second major advance in breeding came in 1927 when Henri Lecoufle at Vacherot and Lecoufle Company in France registered the hybrid between the *rimestandiana* and *grandiflora* forms of *P. amabilis*. This hybrid, P. Elisabethae, had the heavy substance of the *rimestandiana* from and the improved flower shape of the *grandiflora* form.

Through extensive in-breeding and out-crossing to *P. aphrodite* Rchb. superior hybrids were created, the most important of which was P. Doris. This hybrid was registered in 1940 by Duke Farms in New Jersey. P. Doris produced long, arching inflorescences on plants that were large and vigorous. The flowers were pure white, huge, and flat. Their heavy substance made them ideal for cut-flower production.

Production Protocols

Once cut-flower hybrids were developed, research began on developing commercial production protocols. The first experiments were preformed in the 1930s by H.O. Eversole in California (White 1942). He determined that *Phalaenopsis* grew the fastest and produced the most flowers in a sand-peat medium. Prior to this time, nearly all orchids were grown in living moss. Because of the difficulty in obtaining high quality peat, osmunda fiber became the medium of choice during the 1940s. Repotting orchids in osmunda fiber was both difficult and labor intensive. During the 1950s, independent research by O. Wesley Davidson at Rutgers University working with George Off at the Off Orchid Company and by Rod McLellan at the Rod McLellan Company resulted in the development of bark-based media. With these media, repotting was fast and easy. Today, the Rutger #3/Off mix is the most popular bark medium used.

Coupled with the development of improved potting media was the formulation of better fertilizers. Research on nutrition by Ratsek (1932), Evers and Laurie at Ohio State University (1940), Withner at Brooklyn College (1942), Fairborn at the Missouri Botanical (1944), Beaumont and Bowers at the University of Hawaii (1954), Davidson at Rutgers University (1957), and Sheehan at the University of Florida (1960) resulted in improved fertilizers. Before 1960, few growers fertilized their orchids. These studies showed that fertilization was critical for commercial production.

Another important research discovery was made by Gavino Rotor at Cornell University. In 1952, he reported that short days induced flowering in *P. amabilis* hybrids and that high temperatures inhibited flowering. All of this data was used to develop improved production protocols which increased the rate of plant growth and the yield of cut-flowers.

MARKET DEVELOPMENT

Between 1930 and 1950, the predominant cut-flower market was for white flowered hybrids. One of the reasons for the predominance of white flowers was the lack of quality hybrids in other colors. Pink cut-flower hybrids were developed during the 1950s. Interestingly, the genetic background of these pink hybrids was not significantly different than that of the white hybrids. The pink species (*P. schilleriana* Rchb. and *P. sanderiana* Rchb.) were not suitable for cut-flower production because of their thin substance. In addition, these species quickly wilted if the pollen was accidentally removed or disturbed during harvest. Many of the cut-flower pink hybrids that were developed actually arose from *P. amabilis*. *Phalaenopsis amabilis* is not completely white, but has a pink flush on the back of it's sepals and petals. Through inbreeding and intense selection, hybrids were eventually developed that were solid pink in color. These pink forms of *P. amabilis* (i.e. P. Doris) were then used in breeding with *P. schilleriana* and *P. sanderiana* to create quality hybrids.

By 1960, only a handful of closely related species (*P. aphrodite*, *amabilis*, *schilleriana*, and *sanderiana*) were in the background of nearly every hybrid created. The other species or "novelty" species were rarely used in breeding. Oscar Kirsch (1960) in Hawaii stated of novelty hybrids that "*many of these new creations would not be of value as commercial flower producers*." There were many reasons why they were of little value. First, the commercial market demanded cut-flower plants that produced long inflorescences with lots of large flowers. Novelty hybrids usually produced short inflorescences with a few small flowers. Second, the growers needed uniformity in both the product and production of the product. Populations of novelty hybrids generally contained plants that flowered at different times, had different growth habits and had different flower colors. Third, the cut-flower market wanted flowers that were uniform in color and not patterned. Many novelty hybrids produced flowers that had unusual colors.

In order to develop cut-flowers in an expanded range of pure colors without markings, the novelty species had to be used. Although the breeding protocol to create the "colored" cut-flower hybrids was obvious—cross the novelty species with the white, cut-flower hybrids and then backcross to the white parent—the problems associated with this approach were not. First, there were few novelty species in cultivation. Second, there was no experience on the genetic influence of the novelty species in breeding. Third, the modern primary hybrids were not very fertile due to chromosomal problems. The original primary hybrids made prior to 1900 used diploid forms of *P. amabilis*; while the modern recreation of these hybrids used tetraploid forms of *P. amabilis* (i.e. P. Doris).

The first novelty species to be used extensively in hybridization was *P. equestris*. This species was used to create a unique flower that had white petals and sepals with a red lip. The first *P. equestris* × *P. amabilis* hybrid was made by Seden in 1875 and had diploid parents. Its flowers were pale pink with a solid, dark red, lip. They were not flat and had poor substance and open shape. When a tetraploid, white, cut-flower hybrid was crossed with a diploid *P. equestris*, the results were quite different. These hybrids produced flowers that were nearly white with a pale red, stained lip. The flowers were reasonably large with heavy substance, but had poor shape. The most important of these hybrids was P. Sally Lowrey (*P. equestris* × P. Pua Kea). This hybrid was registered in 1954 by Oscar Kirsch in Hawaii. Through intensively backing-crossing of P. Sally Lowrey to white hybrids followed by sib-mating, improved forms were created that were pure white with dark red lips. In addition, these flowers had the improved form, size, and substance of the cut-flower hybrids.

During the 1960s, consumer preference shifted from cut-flowers back to potted plants. The parlor plant craze was reborn. Unlike Victorian homes, modern homes were ideally suited to growing *Phalaenopsis*. Novelty species were now used to create their own unique hybrids and not just for introducing color into cut-flowers. All of the species were re-introduced into cultivation and many were improved through intraspecific hybridization. In several instances, polyploid forms of the novelty species were created. These improved species were used to create primary hybrids that were far superior to those created at the turn-of-the-century.

Experimental crosses determine the genetic influence of the various species. For example, it was discovered that the brown spotting found on *P. amboinensis* J.J.Sm. flowers was not expressed in its hybrids with *P. amabilis*; while the spotting in *P. mannii* Rchb. was expressed. Additional studies showed that certain species combinations produced new characteristics. For example, when the solid colored *P. pulchra* Rchb. was crossed to hybrids with fine spotting, the progeny had large blotches of colors. All of this information and experience was used to create a wide range of unique hybrids.

PHALAENOPSIS DEVELOPMENT

Phalaenopsis grew in popularity and in the 1980s displaced *Cattleya* as the most popular orchid. At this time in Europe, a new, floral, marketing strategy was being developed. This strategy was aimed at the mass-market consumer and not at the conventional gardening hobbyist. In the Netherlands, a large-scale cooperative was created for growing and marketing all plants, including orchids. Individual growers specialized in a single crop, or even a single cultivar. The growers then jointly sold their product at an auction. In this manner, it was possible to supply wholesalers with a wide range of uniform, quality products throughout the year. Jan Post (1985) stated that in order to be commercially successful "*a pot plant market needs a lot of plants which no grower is able to handle and fulfill alone. Only with a large quantities from several growers will you create a orchid market for the consumer*."

The first orchid to be commercial marketed in this manner was *Vuylstekeara* Cambria 'Plush'. In 1975, Klass Schoone from the Netherlands began to propagate this clone for the mass-market. Since conventional methods for vegetative propagation were inadequate, Schoone turned to tissue culture. Orchids were the first plants to be commercially propagated through tissue culture. By 1985, over 100,000 tissue culture propagated plants of V. Cambria 'Plush' were being sold per year!

Tissue Culture Protocols

The first experiments in orchid tissue culture were carried out in Knudson's laboratory at Cornell University. In 1949, Gavino Rotor at Cornell University demonstrated that inflorescence nodes from *Phalaenopsis* could be induced to form a plantlet if aseptically placed on seed germination media. More than a decade later, Georges Morel (1960) at the Central Station for Plant Physiology in France reported that excised *Cymbidium* Sw. shoot tips could be induced to form multiple plantlets when cultured on seed germination media supplemented with phytohormones. Shortly after this report, Donald Wimber (1963) at Brookhaven National Laboratory developed a successful method of using tissue culture to commercial propagate *Cymbidium*.

Tissue culture techniques that were commercially successful for many orchids could not be used with *Phalaenopsis*. In *Phalaenopsis*, tissue culture propagation produced too much genetic variation. In some instances, over 50% of the propagated plants produced flowers that were significantly different than the mother plant. Therefore, mass-market *Phalaenopsis* were seed, and not vegetatively, propagated. Recently, tissue culture protocols specific for *Phalaenopsis* have been developed by Tse and others (1971) at the University of California, Intuwong and Sagawa (1974) at the University of Hawaii, Reisinger and others (1976) at the University of California, Zimmer and Pieper (1977) at the Technical University in Germany, Haas-von Schmude (1983) in Germany, Griesbach (1983) at the US Department of Agriculture, Homma and Asahira (1985) at Kyoto University in Japan, Tanaka (1987) at Kagawa University in Japan, Hinnen and others (1989) at the Agricultural University in the Netherlands, Tokuhara and Mii (1993) at Chiba University in Japan, Ernst (1994) at the University of California and Zhou (1995) at Sapporo Breweries in Japan, and Park and others (1996) at Shizuoka University in Japan. These methods, while generally successful, still can not be used to propagate all cultivars. In certain cultivars, these methods still produce too much variation. Due to the tremendous increase in uniformity with vegetatively propagated plants, the future mass-market *Phalaenopsis* will most like be tissue culture propagated and not seed propagated.

Breeding

Breeding for the mass-market was very different than breeding for the hobbyist or cut-flower markets. In the hobbyist and cut-flower markets, emphasis was placed exclusively on floral traits; while in the mass-market, vegetative characteristics were of nearly equal importance with floral traits.

The first *Phalaenopsis* that were sold in mass-market were cut-flower hybrids that were selected for more compact growth and flowering. The development of hybrids specifically for this market is in its infancy. Currently, *Phalaenopsis equestris* is being heavily used as parent. Unlike in breeding for cut-flowers, this species is not being used to introduce a single trait (i.e. red lip) into the white hybrids. Instead, the white hybrids are being used to introduce a single trait (i.e. better shape) into the species.

The first important hybrid in this line of breeding was P. Cassandra (*P. equestris* × *P. stuartiana*) which was made by Seden and registered by Veitch in 1899. P. Cassandra was remade many times, but the break through came in 1978 when Herb Hager at Herb Hager Orchids in California used P. Cassandra to make P. Be Glad. The other parent of P. Be Glad, P. Swiss Miss, was hybrid a between *P. equestris* and a white with a red lip, cut-flower hybrid. P. Be Glad produced flowers with greatly improved shape and size. The plants, however, were less floriferous and much larger in size.

The next step logical step in this line of breeding was obvious—backcross P. Be Glad to *P. equestris*. This hybrid, P. Be Tris, was registered in 1989 by Frank Smith at Krull-Smith Orchids in Florida. A triploid form of P. Be Tris was recently created by Amado and George Vasquez at Zuma Canyon Orchids in California. The tetraploid form of *P. equestris* which was used to create the triploid hybrid was produced through chemical treatment. During the 1970's, Robert J. Griesbach (1981) in cooperation with Arnold Klehm at Klehm Growers in Illinois developed procedures for using colchicine to double the chromosome number of *Phalaenopsis* seedlings. A colchicine-induced tetraploid form of *P. equestris* was seed propagated and distributed by Klehm Growers, the US Department of Agriculture and the American Orchid Society. Of the seed propagated tetraploids, *P. equestris* 'Riverbend' was the most widely distributed clone. The triploid forms of P. Be Tris are far superior to *P. equestris*, with more distinct coloration, better shape and heavier substance.

Production Protocols

Production protocols that were developed for cut-flowers were not the best for potted plant production. Extensive research in plant physiology by Sheehan (1960) at the University of Florida, Poole and Seeley (1978) at Cornell University, Krizek and Lawson (1979) at the US Department of Agriculture, Sakanishi and others (1979) at Oska University in Japan, Tanaka and others (1988) at Miyazaki University in Japan, Endo and Ikusiuma (1989) at Chiba University in Japan, Ota and others (1991) at Nagoya University in Japan, Doi and others (1992) at Kubota University in Japan, Kubota and Yoneda (1993) at Nihon University in Japan, Porat and others (1994) at the Hebrew University in Israel, and Wang (1995) at Texas A&M University helped to define the precise factors essential for maximum plant growth and development. The practical results of this research was the development of large-scale, production protocols (Fig. 3).

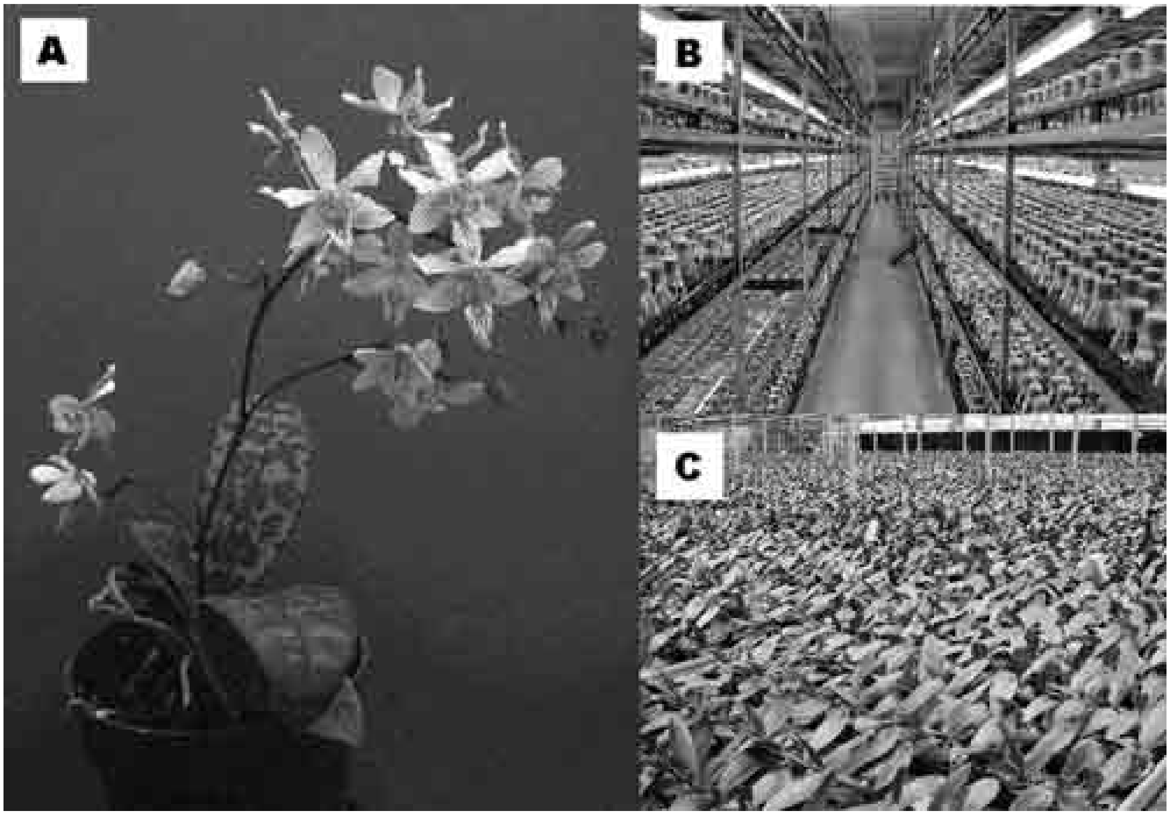

Fig. 3. *Phalenopsis* production. A) dwarf cultivar P. Hummingbird; B) Tissue culture propagation laboratory in Taiwan; and C) Production greenhouse in the Unites States.

FUTURE POTENTIAL

Phalaenopsis production is now international in scope. For example, in one operation breeding occurs in the United States. Selected clones are sent to Japan where tissue culture progation is initiated. Successful cultures are then sent to China for mass proliferation. In vitro grown plantlets are next sent to the Netherlands for greenhouse production. Finally, flowering plants are returned to the United States for sales. Very few *Phalaenopsis* are bred, propagated, flowered, and sold in the same country.

At this time, production does not meet the demand. It is widely expected that sales will increase as production increases. Demand for *Phalaenopsis* should continue well into the future as new types are developed. Based upon today’s breeding efforts, the cultivars of the future will have a compact growth habit, variegated foliage, fragrance, and be ever flowering.

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Phaseolus acutifolius A. Gray

Fabaceae

Tepary bean

We have information from several sources:

Range of Yield Components and Phenotypic Correlations in Tepari Beans (*Phaseolus acutifolius*) Under Dryland Conditions—Sathyanarayanaiah Kuruvadi and Isaac Sanchez Valdez

Tepary Bean: A Short Duration Summer Crop in Virginia—Anwar A. Hamama and Harbans L. Bhardwaj

New Crops and the International Agricultural Research Centers—Robert B. Bertram

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

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Dry Edible Beans: A New Crop Opportunity for the East North Central Region

Glenn H. Sullivan and Lonni R. Davenport

Dry edible bean production in the United States increased from 0.8 million tonnes in 1970 to 1.5 million tonnes in 1990 (Table 1). Production expansion during this period was led by a 21% increase in domestic consumption and a 153% increase in export trade (USDA 1990). The most common commercial classes of dry beans grown in the United States include: small red, kidney, pinto, navy, and great northern (*Phaseolus vulgaris*); small lima (*P. lunatus*); and large lima (*P. limensis*). The largest share of domestic dry edible bean production in 1990 was comprised of pinto and navy beans, with 42 and 20% of total United States production, respectively (Table 2).

The dry bean industry is characterized by high regional concentration in production and processing (Fig. 1). However, production concentration is geographically dislocated from dry bean processing facilities. Dry bean processors are located predominantly in the eastern regions of the United States and Canada, while production expansion between 1970 and 1990 has accrued in the western regions (Table 1). This geographic dislocation between production and processing, combined with changing economic conditions within the industry, has forced dry bean processor to consider strategies for procuring supplies from areas with greater geo-economic relevance to their processing facilities and final demand.

PRODUCTION AND MARKET CONSIDERATIONS

With the exception of Michigan in the East North Central Region (ENCR), dry edible bean production has concentrated in the western regions of the United States (Table 1). Michigan led the nation in dry bean production in 1990, with about 17% of total production; followed by North Dakota and Nebraska with about 15% each. During the period 1970 to 1990, production in the West North Central Region (WNCR) increased 413%, followed by the Mountain Region (MR) at 96% (Table 1). Total dry bean production in the ENCR decreased 11.5% during this period.

Pinto beans comprise the largest volume of any dry bean class produced for human consumption in the United States (Table 2). Total pinto bean production increased 151% between 1970 and 1990, with North Dakota and Colorado accounting for almost half of the crop. Exports and rising domestic demand for ethnic foods have contributed significantly to continued production expansion in pinto beans.

Navy beans accounted for the second largest volume of dry edible bean production in 1990, however, their domestic share of total production has declined (Table 2). This decline resulted primarily from lower export demand in Canada and the United Kingdom since 1980. Michigan's overall decline in dry bean production between 1980 and 1990 was directly attributed to weaker market demand for navy beans. Michigan accounts for over 50% of all navy bean production in the United States.

Food service industry demand in the United States has generated new production opportunities for dry bean classes not previously grown in large quantities, including small red, small white, and pink beans (*P. vulgaris*); blackeye pea (*Vigna unguiculata*); and garbanzo/chickpea (*Cicer arietinum*). Next to pinto beans, these specialty dry bean classes collectively generated the highest rate of domestic production expansion between 1970 and 1990 (Table 2). The small red dry bean class currently exhibits the greatest demand growth, and the greatest potential for production expansion in the ENCR.

ECONOMIC CONSIDERATIONS

Total farm value of dry edible bean production in the United States was estimated at $906 million in 1990; up from $737 million in 1980 (USDA 1991). While producers in the ENCR accounted for only 17% of the farmgate value for all domestic dry bean production in 1990, they are strategically positioned geographically and economically to significantly expand production (Sullivan 1990). Nearly two-thirds of all dry bean processors are located in the eastern regions of the United States, with the largest concentration in the ENCR and Ontario, Canada (Fig. 1). In addition, western dry bean production and transportation costs since 1987 have continued to increase at rates greater than consumer prices, thus encouraging eastern processors to lower costs by developing supply alternatives in closer proximity to their processing operations.

Potential net returns from dry edible beans as an alternative crop favor production expansion in the ENCR (Westcott and Zepp 1989). At current yields, gross receipts of $576/acre ($1,423/ha) are possible. Net returns at this level compete favorably with maize and soybean production under midwestern conditions in most years. Assuming designation by the Secretary of Agriculture under the triple-base statutes of the 1990 Farm Bill, producers in the ENCR could further increase their competitive position. Producers could substitute dry bean crops for a portion of their program area without accruing future crop base penalties. Under this program provision, the breakeven price for dry edible bean production would be consistently lower for ENCR producers than for producers in western regions (Westcott and Zepp 1989). While dry bean prices have been well above $16.50 per hundredweight ($363.66/t) over the last ten years (Table 3), prices at this level would still generate net returns that are competitive with maize in the ENCR. By comparison, dry bean prices would have to consistently exceed $24 per hundredweight ($529/t) to profitably compete with maize production in most western regions. This price level would also encourage the expansion of dry bean imports into the United States.

FUTURE PROSPECTS

Studies conducted by the Purdue Center for New Crops, in cooperation with the Brooks Foods Division of Curtice-Burns, Inc., confirmed that market and production opportunities existed for selected dry bean classes in the ENCR; particularly for the small red bean class. These studies further confirmed that dry edible bean production expansion in the ENCR has not been slowed by economic factors, but rather by lack of cultivars adapted to regional climatic and cultural conditions.

A statewide research and development initiative is geared to expand dry edible bean production in Indiana. The Indiana Business Modernization and Technology Corporation, and the Indiana Commissioner of Agriculture's Value-Added Grants Program provided development grants to help accomplish the objectives of this program initiative. Brooks Foods has provided the industry leadership for developing, testing, multiplying and commercializing small red bean cultivars that can be adapted to farming conditions in Indiana and the ENCR. Promising cultivar selections were made and multiplied in cooperation with Asgrow Seed Company in 1990 for further field testing in 1991 and 1992. Seed multiplication for limited commercial plantings has been targeted for 1993, with full commercialization by Brooks Foods expected in 1994. Market and economic feasibility assessments indicate that these initiatives could increase dry edible bean production in the ENCR by 37 thousand tonnes annually (Sullivan 1990). This level of expansion translates into nearly 45 thousand acres (18,225 ha) of new production opportunities for growers.

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Table 1. Dry edible bean production, by state and region.

Region	1970		1980		1990	
Region State	Production (tonnes)	Value ($1000)	Production (tonnes)	Value ($1000)	Production (tonnes)	Value ($1000)[z]
East North Central						
Michigan	279,100	59,684	351,631	204,653	246,985	143,204
Mountain						
Colorado	90,630	14,985	105,326	66,641	193,914	120,128
Idaho	89,541	15,595	151,003	94,211	161,482	97,544
Wyoming	23,043	3,861	40,416	24,681	43,772	23,160
Pacific						
California	120,930	31,992	172,958	124,685	140,979	113,442
Washington	29,938	6,006	48,989	29,700	41,368	23,712
West North Central						
North Dakota	18,280	2,660	121,474	66,147	227,027	125,125
Nebraska	70,218	12,384	123,833	73,437	226,981	128,102
Other	67,541	13,165	96,798	53,292	188,471	116,257
United States	789,219	160,332	1,212,427	737,447	1,470,979	906,391

[z]Estimated. Source: NASS/USDA, CED/ERS, TVS-252, November 1990; TVS-253, April 1991; TVS-254, August 1991.

Table 2. Dry edible bean production, by commercial class of bean.

	Production (tonnes)		
Class	1970	1980	1990
Baby Lima	21,682	20,276	24,948
Large Lima	25,311	34,383	20,866
Great Northern	64,865	96,209	128,006
Pinto	244,218	468,705	613,382
Navy	234,965	259,323	299,059
Red Kidney[z]	59,059	79,698	106,777

Other	139,119	253,835	277,603
Total	789,219	1,212,427	1,470,979

[z]Not comparable to previous years, 1990 estimates include both light red and dark red kidneys.
Source: NASS/USDA, CED/ERS, TVS-252, November 1990; TVS-253, April 1991; TVS-254, August 1991.

Table 3. Average annual grower price by dry edible bean commercial class ($/tonnes).

Class	1981/82	1985/86	1989/90
Great Northern	586.70	595.79	726.54
Pinto	392.93	487.08	893.24
Small Reds	463.93	512.44	737.57
Pinks	397.56	505.61	775.28
Baby Lima	590.49	449.38	742.42
Large Lima	814.09	515.97	949.47
Blackeye Pea	687.30	503.62	686.64
Small Whites	---	451.80	644.96
Lt. Red Kidney	692.15	590.94	947.04
Garbanzo (chickpea)	1,046.27	766.67	795.12
Navy	702.95	409.24	657.53

Source: NASS/USDA, CED/ERS, TVS-252, November 1990; TVS-253, April 1991; TVS-254, August 1991.

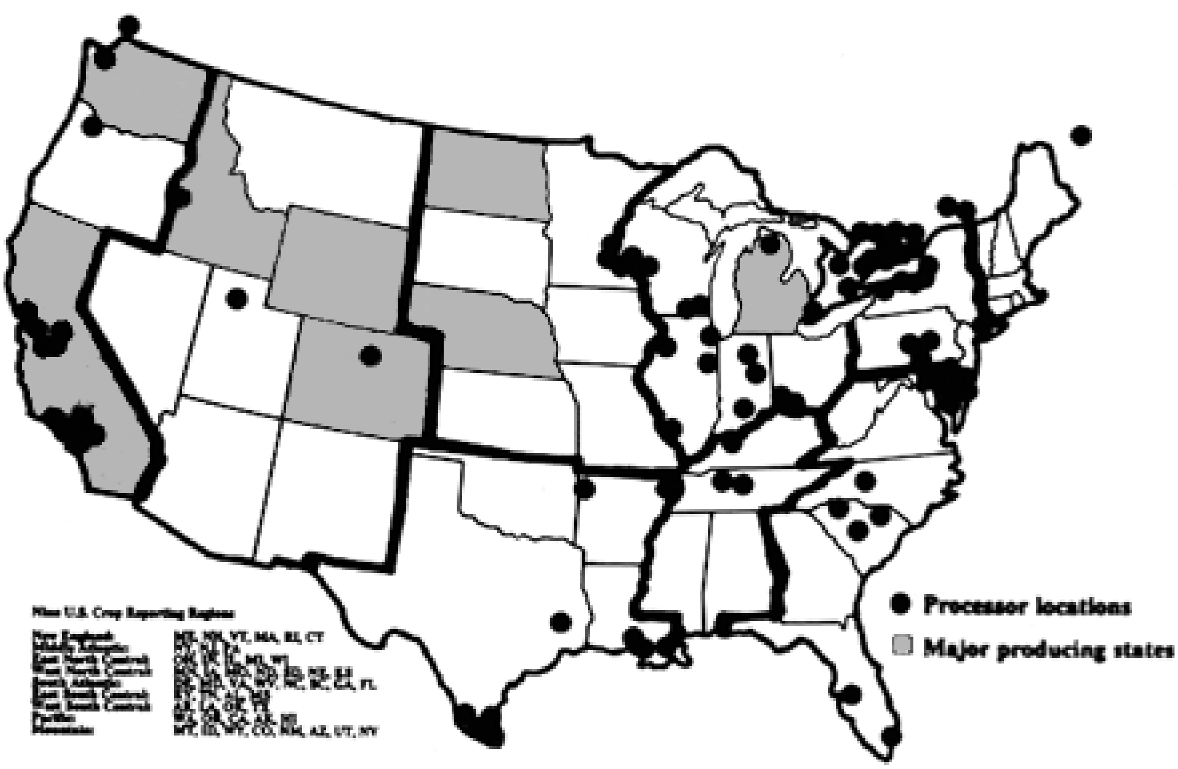

Fig. 1. Dry beans production and processor locations.

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Beans

(*Phaseolus* spp.)

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Of the genus *Phaseolus sensu stricto*, which includes 55 species, five have been domesticated. The pre-Columbian peoples grew them for thousands of years as a main source of protein, since animals did not have an important role as a source of food or draught power, particularly in Mesoamerica.

As early as the pre-Columbian period, the kidney bean (*P. vulgaris* L.) had gained wider acceptance and was selected more intensively. The early chroniclers inform us that, in the Aztec and Incan empires, great importance was given to this species and it was used to pay tributes. It gained even more popularity after the conquest and, from 1880, with the exception of isolated studies the work on genetic improvement was mainly concentrated on this bean. This preferential treatment was detrimental to the other species which are of greater or comparable interest in modern agriculture, at least in areas that do not offer optimum ecological conditions for their development.

The ancestral form of *P. vulgaris* grows within the boundary between two climatic zones subtropical dry and tropical temperate where pre-Columbian societies established many settlements, a tact which may explain the acceptance of the species. To cover the greater part of the area occupied (except for certain Andean regions), the Pre-Columbians domesticated four other species.

The five ancestral forms were lianas which grew in different ecological niches. Biochemical studies have shown how *P. lunatus* was domesticated in several points of Mesoamerica and *P. vulgaris* in the Andes. Except in the latter region, uniformity in selection pressure led to a considerable similarity in evolutionary stock. With the exception of the tepary bean, the association with maize—although it was late in the Andes—also contributed to this standardization. The levels of evolution of the five species have been varied and there is a great potential for exploitation; for example, as regards the growth habit in *P. polyanthus* and the size and colour of the *P. acutifolius* seed. The ecological potential of these species would enable some of them to be developed even more profoundly than *P. vulgaris*.

At a time when the model of an agriculture which is both sustainable and productive has been accepted, beans deserve to be given renewed attention.

Phaseolus coccineus

Botanical name: *Phaseolus coccineus* L.

Family: Fabaceae

Common names: English: scarlet runner beans: Spanish: ayocote (name of Nahuatl origin, central Mexico), patol (Mexico [Zacatecas]), botil (Mexico [Chipas]), chomborote, piloy (high platear of Guatemala), cubá (Costa Rica)

This species has been cultivated in the high parts of Mesoamerica for many centuries. In pre-Columbian Mexico. the people of the Anahuac cultivated it extensively and ensured its distribution. Its introduction into southern Colombia (Antioquia and Nariño) and Europe (where it is known as scarlet runner bean and haricot d'Espagne) could have occurred in the seventeenth century before reaching other parts of the world. such as the Ethiopian highlands. It has been found in archaeological remains only in Mexico in Durango and Puebla. and wild only in Tamaulipas. Although archaeological information is very scarce. it could be assumed that its Mexican domestication took place in humid high zones.

Changes in maize varieties (earlier-maturing and with softer stems) and the use of fertilizers (for example, urea) and herbicides in maize yields led to the gradual abandonment of this crop in eastern Guatemala and in Costa Rica. It is reasonable to suppose that the same is happening in other areas of its cultivation. Because of its ecological niche *P. coccineus* has suffered heavy competition from exotic crops with a higher consumption and better market, for instance vetch, broad bean, cabbage, garlic and onion.

P. coccineus has been used in its nuclear area, particularly for its dry or green seeds. The consumption of young seeds enables the crop to be expanded to higher altitudes, since the fleshy root produces a second growth after light frosts (for example in Huehuetenango, Guatemala). The root of this legume has medicinal uses in Mexico and the flowers are also eaten. Its gaudy influorescences may be the reason for its recent expansion as an ornamental plant in Europe and the United States. The green pod is used as a vegetable in western Europe and the dry seeds (white seeds) are eaten in some traditional dishes.

Botanical description

A pluriannual species of great vegetative vigour with stems of several metres (only in a few modern cultivars are there shrubby forms) which emerge from a fleshy root. *P. coccineus* is easily distinguished by: its large seeds (the weight of 100 seeds is 80 to 170 g and 6 to 12 g for the wild form) and small, narrow, elliptical hilum; and its large influorescences (20 cm and in excess of 20 fruit-bearing stems) with scarlet, white or, more rarely, two-colour flowers. It carries out hypogeal germination, has a fleshy root which is divided and generally fusiform and which allows cotyledonary young shoots to resprout over several consecutive years. It flowers 50 days after sowing. with early varieties, or at the start of the rains, and continues to produce flowers over a long period, except in the shrubby varieties. In the majority of cases *P. coccineus* undergoes cross-pollination. assisted by its extrorse stigma and nectaries and through the action of bees and humming birds. Thus far, it is considered self compatible.

The seed of wild varieties is dispersed through explosive dehiscence of the pods during the dry period. In some wild populations there is a short latency; the seeds viability in natural conditions does not exceed three years.

Figure 3. Beans: A) *Phaseolus coccineus;* A1) legume; A2) seeds; B) *P. acutifolius*; B1) legume; B2) seeds

Ecology and phytogeography

Like *P. polyanthus, P. coccineus* tolerates higher precipitations than other species of *Phaseolus* (Table 3), provided that the soil has good drainage: that is with derivatives of volcanic ash, fine particles, etc. It grows at cooler temperatures than other cultivated species and is generally heliophytic. although it tolerates mists.

Table 3. Selected cultivated species of *Phaseolus:* altitude, daytime temperature, mean annual precipitation, duration of growth cycle from start to end of harvest, yield potential in tropical areas

Species	Altitude (m)	Temperature (°C)	Precipitation (mm/year)	Growth cycle (days)	Yield (kg/ha)
Phaseolus coccineus	1400–2800	12–22	400–2600	90–365	400–4000
Phaseolus acutifolius	50–1900	20–32	200–400	60–110	400–2000
Phaseolus lunatus	50–2800	16–26	0–2800	90–365	400–5000
Phaseolus polyanthus	800–2600	14–24	1000–2600	110–365	300–3500
Phaseolus vulgaris	50–3000	14–26	400–1600	70–330	400–5000

Its nuclear area extends from Durango to Veracruz and Puebla. In Guatemala. it is traditionally sown on the slopes of the Cuchumatanes range, on the high plateau of Huehuetenango up to Alta Verapaz and Sacatepéquez. and in the highest parts of the rest of Central America. The wild form of *P. coccineus* (although unable to be confirmed as ancestral throughout its distribution) extends from Chihuahua in Mexico to Panama, generally between 1400 and 2800 m in the humid high forest.

Genetic diversity

In its wild form, this species displays a great phenotypical variation in its current state of evolution. in contrast with the other wild species of the genus (there is some similarity with *P. augusti* of South America). Wild *P. coccineus* may be considered to be a complex of several forms, now in active speciation. throughout its distribution range. Some very differentiated forms, such as *P. glabellus*, may have become separated, constituting an early form of a group of which it is now difficult to distinguish all the variants. Allogamy is frequent in these plants, and the crossing of wild and cultivated forms, which have been displaced by humans, has changed the speciation patterns. Because of its active process of evolution, this species complex is not an easy task for the taxonomist but, by the same token, it offers great potential for the plant improver.

In addition to a group of four wild forms with scarlet flowers, mention should he made of another four forms with purple flowers. *P. polyanthus* is a related species at the boundary of the primary genetic stock of the scarlet runner bean, since in some cases it can be crossed with the later, as in Putumayo, Ecuador or in Imbabura, Colombia. Likewise, *P. vulgaris* may he considered to be at the boundary of the primary genetic stock of the scarlet runner bean.

There are only a few definite cultivars, particularly among the climbers; among the indeterminate shrubby cultivars, "Patol Blanco" may be mentioned and, among the determinate shrub cultivars, "Hammond's Dwarf".

There are risks of genetic erosion in areas where the traditional maize field has been changed, as some parts of Mexico (Chiapas, Oaxaca, Puebla and Veracruz), Guatemala and Costa Rica. Along with maize, the three species of bean (*P. coccineus*, *P. polyanthus* and *P. vulgaris*) and gourds were frequently sown in these areas. In the high plateau of Mexico (Durango, Zacatecas), the recent spread of the kidney bean may displace the "patoles" for reasons of cost.

P. coccineus material exists in collections of germplasm, mainly in Chapingo in Mexico (INIFAP), Pullman in the United States (USDA) and Palmira in Colombia (CIAT). The cultivated material has already been collected to a great extent, except in some areas of Guatemala (for example. Quiche), Honduras and Costa Rica. where it may be already too late to make such a collection.

For the wild material. it is necessary to collect around the great cities of Mesoamerica, particularly in the valley of Mexico, since these areas were a centre of diversity of the *P. coccineus*, complex which is very rich in forms. Many areas still remain to be explored, in view of material collected compared with the abundant herbarium material available. The complications involved in handling these forms ex situ mean that they need to he conserved in situ.

Cultivation practices

In most of its area *P. coccineus* is sown with maize and other varieties or species (*P. vulgaris, P. polyanthus*) following documented practices, since precipitations allow their association. In Durango and Zacatecas (Mexico), under heavy rain conditions it is sown alone, either in widely spaced rows or broadcast. depending on the type of ploughing. Manual harvesting is still common; the pods are gathered and left to dry in the sun before being beaten and the seeds are stored in sacks.

Estimation of the yield in cultivated herds is difficult, since farmers intercrop *P. coccineus* with other beans or harvest it periodically. It produces 400 to 1000 kg per hectare in the shrubby forms while, for climbing varieties, the yield can be much higher (Table 3). In the United Kingdom, for crops with young pods, more than 23 tonnes per hectare have been recorded.

Prospects for improvement

The scarlet runner bean has been used on many occasions for improving the common bean but only in very few cases has its own improvement been addressed, although specialists agree on the hardiness of the species against several fungi, bacteria and viruses.

The delayed production of climbing forms may be considered a limitation. The number of shrubby forms is not sufficiently high (especially of those with white seeds) and several of them have a low yield. Not all colours and seed stocks exist in these varieties, and this is particularly the case with shrubby forms. Floral abscission can at times be considerable—perhaps because of the lack of pollinators—and causes yield losses.

Many cultivars root easily and can be maintained over several years thanks to their fleshy root. Their large attractive flowers make insect pollination easy (this crop may be assumed to have a positive effect on local entomofauna). A hybrid scarlet runner bean could be developed; however, unlike the kidney bean or the tepary bean, it is not known whether there would be a strong heterosis effect.

The use of the scarlet runner bean to complement maize in silage deserves investigation since, as well as its fodder value, the plant can limit soil erosion. It may also be useful interspersed in young forest or fruit plantations (to give soil protection, fertilizing value or additional income).

Because of its type of germination. *P. coccineus* is a useful species for fighting the bean fly (*Ophiomyia phaseoli*) in the highlands of East Africa.

Phaseolus acutifolius

Botanical name: *Phaseolus acutifolius*

Family: Fabaceae

Common names. English: tepary bean: Mayan: xmayum (Mexico [Campeche]): Spanish tépari, (name of Opatan origin) (Mexico [Sonora]). escomite or escumite (Mexico [Chiapas]), frijol piñuelero (name of hybrid origin) (Costa Rica)

This species has been grown for a long time in Mesoamerica, mainly as a vegetable in desert zones or areas with a long dry period. Unlike the case of other cultivated species of the genus, *P. acutifolius* was first described in its wild form while the relationship with the cultivated form was recognized later Archaeological findings have shown that this species was grown in ancient times in the southeastern United States, where it apparently penetrated from Mexico 1200 years ago) and Puebla (where it existed 5000 years ago). Geographical distribution of the cultivated form extends from Arizona and New Mexico to Guanacaste, Costa Rica, on the dry subtropical slope of the Pacific. The distribution of *P. acutifolius* is sporadic, which is reflected in its market. The main product is a dry seed which is eaten because of its rich protein (17 to 27 percent) and carbohydrate content It is also used as a young tender string bean and as fodder after harvesting.

It is still not known precisely where the species was domesticated It should be noted that electrophoretic analyses of the phaseolin and isoenzymes indicate that the domesticated populations were few. Either because of its historic extinction, because the initial genetic base was already reduced at the time of its domestication or because of the autogamy of the species, the cultivated genetic potential does not seem to have been very extensive, to judge from its sub sequent development. Following are some of the causes that several authors have reported as having led to neglect of the tepary bean:

- the availability of cheap water in desert areas which enables the cultivation of fodder plants or garden produce and other vegetables of greater value (kidney bean, cowpea), as the tepary bean's yield remains the same or even diminishes with irrigation;
- the loss of eating traditions in indigenous communities;
- the shortage of demand on the big markets.

Its cultivation potential in desert areas is extensive and is still to be explored

Botanical description

P. acutifolius is a desert therophyte and is easily distinguished from other species of beans by its epigeal germination, sessile primary leaves, acute rhomboid folioles, pseudoracemes—with two to four fruit-bearing stems—small pink flowers (white in some cultivars) with very small triangular bracteoles and pods that have sutures marked with five to ten ovules Autogamy appears to be dominant Two wild forms are recognized: var. *acutifolius* with rhomboid folioles and var. *tenuifolius* with linear, sometimes sagittate, folioles. A third wild form appears sporadically with narrowly falcate folioles which. because they have different blastogenic characteristics from the var. *tenuifolius* and possess a certain incompatibility for crossing. could be considered a separate species (*P. parvifolius*).

Thc cultivated form, like the wild forms, has a short cycle, flowering 27 to 40 days after germination and ripening at 60 to 80 days. The plants wither completely (except *P. parvifolius*). In the wild forms, seeds are dispersed within a radius of 3 m by explosive dehiscence of the pods In some cultivars there is a brief postharvest latency of one month. The seeds of the wild plants germinate through the imbibition caused by the heavy desert rainfalls of the following year. However, only in some is germination staggered over three years.

Ecology and phytogeography

The cultivated form is found from 50 m to 1920 m above sea level. It requires an annual precipitation of 250 to 300 mm, although it is grown in Mexico in regions with a precipitation of 150 mm (Sonora) to 750 mm (Campeche). During the vegetative period, the daytime temperature can reach 20 to 32°C. It grows on well drained. sandy, muddy, sometimes organic soils with pH 6.7 to 7.1.

There is an ecological specialization in the wild forms of the tepary bean: var. *acutifolius* of Arizona, New Mexico, Lower California, Sonora, Chihuahua, Durango, Sinaloa and Jalisco occupies semi-sunny habitats with the mesquite on the banks of streams. while var. *tenuifolius* colonizes the sunny slopes with cacti and thorny shrubs in Arizona, New Mexico, Lower California. Sonora, Chihuahua, Durango, Sinaloa, Nayarit, Jalisco, Querétaro, Michoacán, Guerrero, Oaxaca and Jalapa. The cultivated form is a heliophyte and has characteristics that allow it to tolerate excessive sun.

Genetic diversity

Compared with the kidney bean, there is less seed variability. Basically two forms occur: one with a fairly small, rounded, white or black seed; and another with a larger-sized angular, rhombohedric seed that may be white, greenish white, grey, bay, dark yellow, mahogany, black or purple-mottled or coffee in colour. The average weight of 100 cultivated tepary bean seeds is between 10 and 20 g and, for the wild form, between 2 and 5 g. Two cultivars have been cited: one is white (Redfield) and another is dark yellow. Both result from mass selection. Although the cultivated and wild materials do not have a definite habitat, a desert environment is necessary. Whereas the wild varieties are generally climbers with a few guide shoots (2 to 4 m in length), there are two cultivated groups: the indeterminate shrubby varieties with short guide leaves and the indeterminate creepers with long guide leaves, which climb if they find support. The author knows only one escape variety. The secondary genetic stock is not well known: the kidney bean may be considered to be within the tertiary stock.

A good number of cultivars from which collections have been made mainly in Mexico appear to be no longer sown. It seems unlikely that many more cultivated forms will be found but it would be useful to re-examine the southern area of distribution. This examination is an example of a germplasm collection programme that has enabled a good part of the crop's variability to be saved. The two wild forms represent the major source of variation for future improvement of the species. As some plant species are threatened by overgrazing, it would be advisable to collect germplasm from Nayarit to Jalapa.

Cultivation practices

In the southern area of its distribution, the rural communities have conserved *P. acutifolius*, particularly because of its early maturity and reduced cultivation requirements. It is sown on the edge of maize fields, at the start of the rains to obtain the green bean and at the end of the rains to obtain the seed, or on plots around houses in virtually any period. In the northern area of its distribution (southeastern United States, northeastern Mexico), it is sown under heavy rain conditions in small fields with a favourable topography or on the edges of streams, generally alone or with some gourds and tolerated weeds. After the first heavy downpour, the land is ploughed and then sown in rows or broadcast following the second downpour. The plants are pulled up when they reach maturity and are left to dry in the sun. One week later they are trodden on a clean surface while the seeds are collected and winnowed with a basket. The seeds used to be stored in baskets or clay vessels (nowadays in tins or plastic bags), thus maintaining their germinating capacity for three years. In Campeche, to store seed for sowing, packets are made with the unopened pods and placed in contact with the smoke of embers.

Yields are estimated to be 200 to 900 kg per hectare, with wide variations depending on sowing density and rainfall. About 1000 to 2000 kg per hectare are obtained with fertilizer, with harvests of up to 4 tonnes per hectare.

Prospects for improvement

The tepary bean is considered to be a useful species for improving the kidney bean (it is not attacked by mildew or smut, *Xanthomonas phaseoli*), but no programmes have been carried out for improving the tepary bean itself. Unlike many leguminous vegetables, it gives an acceptable yield with less than 400 mm of annual precipitation. Its small seed size could be corrected by improving the species; the variability in colours and seed standards could also be increased. A pronounced heterosis is noticed when lines are crossed and there is a possibility of hybrid tepary beans being produced (it would be necessary to determine whether the secondary stock would make it possible to increase the flower's attractability to insects[1]). Some populations are susceptible to rust, oidium, mildew, root rot, leafminers, bruchids and leafhoppers. Some lines have good or excellent levels of resistance to these pests and diseases. In cultivation, the germplasm has proved susceptible to high temperatures, acidity, aluminum toxicity and common mosaic diseases.

Its potential for introduction into desert areas (the American tropics, the Sahel, the Near East, India) is considerable but it has not been exploited. For example, in July 1985, the author sent a small sample of tepary bean plants to Chincha in Peru for evaluation; in 1989 one of the tepary beans was already being sold under the name of cuarenteno in Chiclayo. In many areas its use as a cover plant or as a crop merged with millet (*Pennisetum* sp.), prickly pear (*Opuntia* sp.), mesquite (*Prosopis* sp.) and jojoba (*Simmondsia* sp.), for human or animal consumption, has not been exploited either. It should be possible to use it as a postharvest crop when temperatures are still favourable and residual humidity is low. One of the main reasons for promoting cultivation of the tepary bean is to limit the use of water in subdesert areas.

Research should be orientated towards increasing the collection of germplasm; distributing seed from gene banks to farmers; divulging information through agricultural extension services on the cultivation potential of the tepary bean in dry zones; setting up seed improvement projects; developing food technologies suited to leguminous vegetables (for example, industrial processing of proteins), which would free the farmer from market requirements; and promoting information on the methods of consumption in order to re-upgrade the use of this legume.

[1]No cytoplasmatic androsterility or agents re-establishing fertility have been recorded in *P acutifolius*.

Phaseolus lunatus

Botanical name: *Phaseolus lunatus* L.

Family: Fabaceae

Common names. English: butter bean, Lima bean, Burma bean, duffin bean, Rangoon bean

There are two main genetic stocks domesticated from two separate wild forms and with morphotypes from a different seed.

> **Common names of the small-seed cultivars** (24 to 70 g per 100 seeds). Mayan: ib (Mexico [Yucatán]); patashete (Mexico [Chiapas]); ixtapacal (Guatemala [Suchitepéquez]); Spanish: sieva, comba (Colombia [Guerrero]), furuna (Mexico [Jalapa]), chilipuca (El Salvador), kedeba (Costa Rica), frijol caballero (Cuba), haba (Puerto Rico, Panama), carauta (Colombia [Atlantic]), frijol de año (Colombia [Tolima]), guaracaro (Venezuela); French: pois souche (Haiti)

The Caribbean group is made up of small, round seed material distributed in that area.

> **Common names of the large-seed cultivars** (54 to 280 g per 100 seeds). Spanish: lima (because of its origin from the coast of Peru), torta (Colombia [Nariño, Huila], Ecuador [Imbabura, Azuay, Loja]), layo (Peru [Cajamarca]), pallar (Peru [Lambayeque, La Libertad, Lima, Ica, parts of the range]), palato (Bolivia [Chuquisacal), poroto manteca (Argentina)

Archaeological findings in Ancash, Peru, indicate that, after *Lagenaria siceraria*, the large-seed species were among the first to be cultivated (8 000 years ago), while the small-seed materials in Mesoamerica date back only 1 200 years. The large-seed material appeared 5 000 years ago on the coast of Peru, where they were of great nutritional and cultural value, particularly for the Mochican and Nazca peoples. Distribution of the wild form on the northern range (electrophoresis test results show that it is the ancestor of the Andean stock) suggests that domestication took place in this area and that it expanded towards the high parts of Ecuador and Colombia as well as towards the Peruvian coast and other high parts of Peru and Bolivia. Nowadays, the green seed in particular is eaten.

On the Peruvian coast, dulce de pallar, a kind of Lima bean conserve, is prepared from the dry seed. The aesthetic value of the seeds has enabled them to be used in recreation activities in peasant communities. The small-seed cultivars were domesticated from a wild form, possibly in Mesoamerica and in more recent times. The seeds are eaten dry (the Mayans of today prefer them refried) or green. In Asia the young plants or young leaves are consumed; in Madagascar they are used to prepare hay.

Among the reasons for the present marginalization of *P. lunatus*, apart from abandonment of the traditional diet with the rural exodus and changes in peasant customs, we should mention the presence of a cyanogenic glucoside which in some cultivars, if detoxification is omitted, may cause poisoning. Standardization in the consumption of leguminous vegetables (some varieties of common bean or cowpea) has been prejudicial to the Lima bean because of the presence of this glucoside. The small-seed cultivars, particularly under irrigation, suffer from the competition of soybean (and sometimes the cowpea because of its price). In the Peruvian Andes, Lima beans have heavy competition from the introduced lablab [*Lablab purpureus* (L.) Sweet] which is resistant to weevils, and the introduced pigeon pea [*Cajanus cajan* (L.) Mills], which is more tolerant of drought.

Botanical description

P. lunatus is a pluriannual species (except for a few modern cultivars) with epigeal germination and fibrous roots. Its ancestral forms come from low- or medium-altitude tropical deciduous forests. It is easily distinguished by its half-moon seeds (with the exception of a group of cultivars from the Caribbean that has a spherical seed). It is striated from the hilum and has: deltoid folioles; pseudoracemes with four to 12 fruit-bearing stems; small flowers, with a standard which is greenish (Mesoamerica) or purple (Andes); very small, roundish bracteoles; and smooth, falcate pods with three to six ovules. The two wild forms display marked differences but do not justify differentiated taxonomic treatment because of the considerable introgression among their genetic stocks. It is an autogamous species with an introrse stigma, but cross-pollination may exceed 32 percent.

The earliest genotypes flower 35 days after sowing and complete their cycle in around 100 days. Others may have two flowering cycles per year depending on the distribution of rainfall. In dry areas, the plants sprout from the lower part of the stem with the return of rainfall. In the majority of the traditional varieties, the guide leaves are long (3 to 6 m), indeterminate, creeping (and therefore useful as ground cover) or climbing.

The fibrous roots may attain several metres on filtering soils with deep humidity (Yucatán, coastal Peru), thus giving the plants great vegetative vigour (greater than maize) and a survival period of up to four years. In the wild populations. the seeds are dispersed through explosive dehiscence of the pods.

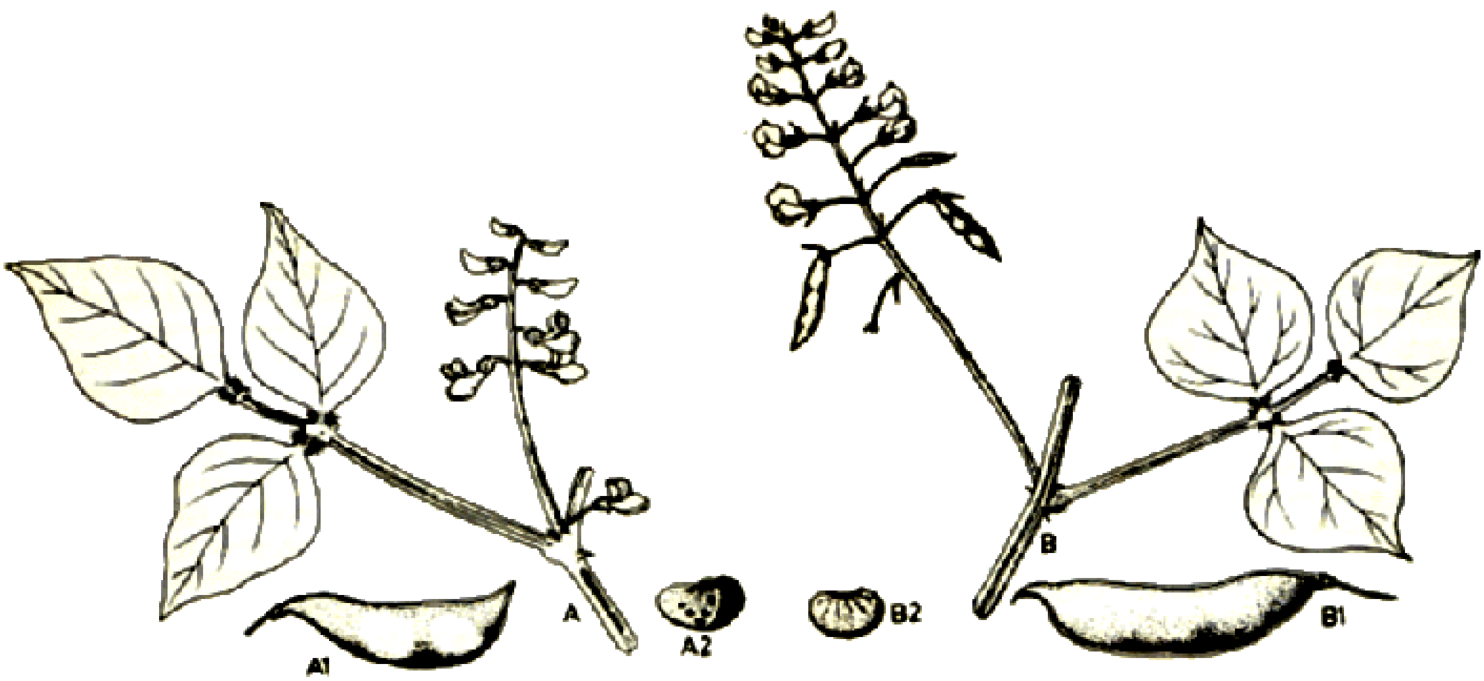

Figure 4. Beans: A) *Phaseolus lunatus*; A1) legume; A2) seed; B) *P. polyanthus*; B1) legume; B2) seed

Ecology and phytogeography

Although not strict, there is a certain distribution pattern of the forms. The small-seed wild form is found from Sinaloa in Mexico to Salta in Argentina, generally below 1600 m. The small-seed cultivars frequently grow at a lower altitude in the Pacific area of Mesoamerica, from Arizona in the United States to Choco on the western range of Colombia as well as the Ecuadoran coast, and from Yucatán and Colombia to Venezuela and in the Antilles. It also exists h northeastern Brazil and in Formosa, Argentina. The larger wild form is distributed in Ecuador and in the north of Peru between 320 and 2030 m. The large-seed cultivars are distributed in Peru from 50 to 2750m and in the high valleys of Chuquisaca and Cochabamba in Bolivia. Curiously, some also exist in the south of Brazil.

P. lunatus is a generally hardy species which prefers dry climates and deep soils (pH 6 to 7.2) with good drainage. Although it is true that some forms tolerate the climate of the lower tropics well, the species' exceptional altitude range should be mentioned, particularly in Peru where some forms withstand low temperatures (Table 3). *P. lunatus*, both cultivated and wild, is rather heliophytic.

Genetic diversity

The intraspecific variability of *P. lunatus* is particularly high in the groups of Siva and Gran Lima varieties and less in the Caribbean group. There are several commercial cultivars, particularly in California (for example. Henderson and Fordhook) and for domestic consumption (unripe green seeds in salads) in the United States. Relatives of the Andean wild form are *P. augusti* Harms, *P. bolivianus* Piper and *P. pachyrhiozoides* Harms. Of the cultivated species, the latter has the widest secondary stock.

There are numerous gene banks, mainly in Pullman in the United States (USDA), Chapingo in Mexico (INIFAP) and Palmira in Colombia (CIAT). Germplasm has been collected in order to save traditional material cultivated in several regions of the American tropics where varieties have rapidly disappeared. It could still be collected profitably in some parts of the Yucatán peninsula, northern Colombia, San Martin in Peru and in Paraguay.

In the case of wild material (particularly of the small-seed tone) many regions fall short for collecting specimens: Tamaulipas, Sinaloa, Michoacán, Oaxaca, Chiapas, Petén in Mexico, El Salvador, Nicaragua, Panama, Venezuela and easten1 Bolivia.

Cultivation practices

In the neotropical zones of America, it is very common to find from one to five *P. lunatus* plants in household vegetable gardens and on small plots, as it is customary for families to add a few green seeds to soups. In the Mayan Yucatán, this bean is traditionally sown as part of the slash-and-burn clearing system with maize, buul (*P. vulgaris*) and gourds. On the coast of Colombia, carauta is found on plots with maize, cassava and guandul. On the coast of Peru, it was frequently found broadcast on the banks of mountain streams where it absorbed the floodwaters. Similar practices may have existed in the *cinteño* valley in Bolivia before the introduction of the grapevine. Nowadays, in Chinca, Peru, it is sown as a commercial monoculture (white seeds) on ridges with irrigation. In many parts of the Andean range (in the dry inter-Andean valleys at 2000 m of Nariño, Colombia; Imbabura and Azuay in Ecuador; and Cajamarca in Peru) *P. lunatus* is frequently seen growing on old walls separating plots and roads or on landslides and slopes. The peasants thus use the spaces of least value. In other parts of Peru (Cajamarca, La Libertad), the Gran Lima types are sown around the edge of small farms. In some places, the plants behave spontaneously and cross with the wild forms that exist in the surrounding area (for example in Succhubamba, Cajamarca).

As it is sown almost individually in many family vegetable gardens. it is difficult to give figures for yield per area. Furthermore, periodic harvesting complicates the evaluation. In the shrubby forms, seed yields of 2000 kg per hectare have been recorded and, in climbing varieties, more than 3000 kg per hectare.

Prospects for improvement

Within the cultivated species, *P. lunatus* competes with *P. coccineus* through the genetic stock which is wider (primary and secondary) and differentiated into a very early form (for which there is genetic progress); it has a good rate of allogamy and heterosis has been found; consequently there are good prospects for improvement. *P. lunatus'* relatively late production, as well as that of the indeterminate creeping forms, may be compensated by exploiting the earlier shrubby forms. There is a wide variation in the glucoside content in the seed, and potential for improvement with types of less than 5 ppm, without any correlation with the colour of the tegument. The evaluation of cultivars to determine the glucoside content will make it possible to establish many materials in traditional areas of cultivation and consumption. Its hardiness and lengthy production may be advantages in adverse conditions where other leguminous vegetables do not prosper. The aesthetic value of the Gran Lima varieties may be considered in the development of handicrafts (which could be useful in remote parts of the Andes). The restoration of traditional dishes and uses (for example in recreation) would also contribute to the crop's promotion. The selection of varieties resistant to grub (*Acanthoscelides* sp.) and weevil (*Apion* sp.), particularly the Gran Lima, and of shrubby forms with a greater diversity of seeds (colour, shape) as well as the study of production techniques (the use of nettings, sowing on slopes, etc.) should be mentioned as research priorities.

Phaseolus polyanthus

Botanical name: *Phaseolus polyanthus* Greenman

Family: Fabaceae

Common names. Spanish: botil (Mexico [Chiapas]), piloya (Guatemala [Chimaltenango]), dzich (Guatemala [San Marcos]), piligüe (Guatemala [Alta Verapaz]), petaco (Colombia [Antioquía and western region]), cache (Colombia [Cauca, Huila and southern region]), matatropa (Colombia [Huila]), toda la vida (Ecuador, northern region of Peru).

The taxon *P. polyanthus* was recently acknowledged as a result of identification of its ancestral forms. There are no recordings of this legume on archaeological sites, in spite of the fact that the seeds found have been analysed thoroughly. The ecological conditions under which this species grows may not have been favourable for its preservation. Mention has been made of how old this crop must be in Mexico. In comparison with the wild forms and the other species, *P. polyanthus* is less evolved, which appears to be the result of its more recent domestication.

It has frequently been cultivated together with maize, gourds and two species of bean (*P. coccineus* and *P. vulgaris*) in Mesoamerican regions with a humid climate and at an intermediate altitude. Like the scarlet runner bean, this crop has been reduced with modification of the traditional maize field system in many parts of Mesoamerica. If peasants have to cease cultivating a species of bean, they keep the kidney bean, which generally obtains the best price. Among the other causes of its marginalization is the extension of coffee plantations and livestock rearing in its area of cultivation. As their incomes increased. peasants tended to abandon consumption of this legume. Traditionally, the green seed is preferred (either because it is easier to digest or because of its softer tegument) when the pod reaches physiological maturity and the dry seed is favoured less: it is eaten in soups. stews or even as a sweet (Amazon region).

Botanical description

Only pluriannual forms of *P. polyanthus* are known, which can live from two to tour years. In drier parts (for example, western Cajamarca, Peru) it tends to behave as an annual. It is easily distinguished from the other species by its epigeal germination; fibrous, fasciculate roots; inflorescences with six to 16 fruit-bearing stems; primary bracts and long, narrow bracteoles (giving the pseudoraceme the appearance of a spike); white or lilac flowers (purplish pink in the wild form); and terminal stigma. Its seed (70 to 100 g per 100 seeds for cultivated varieties and 16 to 25 g for wild forms) has a wide, elliptical hilum and the parahilum is frequently broken.

Ecology and phytogeography

P. polyanthus is distributed in intermediate altitudes (800 to 2600 m) in cool, damp climates with one dry period per year (Table 3); it has a long flowering period (two to five months) and can have two flowering and fruit-bearing periods per year if the rainy season is heavy (Colombia, Venezuela). It prefers deep, organic, damp and well-drained soils with pH 6.2 to 6.5 and it tolerates a degree of shade.

The cultivated form is found in Puebla, Veracruz, Oaxaca and Chiapas (Mexico). In Guatemala. it can be seen in Huehuetenango, San Marcos, Quezaltenango, Totonicapán, Baja and Alta Verapaz, Sololá, Chimaltenango and Sacatepéquez. It is also distributed in the upper parts of the Caribbean (Jamaica, Dominican Republic) and Costa Rica. It is cultivated in South America, where it is found in secondary vegetation, including wooded vegetation, from Mérida in Venezuela to Apurimac in Peru and in the western and central ranges of Colombia (the petaqueras of Antioquía), Ecuador (Azuay, Pichincha, Tungurahua) and northern Peru (Cajamarca, Amazon, Junín). To date, the wild form has been found only in the central-western part of Guatemala, where it is a liana that grows in the low, humid mountain forest; the possibility of it also occurring in the mountainous zone of the Jalisco-Michoacán boundary in Mexico should not be excluded.

Genetic diversity

This species is considered to be the least evolved of the cultivated *Phaseolus* species, hence it should have a greater potential for future development. There is little phenotypic variation (only the indeterminate climbing growth habit), including in the seeds. Normally it has orangy yellow seeds, but other colours do appear: reddish brown, bay, black and creamy white, for example. Seeds of the latter colour were found by the author in the Amazon region of Colombia and in Loja, Ecuador. It may have potential as a commercial crop in northern Peru and may compete as a plant with the caballeros (*P. vulgaris* with a large, round white seed), which do not produce in humid areas. Greater variation is seen in the seed where natural hybrids exist with *P. coccineus* (for example, in Putumayo, Colombia) and with *P. vulgaris* (for example in Tolima, Colombia) where colours may be combined with purple, coffee, etc. To date, there do not seem to be any properly recorded cultivars.

It is evident that *P. coccineus*, *P. polyanthus* and *P. vulgaris* are genetically close as a result of natural introgression among the species. However, each comes from a different and individualized ancestral form. The reason for this relationship should be found in the origin of the ancestral forms. Other species of the *P. coccineus* complex may also be considered to be close to the cache; the genetic stock of *P. polyanthus* is therefore wide.

An exact evaluation of genetic erosion in this species is difficult: in some parts of Guatemala (San Marcos, Chimaltenango) and Costa Rica, where the traditional maize field cultivation system has been modified, certain genotypes are disappearing; in others (Cauca, Tolima, Amazon region, in Colombia and Junín in Peru) it appears to extend into ruderal vegetations because peasants throw seed on roadsides and in smallholdings, etc. One farmer in Huila, Colombia, mentioned that it was the first seed that he sowed in the slash-and-burn system of Los Paez. The species' hardiness in humid environments provides food when the maize harvest is insufficient and explains its frequent presence in secondary forests in Colombia, Ecuador and northern Peru. It is even more difficult to evaluate erosion, as it is a predominantly allogamous species (although the local variation of this allogamy is not well known). However, it does seem useful to document the evolution of the native material in its areas of genetic cultivation in Mexico and Guatemala and to collect germplasm in appropriate cases. In the southern area of its distribution, where there seems to be less variation and erosion, collection would not seem to be urgent. The situation is different in the case of the wild ancestral form: its distribution area in central-western Guatemala is threatened by urbanization and agriculture (the primary forest where it grows is being cut down to set up coffee plantations). It is urgent to complete collection of germplasm and to ensure that at least some plant species are included in *in situ* conservation within the perimeter of natural parks. This method should also be considered for the few sites where there is natural introgression.

There are collections of this species, mainly in Chapingo in Mexico (INIFAP); Chimaltenango in Guatemala (ICTA); La Molina in Peru (INIAA); and Pullman in the United States (USDA). The widest collection is that of the CIAT in Palmira, Colombia.

Cultivation practices

The majority of the cultivation practices mentioned for the tepary bean in the high humid zones of Central America also apply to the cache bean. Although it is sown mixed with tepary beans, it frequently ripens a little earlier; separate harvesting (especially to eat it when green) is possible but is not always practiced. In the Andes it is frequent to see it in enclosures or in family vegetable gardens where it grows without any special care.

Prospects for improvement

A limiting factor appears to be the lesser digestibility of *P. lunatus* which has been verified in certain areas (Amazon region). The documentation of current consumption practices in peasant communities must be considered a priority before embarking on an investigation of its nutritional quality. It should be borne in mind that until the very recent past these beans were eaten several times a week. The lack of variation in seed colour is a problem which could be corrected partly with the distribution of germplasm from collections and through additional gatherings, particularly where there is introgression with *P. coccineus* and *P. vulgaris.* Variation in colour, type of seed and growth habits could be obtained through cross-breeding programmes that explore the primary and secondary genetic stock of *P. polyanthus.* Evaluation is still very much in its initial stage and is a priority for agrarian research. It would be very useful, since it is known that this species offers characteristics of resistance to several pests and diseases such as *Ascochyta* sp. (in the cool, humid parts of the Andes) and *Ophiomyia phaseoli* (in East Africa), respectively. There are genotypes ready for delivery to the farmer, particularly in conditions that are adverse to the kidney bean. The consumption of *P. lunatus* as a green seed could be recommended and recipes developed to improve preservation of the green seed. Its cultivation could also be encouraged in family vegetable gardens. Since the plant is attractive to livestock, it could be considered as a fodder crop in association with maize. In agrosilvicultural contexts (for instance in young plantations or hedges against erosion), it is possibly the best bean species to use. Its role in coffee plantations could also be considered from the point of view of fertilizing value and soil protection.

Conclusion

The bean was domesticated at a time when the current knowledge of molecular genetics and nutritional science was obviously not available to ensure selection of the material with the best evolutionary and nutritional potential. In addition to the kidney bean, four other species have been domesticated and have been maintained for thousands of years. It is not known whether the initial success of the kidney bean was due to its greater evolutionary potential compared with the other species or whether particular circumstances caused its domestication. Nor are all the reasons known for its promotion throughout the 200 years after 1492. Consequently, the germplasm collected of those species during the last 60 years, and the information relating to them, are possibly scarce in relation to what must have existed before the conquest. However, what has been able to be recovered is surprising and offers promise. In spite of all the changes that have occurred with the kidney bean since the fifteenth century, it has been difficult to modify its ecology drastically and the alterations that the latter may have suffered have had negative effects on species yield. Ought we not now give the neglected beans an opportunity?

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Phragmites australis (Cav.) Trin. ex Steud.

Syn.: *Phragmites communes* Trin.
Phragmites vulgaris B.S.P.
Poaceae
Common reed

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Common reed provides high quality warm-season forage and is readily eaten by cattle and horses. However, it becomes tough and unpalatable after maturity. Animals grazing this grass during winter should be fed a protein concentrate. Extensively used in Mediterranean region and elsewhere for building dwellings, lattices, fences, arrows by Indians, and for weaving mats and carrying nets. Young shoots sometimes used as a vegetable. The stalks exude a manna-like gum which is eaten. The rhizomes and roots also serve as emergency food. In Russia they are harvested and processed into starch. A variegated form is grown as an ornamental. The reed is useful in the manufacture of pulps for rayon and paper. It contains over 50 percent cellulose and has a fibre

0.8–3.0 mm long and 5.0–30.5 μm in diameter. Pens for writing on parchment were cut and fashioned from this reed, and the stems were used as a linear measuring device. It is also useful in the production of homogeneous boards. It can be processed into a fine fibrous material suitable as a filler in upholstery. Flowering stalks yield a fiber suitable for rope making. It is also used for thatching and for making partitions, fences, coarse mats, baskets, sandals, etc. Thin stems are made into pens; panicles are used for making brooms and for decoration.

Folk Medicine

According to Hartwell (1967–1971), the plant is used in folk remedies for condylomata, indurated breast, mammary carcinomata, and leukemia. Reported to be alexeteric, diaphoretic, diuretic, emetic, refrigerant, sialogogue, stomachic, and sudorific, the common reed is a folk remedy for abscesses, arthritis, bronchitis, cancer, cholera, cough, diabetes, dropsy, dysuria, fever, flux, gout, hematuria, hemorrhage, hiccup, jaundice, leukemia, lung, nausea, rheumatism, sores, stomach, thirst, and typhoid.

Chemistry

Per 100 g, the reed is reported to contain (ZMB): 415 calories, 10.6 g protein, 2.1 g fat, 72.7 g total carbohydrate, 31.9 g fiber, 14.6 g ash, 480 mg Ca, 60 mg P, and 130 mg Mg. Leaves are reported to contain 17.1 g protein, 3.5 g fat, 63.7 g total carbohydrate, 27.4 g fiber, and 15.7 g ash. Stems are reported to contain 4.8 g protein, 0.8 g fat, 90.0 g total carbohydrate, 41.2 g fiber, and 4.4 g ash. According to Hagers Handbook (List and Horhammer, 1969–1979), the fresh herb contains 5.15 mg Vit. A/100 g, and 91.1 mg Vit. C as well as Vit. B_1, and B_2, the triterpene β-amyrin, taraxerol, and taraxeron ($C_{30}H_{48}O$). The rhizomes contain: moisture, 5.3; nitrogenous substances, 5.2; fat, 0.9; NFE, 50.8; CF, 32.0; sucrose, 5.2; reducing sugars, 1.1; and ash (rich in silica), 5.8%. Asparagine (0.1%) is also present. *P. communes* is rich in pentosans and may be used for the production of furfural; nodes and sheaths yield 6.6% and the underground parts over 13% of furfural. The pentosan content increases throughout the growing period and is maximum in the mature reed. The reed can be used also for the preparation of absolute alcohol, feed yeast and lactic acid. Analysis of the young grass gave: protein, 11.4; EE, 2.3; carbohydrates, 43.1; CF, 31.05; mineral matter (with high silica content), 10.8; calcium (CaO), 0.94; and phosphorus (P_2O_5) 0.39%. The reed is reported to contain a wax and a saponin. Leaves have a high ascorbic acid content (200 mg/100g).

Description

Perennial grass; culms erect, 2–4 m tall, occasionally up to 6 m, with stout creeping rhizomes, often also with stolons; leaf-blades broad, flat, 1.5–6 dm long, 1–6 cm broad, glabrous, green or glaucous, the sheaths overlapping; panicle tawny or purplish, 15–40 cm long, the branches ascending, rather densely flowered; spikelets 10–17 mm long, the florets exceeded by the hairs of the rachilla; first glume 2.5–5 mm long; second glume 5.7 mm long; lemmas glabrous, sharp-pointed, not bifid, with long hairs confined to rachilla joints; lowest floret staminate. Fl.

July–October.

Germplasm

There is considerable variability in glaucousness of leaves, shape and denseness of panicle and growth habit. The variegated form, or Spire-reed, is sold as an ornamental grass. Reported from the Eurosiberian Center of Diversity, reed or cvs thereof is reported to tolerate fire, frost, high pH, salt, weeds, and waterlogging.($2n$ = 48, 36, 54)

Distribution

Native to Eurasia, Africa, but now widespread throughout the world; throughout United States, Mexico, West Indies to Chile and Argentina, Australia.

Ecology

Grows in marshes and swamps, along streams, lakes, ponds, ditches, and wet wastelands, often weedy and very difficult to eradicate, as the stoloniferous rhizomes may reach 10 m or more in length. Grows best in firm mineral clays, and tolerates moderate salinity, where water level fluctuates from 15 cm below soil surface to 15 cm above. Tolerates burning if water is above soil surface, but burning is not essential for management. In Gulf Coast marsh rangelands, it is often co-dominate with Big cordgrass (*Spartina cynosuroides*). Ranging from Cool Temperate Steppe to Wet through Tropical Desert to Moist Forest Life Zones, reed is reported to tolerate annual precipitation of 3.1 to 24.1 dm (mean of 16 cases = 9.8) annual temperature of 6.6 to 26.6°C (mean of 16 cases = 14.8) and pH of 4.8 to 8.2 (mean of 12 cases = 6.2). (Duke, 1978, 1979)

Cultivation

Rarely if ever really cultivated. However, stands may be started by transplanting young plants or rooted stolons. Starts growth in February in southern locations, later further north. Foliage stays green until frost. New shoots grow from buds at nodes of old stems, stolons or rhizomes.

Harvesting

Giant reed cannot withstand prolonged heavy grazing. Its upright growth makes it easy for livestock to remove all the leaves. For maximum production, no more than 50% of current year's growth by weight should be grazed off during the growing season. Water control that lowers the water level but does not drain the area increases production. Grazing deferments of 60–90 days improve plant vigor. The straight hollow stems are cut in autumn and dried for arrowshafts, pipestems, loom rods, screens, roofing for houses and adobe huts, etc. Leaves are also gathered and used for weaving mats and other objects.

Yields and Economics

Though the plants grow profusely wherever they occur, few yield data are available. A very useful grass wherever it grows, especially in the Mediterranean region, North Africa, and western North America. Although used extensively locally, its products do not enter commercial markets.

Energy

Reed swamps in Europe produce 7.5–13.0 MT/ha/yr. According to the Phytomass files (Duke, 1981b), annual productivity ranges from 40 to 63 MT/ha. Reeds are currently being harvested from Swedish lakes at a cost of ca $50/MT (ca $2.86/GJ gross thermal value), which rises to $60/MT after transportation and final processing ($3.43/GJ gross thermal value). These costs are expected to diminish as machines and methods are optimised (Palz and Chartier, 1980).

Biotic Factors

Because of its extensive use, a great number of fungi have been reported on giant reed; however, none of them have seemed to have caused any great damage to the grass. Reported are the following fungi: *Belonioscypha vexata, Belonopsis excelsior, Bispora hamonis, Chaetomella atra, Cladosporium herbarum, Clasterosporium lindavianum, Claviceps purpurea, C. microcephala, Coniosporium arundinis, C. sorghi, Cyphella capula, Dinemasporium strigosum, Diplodina arundinacea, D. donacina, Epicoccum neglectum, Fomes fomentarius, Fusarium graminearum, Graphyllium dakotense, G. graminis, G. manitobiense, Hadrotrichum phragmitis, Helminthosporium fusiforme, Helotium robustius, Hendersonia arundinacea, H. fuckelii, H. graminicola, H. phragmitis, Hymenella arundinis, Lachnum acutipilum, Leptosphaeria arundinaceae, L. culmifraga, L. donacina, L. littoralis, L. phragmiticola, Leptostroma phragmitis, Lophiostoma arundinis, Lophiodermium arundinaceum, Melaconium echinosporum, M. sphaerospermum, Melanopsamma pomiformis, Meliola arundinis, Microdiplodia machlaiana, Mollisia arundinacea, M. riparia, Napicladium arundinaceum, Nervossia iowensis, Papularia sphaerosperma, Phyllosticta phragmitis, Piricularia grisea, Pirostoma circinans, Placosphaeria dothideoides, P. rimosa, Pleospora adscondita, Pseudographis phragmitis, Puccinia argentea, P. isiacea, P. invenusta, P. magnusiana, P. phragmitis (rubella), P. trabutii, Pythium debaryanum, P. ultimum, Rhabdospora arundinis, Rhopographus clavisporus, Scirrhia ramosa, Scolecotrichum graminis, S. maculicola, Selenophoma donacis, Sphaerella phragmitis, Stagonospora arenaria, S. dolosa, S. neglecta, S. graminella, S. simplicior, S. vexata, Tapesia hydrophila, Teichospora phragmitis, Torula herbarum, Trichobelonium kneiffii, Uromyces blandus, Ustilago grandis, U. hypodytes, Volutella therryana.* The nematode *Subanguina radicicola* has been isolated from this grass.

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Phyllanthus Species: Sources of New Antiviral Compounds

David W. Unander, P.S. Venkateswaran, Irving Millman, Herbert H. Bryan, and Baruch S. Blumberg

INTRODUCTION

Phyllanthus has more than 700 species in at least 10 sub-genera (Holm-Nielsen 1979, Webster 1956-58). A survey of 300 ethnobotanical references of *Phyllanthus* spp. arranged taxonomically suggested some uses were clustered by subgenus. A summary of the number of species per sub-genus used traditionally in various places to treat possible symptoms of liver disease (such as jaundice) is presented in Table 1. Among the herbs of subgenus *Phyllanthus* used medicinally, we found that aqueous extracts of *P. amarus* Schum. & Thom., *P. debilis* Klein, *P. fraternus* Webster, *P. niruri* and *P. urinaria* L. all inhibited viral DNA polymerase (DNAp) of hepadnaviruses in vitro. (Hepadnaviruses include human hepatitis B virus and several animal hepatitis viruses.) Additionally, extracts of less common species in the same sub-genus, such as *P. mimicus* Webster or *P. odontadenius* Muell. Arg., also had such anti-DNAp activity. Extracts of species from sub-genera not reported as being used for symptoms of liver disease generally had much weaker inhibitory activity (data unpublished).

The ultimate goal of our research is to develop a therapy for carriers of hepatitis B virus (HBV) which would reduce the incidence of liver cancer. Since its identification (Blumberg et al. 1967, Blumberg 1977), the virus has been found to be associated with cirrhosis, chronic liver disease and primary liver cancer as well as acute serum hepatitis. More than 200 million people worldwide are estimated to be carriers, many of them asymptomatically (Ghendon 1987). A series of studies have shown that persistent HBV infection is associated with a greatly elevated risk of developing liver cancer (Beasley et al. 1981, Dodd and North 1987). Although a safe and effective vaccine exists, and is being vigorously promoted, there is no effective therapy for carriers.

Aqueous extracts of *P. amarus* collected near Madras, India, (initially published under the name *P. niruri* L.) inhibited viral DNAp in vitro. In addition, they eliminated detectable virus from the sera of woodchucks (*Marmota monax*) acutely or chronically infected with the woodchuck hepatitis virus (WHV) (Venkateswaran et al. 1987). Endogenous DNAp is packaged with viral DNA in hepadnaviruses like HBV or the closely related WHV. In a small clinical trial in India, administration of powdered *P. amarus* eliminated detectable antigen from the sera of 59% of the treated human carriers as compared to 4% of controls (carriers receiving a placebo) who cleared the virus naturally (Thyagarajan et al. 1988). Studies are in progress to characterize the compound(s) responsible for these effects.

SOURCES OF ANTI-DNAP VARIABILITY

In Experiment 1, plants of *P. urinaria* and *P. debilis* were grown in the greenhouse in a 2 x 2 factorial design comparing soils of differing fertility (fertilized regularly with a 0.04N-0.06P-0.07K solution vs. not fertilized) and different moisture and structure conditions (a commercial peat mix regularly watered vs. sand infrequently watered). Six month old plants were harvested, lyophilized and ground. Aqueous extracts were made using 5 g ground plant in 20 ml water at 60°C for two hours, mesh-filtered, centrifuged, and the supernatant passed through a 0.45 µm micropore filter (Nalgene 125, Nalge Co., Rochester, NY). Dried whole and ground plants and extracts were stored at -15°C. Extracts were made of two random samples of ground plant per treatment combination. Activity was expressed as µg of dry matter per ml of extract producing 50% inhibition of WHV DNAp, after Venkateswaran et al. (1987), and analyzed after testing for homogeneity of variance.

Various morphological variables (e.g., plant height weight, amount of branching), were significantly affected by differing soil conditions (data not shown). The only effects on inhibition of viral DNAp, however, were for gross soil fertility on *P. urinaria* (84 and 38 µg/ml for fertilized and unfertilized, respectively) and, in the pooled analysis, species (139 and 61 µg/ml for *P. debilis* and *P. urinaria*, respectively). Regression analyses showed significant effects on *P. urinaria* of available N or P or percent saturation of K. Genetic differences in viral DNAp inhibition were greater than any effects from soil conditions.

In Experiment 2, plants of *P. amarus* were grown in the greenhouse in a 2 x 3 factorial design comparing soil moisture and structure conditions as in experiment 1, and three levels of soil pH and in a 2 x 2 factorial comparing soil moisture and structure conditions and high vs, low Ca levels. *P. amarus* was commonly found in calcareous sites in Puerto Rico but much less commonly in other soils, so a preference for high pH, high Ca or both was hypothesized, and the effect of these variables on activity of plant extracts against WHV DNAp was tested. Media of average pH 5.5, 7.5 and 10.5 were made using aluminum sulphate, calcium sulphate and hydrated lime, respectively. The treatments in sand had mean pH values about one log unit greater than those in the peat mix (i.e., 11.5 vs. 10.5). To test the effect of Ca apart from pH, pulverized limestone was added or not added to the sand or peat mix. In this test, the pots with and without Ca had pH means of 8.0 and 7.0, respectively. Water samples taken from the bottom of pots during watering were used to follow pH. A more acidic treatment was also attempted, but *P. amarus* did not survive more than two weeks at about pH 4.5. In this experiment individual plants served as replicates with three replicates in the first test and two in the second. Extracts, assays and analyses were done as described.

Soil conditions significantly affected plant growth. Optimum growth seemed to be in soil slightly above neutral and with high Ca, as expected. For the effects of plant extracts on viral DNAp, soil pH as a main effect was non-significant. Using data from both tests, the linear regression of DNAp inhibition on soil pH showed an effect at P = 0.09. The R^2 value (0.11), however, suggested relatively little variability in the inhibition of viral DNAp was explained by pH. Soil moisture or structure significantly affected DNAp inhibition of plant extracts in the pH test (158 and 263 µg/ml for the sand and peat respectively). The interaction of moisture and pH had an effect at P = 0.10. Means over pH treatments ranged from 174-246 µg/ml with greatest activity at higher pH, over all six treatment combinations, means ranged from 85-332 µg/ml (greatest and least activity at high pH, sand and low pH, peat, respectively). Plants from high pH in sand were significantly stunted relative to other treatments, with average dry weight per plant of 1.7 g vs. an average for the other five treatments of 6.6 g. Plants at high soil pH in peat had mean inhibition values (262 µg/ml) similar to those at lower pH, illustrating the interaction observed between pH level and peat vs. sand. No regressions of DNAp inhibition on specific soil macronutrient data were significant. In the test examining high Ca vs. no Ca and sand vs. peat, neither main effect was significant

In Experiment 3, genetic differences among accessions were tested. Plants of *P. urinaria* from seed collected in India, the Ivory Coast Hawaii, Puerto Rico, Trinidad, Venezuela or Vietnam were grown randomized on one greenhouse bench using the same growing regime. Based on an analysis of extracts derived from two plants/seed source, there were highly significant differences among seed sources in inhibition, with means ranging from 70 to 532 µg/ml. This suggests that genetic variability for inhibition of DNAp exists in *P. urinaria*. Plants of *P. amarus* from seed collected from two sites in India and three sites in Puerto Rico were grown in a similar experiment with three plants/seed source but seed source was non-significant at P = 0.25, with means for viral DNAp inhibition ranging from 192 to 409 µg/ml. A third test using the same procedure examined different accessions of *P. amarus* from sites in Florida, India and Puerto Rico. No significant differences were found; means ranged from 122 to 163 µg/ml. These latter two tests were respectively grown in the winter and the summer.

CULTIVATION

Although common in the tropics, the *Phyllanthus* species of interest are generally small and often scattered in distribution. The only reference found which discussed cultivation (Kangsu Medical Institute) recommended fertile, well-drained soil for growing *P. urinaria*. To produce sufficient quantities for large scale extraction, a system was developed at the University of Florida Tropical Research and Education Center at Homestead, using black plastic mulch and trickle irrigation Since plants with the strongest inhibition of viral DNAp in our studies had consistently come from the warmest environments, a tropical site was desired. Southern Florida was chosen as being both tropical and efficient for shipment of harvested plant The soil at Homestead, which is a crushed oolitic limestone, was also considered well-suited to *P. amarus*. Wild plants of *P. amarus* were abundant in fallow fields around Homestead following periods of rain.

The first plot served as an experiment to establish *P. amarus* as a row crop and to test two fertility levels. Plots were fertilized with 560 or 1120 kg/ha 6N-5.2P-10K before mulching in a randomized block design with three replicates. Seed of *P. amarus* were sown using 1.5% cellulose gel (N-Gel, Hercules Co.) at 0.15 g seeds/liter (100 seedweight = 0.015 g). Approximately 50 cc of gell/hill were applied. Hills were holes set 30 cm apart in the mulch. Hills were in four rows spaced 30 cm apart on raised beds 1.7 m wide for a planting density of approximately 7,500 hills/ha.

Six months after planting, whole plants weighed an average of 7.5 g (lyophilized dry weight). Aqueous extracts were made as described. Extracts were made of shoots and roots by fertility treatment and replicate. The average DNAp inhibitory activity over all samples was 142 µg/ml. The two levels of fertility did not significantly affect viral DNAp inhibition. Roots were significantly more active than shoots (66 and 151 µg/ml respectively), but roots only accounted for about 10% of the total dry weight. This range of activity was consistent with earlier results obtained with plants collected in the wild (Venkateswaran et al. 1987). Cultivation, irrigation and fertilization thus did not reduce DNAp inhibitory activity over the far more laborious collection from the wild. Stand establishment measured as hills with any plants six months after planting, was only about 70% in this first plot. Variables affecting seed germination and longevity have not yet been well-characterized. Total potential production was estimated to be at least 40 kg/ha (dry weight) but should be substantially greater once stand establishment can be improved. At the rates used by Thyagarajan et al. (1988), 1.8 kg of dried whole plant would have provided a course of treatment for 100 persons.

CONCLUSIONS

P. amarus and closely related species appear to contain activity against the endogenous DNAp of hepadnaviruses. This may be the basis for traditional uses of these species against disease symptoms such as jaundice, which, retrospectively could, in at least some cases, have been caused by hepatitis B virus. This DNAp inhibitory activity was relatively unaffected by soil conditions, but differed among accessions, suggesting that genetic variability does exist for this trait. Plants proved easy to grow and biological activity of the cultivated material was equivalent to material collected from the wild.

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Table 1. Phyllanthus subgenera, number of representative species, regions where found, number of species used as liver disease remedies and references.[z]

		Location							
Subgenus	Approx. no. of spp.	North America	South America	West Indies	Africa	Asia	Australia	Oceania	No. spp. used as liver disease remedies
Isocladus	70	x	x	x	x	x	x	x	3[y]
Kirganella	50	x	x	x	x	x	x	x	1[x]
Phyllanthus	140	x	x	x	x	x	x	x	9[w]
Gomphidium	155		x				x	x	0
Conami	20	x	x	x	x				0

Eriococcus	30				x		0
Phyllanthodendron	10				x		0
Botryanthus	15	x	x				0
Xylophylla	60	x	x				0

[z]Summarized from a series of papers in preparation by D.W. Unander and G.L. Webster examining 300 ethnobotanical references from a taxonomic perspective and incorporating recent taxonomic changes by G.L. Webster.

[y]Kangsu Medical Institute 1975, Kirtikar and Basu 1975, Stehlé 1986.

[x]Al-Kindi ca. 850, Antarkar et al. 1980, His Majesty's Government of Nepal 1982, Kirtikar and Basu 1975, Oliver 1950, Said 1969.

wAmadeo 1988, Bunyapraphatsara 1987, Cruz 1965, Freise 1934, Gooding et al. 1965, His Majesty's Government of Nepal 1984, Kangu Medical Institute 1975, Kirtikar and Basu 1975, MacRae et al. 1988, Morton 1981, National Institute of Health 1977, Oliver 1960, Petelot 1954, Purl 1970, Singh 1986, Stehlé and Stehlé 1962, Watt 1892.

Last update March 31, 1997 aw

Phytolacca americana L.

Phytolaccaceae

Pokeberry

We have information from several sources:

The Herb Hunters Guide—.Sievers, A.F. 1930.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Wednesday, July 08, 1998 by aw

Rocha S.F.R. and Lin Chau Ming. 1999. *Piper hispidinervum*: A Sustainable source of safrole. p. 479–481. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Piper hispidinervum: A Sustainable Source of Safrole

Sérgio F.R. Rocha and Lin Chau Ming

Piper hispidinervum (C. DC.), Piperaceae, is a promising source of sassafras oil, the source of safrol, currently derived from endangered plants of the Lauraceae such as *Ocotea pretios* Ness (Mez.), *Cinamomum petrophilum*, *C. mollissimum*, and *Sassafras albidum* Nutt. The essential oil of *P. hispidinervum* contains high levels (83–93%) of safrole in leaves which can be easily extracted by hydrodistillation.

SAFROLE

Safrol a phenolic ether (Tyler et al. 1982), is a colorless or slightly yellow liquid, $C_{10}H_{10}O_2$, molecular wt 162.18, with density of 1.096 at 20°C, and melting point about 11°C. The oil is insoluble in water, very soluble in alcohol, miscible with ether and chloroform. The DL_{50} (oral) is 1.950 mg/kg in rats and 2.350 mg/kg in mice (Budavaris 1989).

Sassafras oil is important to several products. It was used as an ingredient in popular beverages, such as "pinga com sassafras" in Brazil, and was once used as an ingredient for "root beer" in the United States. It has been used as a topical antiseptic and pediculicide, but it may be carcinogenic.

Safrole is an important raw material for the chemical industry because of two derivatives: heliotropin, which is widely used as a fragrance and flavoring agent, and piperonyl butoxide (PBO), a vital ingredient of pyrethroid insecticides. Natural pyrethrum in particular would not be an economical insecticide without the addiction of PBO as a synergist and the future of the natural pyrethrum industry is linked to the continued availability of PBO. Safrole has many fragrance applications in household products such as floor waxes, polishes, soaps, detergents, and cleaning agents.

Markets and Demand

Japan, Italy, and the United States are the most important markets for sassafras oil, and the total annual demand is estimated to be around 2,000 tonnes. Brazil has manufacturing capacity for both heliotropin and PBO (equivalent to about 500 t of sassafras oil), although a shortage of domestically produced oil has led to importations of oil from China. The worldwide sassafras oil price is US$4 to 6/kg.

The demand for sassafras oil is determined by the market for heliotropin and PBO. Heliotropin consumption is increasing, particularly in Eastern Europe, Asia, and some developing countries, and sassafras oil is the favorite raw material for its manufacture. If price rises markedly, synthetic heliotropin would become more attractive.

Sources

In Brasil, sassafras oil has been extracted commercially from *Ocotea pretiosa*, a perennial tree native to coastal tropical rainforests from Bahia to Santa Catarina, in Mata Atlantica. This species is also found in Colombia and Paraguay (Rizzini and Mors 1995). This was based on a discovery in l939 that wood distillation from a large tree in the state of Santa Catarina yielded a rich source of sassafras oil, containing 84% safrole. These trees were indiscriminately harvested, placing this species on the endangered list. Until the 1960s, Brazil was the major exporter of sassafras oil in the world, but production has declined with the depletion of this natural resource. Governmental restrictions in the late 1980s have resulted in a further decline in production and in the falling level of Brazilian exports. No significant replanting has ever occurred.

Vietnam has been exported sassafras oil since 1990 from wild trees of *Cinnamomum camphora*, but supplies from this source may be relatively short-lived. Current exports are estimated to be several hundred tonnes/year.

PIPER HISPIDINERVUM AS A SAFROLE SOURCE

In the early 1990s, certain forest shrubs of the Piperaceae, indigenous to the humid forests of Central America and Greater Amazonia, were found to contain high levels of safrole in their leaves. The Brazilian Amazon contains a wide variety of *Piper* species but attention had focused on *P. hispidinervum* and *P. callosum*, two species with high safrole content. Subsequently, *P. callosum* has been dropped in the research work in favor of the more promising *P. hispidinervum*.

This effort was carried out by Museu Paraense Emilio Goeldi in Belém in collaboration with the Center for Agroforestry Research (CPAF-EMBRAPA) in Acre.

Piper hispidinervum known as "pimenta-longa" in Brazil, has been described by Yunker (1972). It is a nodose, branching shrub with rather slender upper internodes, somewhat angular, mostly 1–3 cm long, glabrous or very sparsely pubescent, somewhat glandular dotted. Leaves are oblong-lanceolate or elliptic-oblong, with attenuately acuminate apex and inequilateral base. This species resembles *Piper aduncum* L. to some extent but differs in its scarcely scabrous leaves, glabrous stem, and short peduncle (Yunker 1972). Coppen (1995) suggests that this species is distributed throughout South America, and is especially prominent in the state of Acre in Brazil and may extend into Amazonas.

The species is most frequently found on degraded forest, bordering primary forest or farm land where it occurs as a colonizing "weed," either as a pure stand or along with other *Piper* species. On natural sites, plants develop initially into bushes and at an early stage they appear to inhibit growth of competing vegetation. As the plants age they become more tree-like, up to 10 m tall.

Pilot-scale distillations have been conduced to determine oil quality and yields and permit estimation annual productivity on a per hectare basis. The safrole content of the oil in unselected stock is about 85%, but a improvement to more than 90% is possible through selection. Leaves of *P. hispidinervum* in experimental plots of CPAF-EMBRAPA (Acre) contained 3% essential oils of which 93% is safrole.

Management and Culture

Mixed planting of *P. hispidinervum* with cash tree crops is a practical possibility and would be economically attractive as leaf harvesting would permit an early cash return. Another production possibility is sustainable management in natural vegetation since it occurs in high populations in several open areas bordering primary rainforest. Reforestation projects, in natural or deforested gaps, could take advantage of the vegetative and productive potential of *P. hispidinervum* since it is a pioneer species.

Piper hispidinervum offers excellent conditions for cultivation in areas with facilities for harvest, transport, and industrialization (Chaves 1994). Trials have been established at several sites in Brazil using both rooted cuttings and seedlings designed to provide information in both growth characteristics and biomasss yields (leaf + stem) under various planting and management regimes. Studies undertaken in laboratories of the Department of Horticulture, FCA–UNESP, Botucatu, demonstrated that this plant is positively photoblastic with 50% germination under sunlight but none in the dark.

Crop density studies in Acre state by Sousa et al. (1997) indicate that the highest biomass production was achieved at spacing of 70 × 70 cm. Essential oil yield was 0.3% in branches and 4.0% in leaves; safrole content was not evaluated.

Disease Susceptibility

In the early 1960s, Japanese immigrants to Brazil colonized the state of Pará, and initiated the culture of black-pepper (*Piper nigrum* L.) but it was an agronomic and economical disaster, due to fusarium disease caused by *Fusarium solani* f. sp. *piperis*. Poltronieri et al. (1997) evaluated the resistance of seedlings of *P. hispidinervum* to different isolates of this pathogen, and demonstrated resistance, indicating the possibility of commercial cropping in areas where black pepper had been decimated by the fusarium disease.

Cercospora is a potential pathogen of *P. hispidinervum*. In Xapuri (Acre state), plants infected by *Cercospora* had a reduction of 21% in essential oil produced, but the safrole content was unaffected (Siviero and Pimentel 1997).

FUTURE PROSPECTS

Forest preservation in developing countries is a controversial issue that involves many different interests. The worldwide demand for raw materials, such as safrole, offers an opportunity to these countries that have a source of products in their natural forests.

Forest preservation is best linked to local populations maintenance. In this context, *P. hispidinervum* is more than a new safrole source. The economical exploration of its productive potential could be an important step to assist in the maintenance of the Amazon rainforest, providing a new livelihood option. This might include culture as a crop but also sustainable management in natural vegetation, since this species occurs in high populations in several open areas such as in natural gaps in the forest and in areas bordering the primary rainforest. An integrated project based on this species among research institutes, universities, governmental, and non-governmental institutions could produce a sustainable alternative crop for the tropical rainforest.

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Pine nut

Pinon, Pignolia

Pinaceae *Pinus edulis* Engelm.

***P. quadrifolia* Parl. ex Sudw.**

Source: Magness et al. 1971

The seeds of these species of *Pinus* are gathered from native trees for food by the Indians in southwestern U.S., and occasionally appear in markets. The trees are up to 40 feet, spreading, with stout branches, and with short needles not over 1.5 inches long. Cones are near globose or broad ovate, compact until mature. Seeds are about 0.5 inch long, elongated and angular. They are eaten directly, also used in confections under the name pignolia. The trees are not in cultivation.

Pinkroot

Spigelia marilandica L.

Figure 83.—Pinkroot (*Spigelia marilandica*)

Other common names.—Carolina pinkroot, Carolina pink, Maryland pink, Indian pink, starbloom, worm grass, wormweed, American wormroot.

Habitat and range.—This plant is found in rich woods from New Jersey to Florida and west to Texas and Wisconsin, but occurs principally in the Southern States. It is fast disappearing, however, from its native haunts.

Description.—Pinkroot is an herb with a simple erect stem from 6 inches to 1 1/2 feet high. The pointed leaves are stemless, from 2 to 4 inches long, and one-half to 2 inches wide. The rather showy flowers are produced from May to July in a 1-sided terminal spike. They are tube-shaped, narrowed below, and slightly contracted toward the top, where they terminate in five lanceshaped lobes. The outside and inside of the tube are bright scarlet and the lobes yellow.

The roots of other plants, especially that of the East Tennessee pinkroot (*Ruellia caroliniensis* (Walt,) Steud., syn. *R. ciliosa* Pursh), are often found mixed with the true pinkroot. The rootstock of this plant is larger and not as dark as that of *Spigelia marilandica,* and it has fewer and coarser roots

Part used.—The rootstock, collected after the flowering period.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Pinus elliottii Engelm.

Abietaceae
Slash pine

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

A major source of pulp and tall oils in the deep south of the United States. The wood is very hard, heavy, strong, coarse grained, and durable. It is used for construction and railroad ties. Terpin hydrate is the main synthetic product of turpentine used in pharmaceutical preparations, used as an expectorant in humans and for veterinary bronchitis (Morton, 1977). Other synthetics produced from pine are anethole, camphor, and dl-menthol. Tall oil rosin contains sterols, mainly sitosterol. Russians built a factory in 1968 to produce steroids from pine pulp extractives. They are also pioneering in the commercial production of vitamin A and E. Synthetic materials derived from turpentine are used in perfumery and to impart flavors suggestive of cinnamon, citrus, lemongrass, licorice, nutmeg, peppermint, and spearmint. Menthol from turpentine is added to cigarettes and cosmetic and toilet products (Morton, 1977).

Folk Medicine

Turpentine has long been used internally for catarrh, chronic bowel inflammation, colds, gonorrhea, leucorrhea, rheumatism, And various urinary complaints, rheumatism, and ulcers. Pine tar has been used for many ailments in the past, but lately it is prescribed only for external use in chronic and parasitic skin diseases. It shows up in several of the drugs I have resorted to in the futile efforts to cure my psoriasis. (I have had better luck in substituting rice flour for wheat flour with its glutin.)

Chemistry

Leaves yield ca 0.3% of a balsam scented oil compared to about 0.4% for longleaf pine. This leaf oil consists mostly of borneol, cadinene, camphene, and β-pinene. The natural oleoresin exudate from the resin ducts contains ca 66% resin acids, 25% turpentine, 7% nonvolatiles, and 2% water. Turpentine from slash pine contains 1-α-pinene, while that from longleaf contains some d-pinene. Pinene is the main constituent of turpentine. Dipentene and other monocyclic terpenes constitute 5–8% of gum and refined sulfate turpentine, 15–20% of wood and crude sulfate turpentine. Camphene constitutes 4–8% of wood turpentine, and 0% of gum turpentine. Rosin consists mostly of diterpene resin acids of the abietic (abietic, neoabietic, palustric, and dehydroabietic) and pimaric types (pimaric, isopimaric, and sandaracopimaric). Pine tar contains turpentine, resin, guaiacol, creosol, methylcreosol, phenol, phlorol, toluene, xylene, etc. Crude tall oil contains 40–60% resin acids, 40–55% fatty acids (mostly n-C_{18}, 75% monoenoic, and 25% dienoic, with traces of trienoic and saturates), and 5–10% neutral properties (17).

Toxicity

Raised in the southern US like me, Sam Page, of the FDA, tells me that as a child he was given oral doses (a couple of drops on the tongue) of turpentine as a mosquito repellant, an effective but dangerous application. My mom applied it to cuts and sores as a disinfectant, perhaps less dangerous. (Duke, 1984b)

Description

A fast-growing tree, 15–30 m tall, the trunk attaining a diameter of .6 to 1 m with short, thick branches. Outer bark dark gray, furrowed, breaking into oblong plates; inner bark red-brown. Needles, in 2s or 3s, 18 to 30 cm long. Cones (in spring) are rose-purple and 6 mm thick, the male 3.8 to 5 cm long, densely clustered; the female ca 1.25 cm long. Cones red-brown, maturing and dropping in the second fall, are 7.5 to 14 cm long, narrow-ovate, broadly ovate when open, each scale tipped with a short, straight or recurved spine. Seeds ovoid, 6 mm or more long, smooth, gray, with a glossy, brown, membranous wing 1.5 to 3.5 cm long (17).

Germplasm

Reported from the North American Center of Diversity, slash pine, or cvs thereof, is reported to tolerate hardpan, sand, slope, small fires, and waterlogging. Fast growing strains, resistant to pests and diseases, high in oleoresins, are being developed. When two seed orchards for improved strains were established in 1969, it was estimated that they would not impact the extractive industry for 40 or 50 years (Morton, 1977) ($2n = 24$)

Distribution

Native to southeast US (South Carolina to Florida, Alabama, Mississippi, and Louisiana). Cultivated and naturalized in east Texas. Widely planted in subtropical plantations, e.g. Brazil, India.

Ecology

Ranging from Warm Temperate through Subtropical Moist Forest Life Zones, slash pine is reported to tolerate annual precipitation of 11.2 to 16.0 dm (mean of 2 cases = 13.6), annual temperature of 18.8 to 23.3°C (mean of 2 cases = 21.0), and pH of 5 to 7.7 (mean of 2 cases = 6.4).

Cultivation

Seeds sprout about 2 weeks after planting. Discing the ground following natural or artificial seeding provides for a better, seed-soil contact. Tree can be propagated by grafting and air-layering (Morton, 1977). Not as fire resistant as the longleaf pine, slash pine farmers avoid burning until trees are 3.5–4.5 m tall.

Harvesting

Since 1910, pine oleoresins have been derived from heartwood chips (a lumbering by-product) and from stumps and roots. A ton of wood would yield about 5 gallons of turpentine spirits. Around 1930 more turpentine, rosin, etc. was derived from the wastes of the Kraft sulphate paper processing, a ton of sulphate pulp yielding ca 40 kg "tall oil". Trees begin to bear seed when about 10 years, not attaining full fertility until more than 20 years old.

Yields and Economics

Morton (1977) reported ca 7.5 million hectares in longleaf and slash pines, the two major sources of the resin and turpentine products sold in the US. Around 1935, slash pine replaced the longleaf pine as the leading source of oleoresin, formally called "naval stores". A single tree ca 30 cm in diameter, can average more than 5 kg gum a year over a four year period. Until about 1930, tapping was a main source (80%) of the pine gum produced in the US, down to 5% when Morton's

Major Medicinal Plants was published. By 1970, 40% of domestic rosin and 70% of domestic turpentine were byproducts of sulphate paper production (Morton, 1977).

Energy

Reports in India (Kaul et al, 1982) indicate that total biomass ranges from 169 MT/ha in 10 year old stands to 529 MT/ha in 40 year old stands, indicating annual productivity rates of ca 17 MT/ha/yr in the 10 year olds, 13 MT/ha/yr in the 40 year old stands. Aboveground biomass constituted 81–85% of the total. In Florida, Wang et al. (1982) estimate slash pine yields at 9.4 MT/ha/yr. Pine resins have heat values of 34,018–37,798 kj/kg. Fuel value of slash pine can be upgraded by increasing the resin content, thus increasing the energy content by as much as 12.7%. Wang et al tabulate selected properties of slash pine biomass with and without being resin soaked.

Table 1. Selected properties of slash pine biomass components collected from northcentral Florida.[z]

	Biomass property			
Biomass component	Heat of combustion[z] (kj/kg)	Density[y] (g/cm^3)	Moisture content[x] (%)	Ash content[x] (%)
Stemwood	19,749	0.51	99	0.3
Stembark	20,875	0.27	74	0.7
Branch	19,691	0.41	169	Not measured
Foliage	20,478	Not measured	153	1.9

[z]Frampton, 1980
[y]On dry weight basis
[x]Based on dry weight and green volume

Table 2. Selected properties of resin-soaked slash pine wood collected from northcentral Florida.[z]

Wood sample	Heat of combustion (kj/kg)	Moisture content (%)
Bolt 1[y]	22,952	29.0
Bolt 2[x]	21,227	51.9
Bolt 3[w]	19,921	91.1

[z]Kossuth et al. (1980) 20-yr-old slash pine was treated with 2% paraquat and harvested after 24 mo.
[y]Bolt 1 = first 152 cm above the treatment site.
[x]Bolt 2 = second 152 cm above the treatment site.
[w]Bolt 3 = the remaining merchantable bole to a 7.6 cm inside diameter.

Biotic Factors

According to Morton, seedlings are prey to the weevil, *Hylobius pales* and the pine webworm, *Tetralopha robustella.* Young and old trees are subject to fusiform rust (*Cronartium fusiforme*) and pitch canker (*Fusarium lateritium* forma *pini*). Mature trees are attacked by red heart (*Fomes pini*), butt rot (*Polyporus schweinitzii*) and root rot (*Fomes annosus*). Bark beetles (*Ips* spp.) cause much damage, especially during droughts. The black turpentine beetle (*Dendroctonus rerebrans*) breeds in stumps and attacks mainly trees that have been tapped for gum. Cones are attacked by the rust *Cronartium strobilinum* and the cone moth (*Dioryctria* sp.) (Morton, 1977). Browne (1968) lists the fungi *Amylostereum* sp., *Armillaria mellea, Cronartium conigenum, Dothistroma pini, Fomes annosus, Fomes noxius, Fusarium* spp., *Lophodermium pinastri, Macrophoma pinea, Peniophora sacrata, Peridermium harknessii, Physalospora rhodina, Phytophthora bochmeriae, Phytophthora cinnamomi, Polyporus tomentosus,* and *Sclerotinia fuckeliana,* and the coleoptera, *Aesiotes notabilis, Graphognathus leucoloma, Hylastes angustatus, Hylurgus ligniperda, Lipsanus iniquus, Perperus lateralis,* and *Pityophthorus pulicarius. Pineus laevis* is listed under hemiptera. Hymenoptera listed are *Atta* sp., *Neodiprion lecontei,* and *Sirex noctilio.* Lepidoptera listed include *Arachnographa micrastrella, Aroa melanoleuca, Hyalarctia huebneri, Lachriolepis nephopyropa, Lophodes sinistraria, Nudaurelia cytherea,* and *Rhyacionia subtropica*. Listed under aves are *Alisterus scapularis, Calyptorhynchus funereus,* and *Platycercus eximius,* and under mammalia, *Leggada minutoides, Lophuromys sikapusi, Macaca irus, Mus musculus, Otomys* spp., *Phacochoerus aethiopicus, Potamochoerus porcus, Rattus rattus, Rhabdomys pumilio, Sus scrofa, Sylvicapra grimmia, Thryonomys swinderianus, Tragelaphus scriptus, Trichosurus caninus, Trichosurus vulpecula,* and *Wallabia* sp. Among the nematodes, Golden (p.c. 1984) lists: *Belonolaimus euthychilus, B. gracilis, B. longicaudatus, Caucopaures* sp., *Helicotylenchus dihystera, Hoplolaimus galeatus, Meloidodera floridensis, Meloidogyne arenaria, Tylenchorhynchus claytoni,* and *Xiphinema americanum*.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

White Pine

Pinus strobus L.

Figure 117.—White pine (*Pinus strobus*)

Other common names.—Northern pine, Weymouth pine, American white pine, American deal pine, soft deal pine, spruce pine.

Habitat and range.—The white pine native in this country occurs in woods from Canada south to Georgia and Iowa.

Description.—This large, handsome evergreen tree is sometimes 200 feet in height, with horizontal branches. The slender pale-green leaves or needles are borne five in a sheath and are from 2 to 5 inches long. The flowers are inconspicuous, and the drooping, cylindrical, cigar-shaped, resinous cones are about 5 inches long and about 1 inch in thickness until in fall when the scales spread out to permit the seeds to fall out. It requires two seasons for the cones to mature.

Part used.—The inner bark.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Pistacia vera L.

Anacardiaceae

Pistache, Pistachio

We have information from several sources:

Mediterranean Fruits—Joan Tous and Louise Ferguson

New Subtropical Tree Crops in California—Louise Ferguson and Marylu Arpaia

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Food and feed crops of the United States. Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside links:

California Pistachio Commission

Pistachio—from Mark Reiger, Dept of Horticulture, University of Georgia.

Pistachio Information from the University of California Fruit & Nut Research and Information Center

Pistachio—Descriptors for Pistachio (*Pistacia vera L.*)—Link to the publication on the International Plant Genetic Resources Institute web site

Plantago spp.

Plantaginaceae

Plantain, psyllium

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Psyllium: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Preliminary Agronomic Evaluation New Crops for North Dakota—Marisol T. Berti and A.A. Schneiter

Plum, American

Rosaceae *Prunus* sp.

Source: Magness et al. 1971

Bailey, lists 14 species of native plums, several of which have contributed named varieties. Fruit of most species is gathered from the wild for making jams, and jellies. Hybrids of some of these species with the Japanese plums *P. triflora* are in some cases larger fruited and of a quality superior to that of the wild. However, there are apparently no commercial plantings of these improved kinds, though they are in home gardens, particularly in the Plains States. Various wild plums are called "Sloe."

Two species are in limited commercial production to provide fruit for jam. These are *P. maritima* Marsh., the Beach plum of coastal areas from New Brunswick to Virginia, and *P. subcordata* Benth. of California and Oregon. All the native plums have rather small, near globose fruits, produced on small trees or bushes.

Season, bloom to harvest: 70-120 days.

Production in U.S.: No data, possibly 100 tons commercially.

Use: Mainly jelly and jam. Some eaten fresh.

Part of fruit consumed: All except pit in fresh eating. Peel mainly removed after beating in making jelly and jam.

Beach Plum Small farm sustainability through crop diversification and value-added products.

Plum, Damson and Bullace

Rosaceae *Prunus insititia* L.

Source: Magness et al. 1971

These are small oval (the damsons) or round (the bullaces), firm fruited plums, produced on small trees, and used mainly for jelly and jam. They were grown in Europe before the Christian era and brought to America by the earliest settlers. The small, compact trees are hardy and disease resistant, and thrive better in eastern U.S. than other European plum types. The skin is very acid, making the fruits rather unsuitable for eating out of hand. However, they make highly esteemed jellies and jams, and are grown commercially for that purpose.

Season, bloom to harvest: 100-125 days.

Production in U.S.: No data. Possibly 2,000 tons.

Use: Jellies, jams, culinary.

Part of fruit consumed: Pulp in making jelly and jam, but whole fruit cooked prior to separating out seeds and peel.

Last update July 1, 1996 bha

Plum, Japanese

Rosaceae *Prunus salicina* Lindl.

Source: Magness et al. 1971

The Japanese plums were introduced into the U.S. during the latter part of the 19th century, and have become popular in our market. The fruit is medium to large for plums, 1.5 to over 2 inches in diameter. Shape is variable, but mostly conic to oval. Color generally light to dark red. Flesh generally soft and very juicy when ripe. Peel smooth, with waxy surface. Because these plums have high quality and will cross with American species they have been used in breeding to improve the quality of the hardy native types. Trees of Japanese plums are of medium size, and not very hardy to winter cold, hence commercial production is mainly in Calif.

Season, bloom to harvest: 60-160 days, depending on variety.

Production in U.S.: About 100,000 tons.

Use: Mainly fresh market.

Part of fruit consumed: Generally all except pit. Peel may be separated from pulp in mouth and not eaten.

Last update July 1, 1996 bha

Plum, prune, European type

Rosaceae *Prunus domestica* L.

Source: Magness et al. 1971

This group is the most important of the plums in the U.S. It includes all the prunes grown for drying and most of those canned, as well as a number of varieties mainly marketed fresh. Fruits are medium size, 1 to 1.5 inches diameter, globose to oval, and with a firm, meaty flesh. Peel is smooth, with a waxy surface and adheres to flesh. Trees are medium sized, usually held to 15-18 feet by pruning. Trees are of medium hardiness. Most of commercial U.S. production is in the Pacific States, New York and Michigan; but some plantings occur in all areas of U.S. except the South and the coldest areas. Important varieties include Sugar, Italian, Agen, Imperial, Epineuse.

See also plum oil.

Season, bloom to harvest: 130-160 days.

Production in U.S.: About 475,000 tons.

Use: Mainly dried, canned, fresh market. Prune juice is prepared from the dried fruit.

Part of fruit consumed: All except pit.

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Reid, W. and K.L.B. Gast. 1993. The potential for domestication and utilization of native plums in Kansas. p. 520-523. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

The Potential for Domestication and Utilization of Native Plums in Kansas

William Reid and Karen L.B. Gast

During the 19th century, Great Plains settlers demonstrated great interest in the domestication and utilization of North American plum species (*Prunus* spp.) (Bailey 1898; Goff 1897). In central and western Kansas, native plums represented the most reliable source of fresh fruit for many farm families (Kindscher 1987). By 1901, 305 native plum cultivars had been described, including 37 inter-specific hybrids (Waugh 1901). Interest in native plums waned during the 20th century, as mechanized farming and an increasingly efficient transportation system ushered in an age of agricultural specialization. By 1990, only five crops (wheat, maize, sorghum, soybeans, and hay) accounted for nearly 99% of the value of crops produced in Kansas (Byram 1990). Today, the decline in profits earned from producing traditional grain and forage crops has lead many farmers to search for new crops with greater profit potential. This search for agricultural diversification in the wheat belt has rekindled an interest in the domestication and utilization of native plums as a high value, speciality crop.

Eight species of native plum are found in Kansas, including *P. americana* Marsh., *P. angustifolia* Marsh., *P. besseyi* Bailey, *P. gracilis* Engelm. & Gray, *P. hortulana* Bailey, *P. mexicana* S. Wats., *P. munsoniana* Wight & Hedrick, and *P. rivularis* Scheele (Great Plains Flora Assn. 1986). Of these species, *P. americana*, *P. angustifolia*, *P. hortulana*, and *P. munsoniana*, are collected locally and processed into jams, jellies, and preserves in home kitchens. One species, *P. angustifolia*, has recently become the basis for a growing cottage industry in Kansas.

BOTANY

Prunus angustifolia can be found growing from Maryland to Florida in the east then westward to Kansas, Oklahoma, and Texas (Little 1977). The discontinuous distribution of *P. angustifolia* (Fig. 1) led Sargent (1965) to speculate that this species originated in the west and was moved eastward by native Americans and has since become naturalized in the southeastern United States.

Also known as the sandhill plum in Kansas (Stephens 1973), *P. angustifolia* forms large thickets in the sandy pastures of the central and western portions of the state. Large fruit size, small narrow leaves, and a dwarfed appearance led nineteenth century botanists to label the sandhill plum *P. angustifolia watsoni*, to distinguish it from the Chickasaw plum, *P. angustifolia*, common in southeastern states (Waugh 1903). Although modern botanists do not recognize the sandhill plum as a separate sub-species or botanical variety, the Kansas population of *P. angustifolia* seems uniquely adapted for growth in a climate characterized by high heat (40°C) and drought in summer and bitter cold (-30°C) in mid-winter.

The sandhill plum is a much-branched shrub usually less than 2 m high. Thickets up to 20 m across are quickly formed by root suckers. Bright yellow-green leaves that are folded lengthwise help make sandhill plum colonies easily recognizable in the prairies of Kansas. Leaves are simple, alternate, and narrowly elliptical. Twigs are slender, red, glabrous, and often end in a spine. Many branches grow in a distinctive zig-zag pattern. Small white flowers emerge in early April before leaf burst. Flowers have 5 white rounded petals, 20 stamens, and a single egg-shaped ovary. Fruits ripen from early July to late August. Fruits are globose, average 2.1 cm across, and vary in skin color from orange-yellow to deep red (Fig. 2).

GENETIC DIVERSITY

In 1990, we initiated a study to measure the genetic diversity of *P. angustifolia* in Kansas by establishing a planting of 120 seedlings. Bushes used in this study were produced from seed collected from a native plum population located near Pratt, Kansas in 1988. Fifty-nine bushes produced their first fruit crop in 1991. Fruit weight varied from 2.6 to 13.8 g and fruit skin color from yellow to dark red. The orange-yellow flesh of sandhill plums contained from 9.0 to 19.4% soluble solids and were highly acid averaging pH 3.2.

One bush produced fruit that averaged 2.7 cm in diameter as compared to 'Methley', a Japanese plum, which averaged 3.0 cm in diameter (Norton et al. 1990). However, fruit size in sandhill plum is strongly influenced by crop load (Fig. 3). Differences in total bush yield accounted for 44% of the variation in fruit size with the remaining variation in fruit size due to genetic differences.

The selection of sandhill plum cultivars high in soluble solids is very important to the Kansas plum processing industry. Our seedling sandhill plum population averaged 14.3% soluble solids compared to an average of 17% for 9 Japanese plum cultivars (Norton et al. 1990). We did identify individual sandhill plum bushes that produced fruit containing 19.4% soluble solids.

Fruit was harvested from our seedling planting from July 3 to Sept. 11 with the majority of fruit harvested during late July and early August. The harvest season per bush varied from 1 to 7 weeks and averaged 3.6 weeks. The heaviest yielding bushes had the longest harvest season and produced over 4 kg of fruit.

Bush form varied widely. In the year prior to our first fruit crop, bushes could be easily rated as either prostrate, spreading, bushy, or upright. Precocity in sandhill plum seems closely associated with the prostrate growth form. The highest yielding bushes in the first year of fruiting were those that grew nearly horizontally (Fig. 4) but this growth form is the least desirable horticulturally. Fruit-laden limbs dropping on the ground were more prone to fruit rots and were difficult to harvest.

Evidence of bacterial spot infection caused by *Xanthomomas campestris* pv. *pruni* (Smith) Dye could be found on all bushes in the planting. Disease severity increased with fruit yield because of the negative influence of fruit production on vegetative growth. Those bushes with little or no fruit crop were able to outgrow the spread of the bacterial infection.

POTENTIAL FOR DOMESTICATION

Cultivar Development

Observations of the small sample of sandhill plum germplasm described above indicate that sufficient genetic diversity exists within the species for rapid crop improvement. Increased fruit size and higher soluble solids would lead the list of objectives for developing sandhill plum cultivars suited for the processing industry. Additional crop improvement objectives should include a condensed ripening season, an upright growth form, and resistance to bacterial spot.

A limited search of rural Pratt County, Kansas identified two thickets of that produced ample quantities of sandhill plums averaging 2.6 and 2.7 cm in diameter. A more detailed search should yield a sufficient number of superior individuals to begin screening for possible commercial cultivars.

Rootstocks

Prolific root suckering by *P. angustifolia* will make the commercial culture of this plum on its own roots impractical. Fortunately, *P. angustifolia* is graft-compatible with many of the non-suckering rootstocks that have been developed for other diploid plum species (Okie 1987). Growth and yield responses of sandhill plums propagated onto these Prunus rootstocks are not documented.

Pest Problems

The sandhill plum is susceptible to many of the same pests that attack commercial peach and plum orchards. Plum curculio, *Conotrachelus nenuphar* Herbst, is the primary insect pest of sandhill plum. Fruit drop and fruit damage caused by this insect must be controlled if commercial plantings of the sandhill plum are to be successful. Major disease problems include brown rot [*Monilinia fructicola* (Wint.) Honey] of the fruit and bacterial leaf spot (*Xanthomonas campestris* pv. *pruni* (Smith) Dye). There seems to be little natural resistance to either of these diseases within *P. angustifolia*. However, bacterial spot resistance has been identified in *P. cerarsifera* Ehrh. (Byrne 1989).

Chemical controls for the major pests of sandhill plum are widely available. Since sandhill plum is legally a plum, growers may apply any pesticide registered for use on European and Japanese plums for control of insect, disease, and weed pests.

Mechanical Harvest

Acceptance of sandhill plum as a crop in Kansas would depend in part on the availability of mechanical harvesting equipment. Fortunately, the dimensions and growth habit of the sandhill plum are close to those of the highbush blueberry. Harvesters developed for the blueberry industry should be easily adapted to sandhill plum harvest.

SANDHILL PLUM PRODUCT DEVELOPMENT

Sandhill plum jelly has been a regional favorite ever since the early settlers discovered abundant plum thickets on the Kansas prairie (Kindscher 1987). Until recently, sandhill plum jams and jellies were produced only in rural family kitchens for home consumption. With the rapid rise of consumer interest in regional and/or speciality foods, two Kansas food companies have begun manufacturing sandhill plum products for distribution nationally. Fruit is collected from uncultivated thickets and purchased for $1.10/kg. Products manufactured from the sandhill plum are marketed as uniquely Kansan and command as much as $17.50/kg.

Sandhill plums make distinctive fruit products that are often described as pleasingly tart with an apricot-like flavor. Besides the traditional jams and jellies, four additional Sandhill plum products have been developed by the Value-Added Center at Kansas State University. These include a pancake syrup, a fruit topping for ice-cream, a naturally sweetened fruit spread, and an artificially sweetened fruit spread. The manufacturing process for all six Sandhill plum products is outlined in Fig. 5.

CONCLUSIONS

Continued expansion of the sandhill plum industry will depend on the domestication of *P. angustifolia*. The rich genetic diversity found both within this species and among all native Kansas plums offer tremendous opportunities for crop development. Improvements in fruit size, soluble solids, and bush form can be made rapidly through careful examination of seedling populations. The domesticated Sandhill plum of the future is envisioned as a bush fruit adaptable to mechanical harvest with technology borrowed from the blueberry industry. Successful domestication and market development will provide Kansas farmers with an additional crop and allow them to reap the economic benefits of agricultural diversification.

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Fig. 1. The distribution of *Prunus angustifolia* in North America (Little 1977).

Fig. 2. Sandhill plum fruits are borne in clusters of 1 to 3. The fruits pictured here were light orange with a red blush and averaged 2.5 cm in diameter.

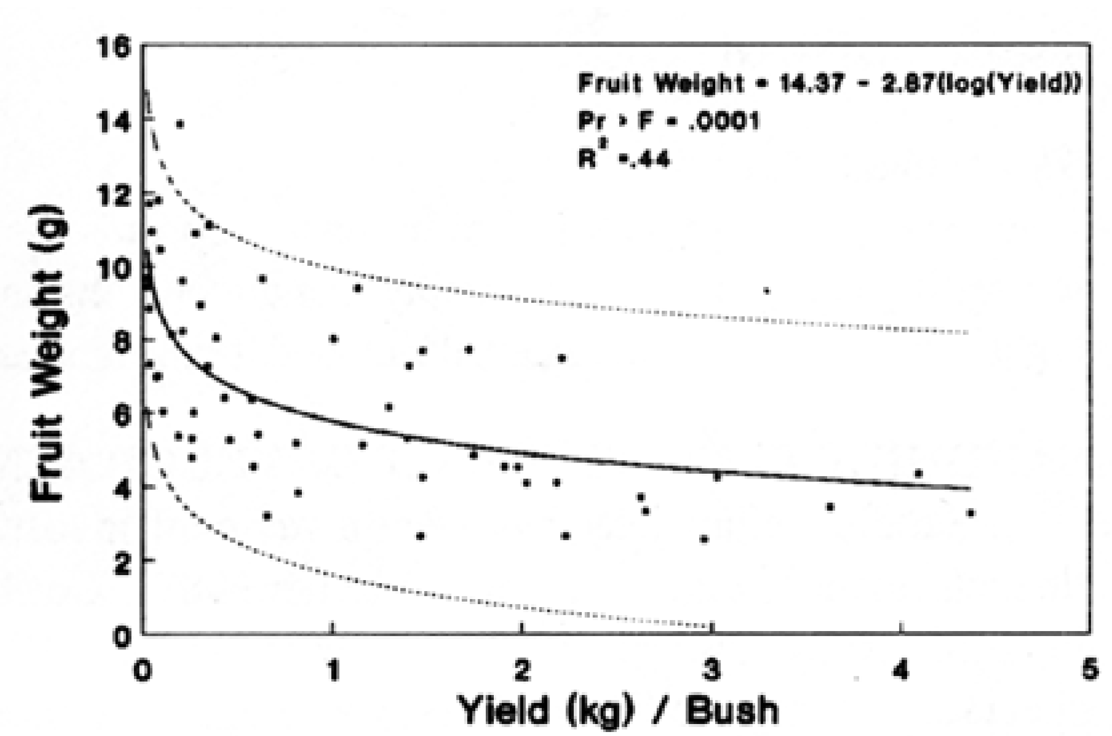

Fig. 3. The relationship between yield and fruit weight of 59 seedling sandhill plum bushes. The regression line (solid line) is bounded by 95% confidence limits (dashed lines).

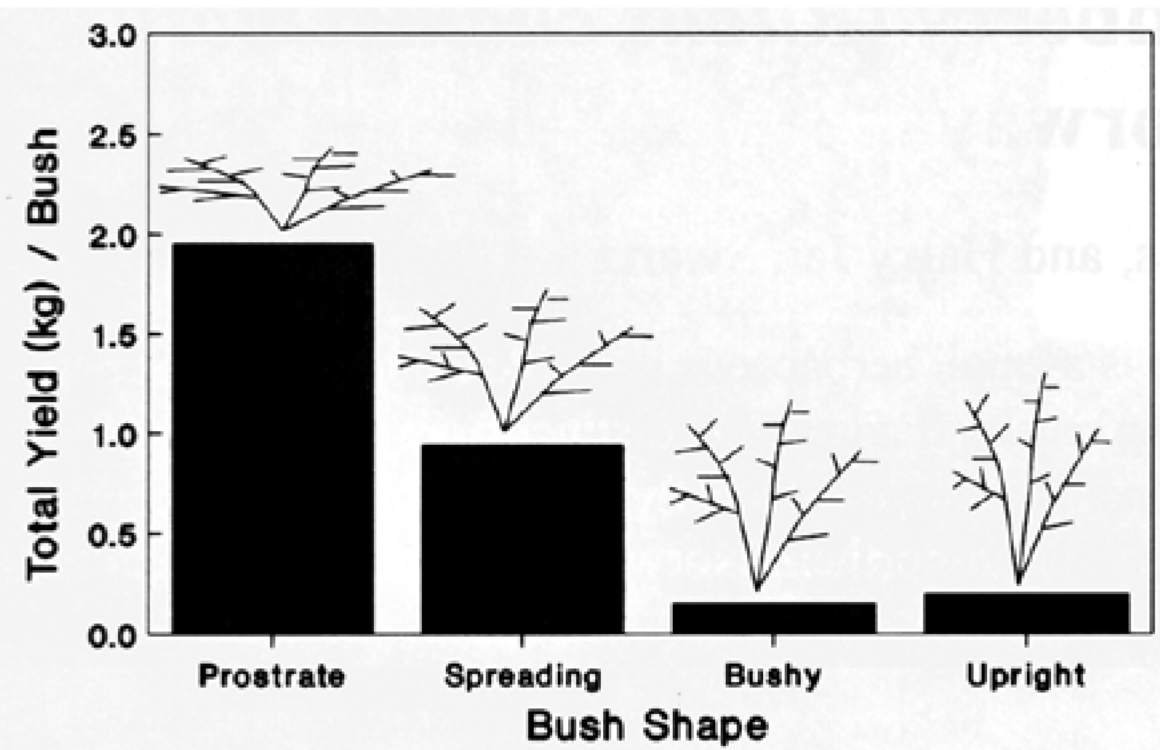

Fig. 4. The relationship between bush shape and fruit yield among 120 sandhill plum seedlings.

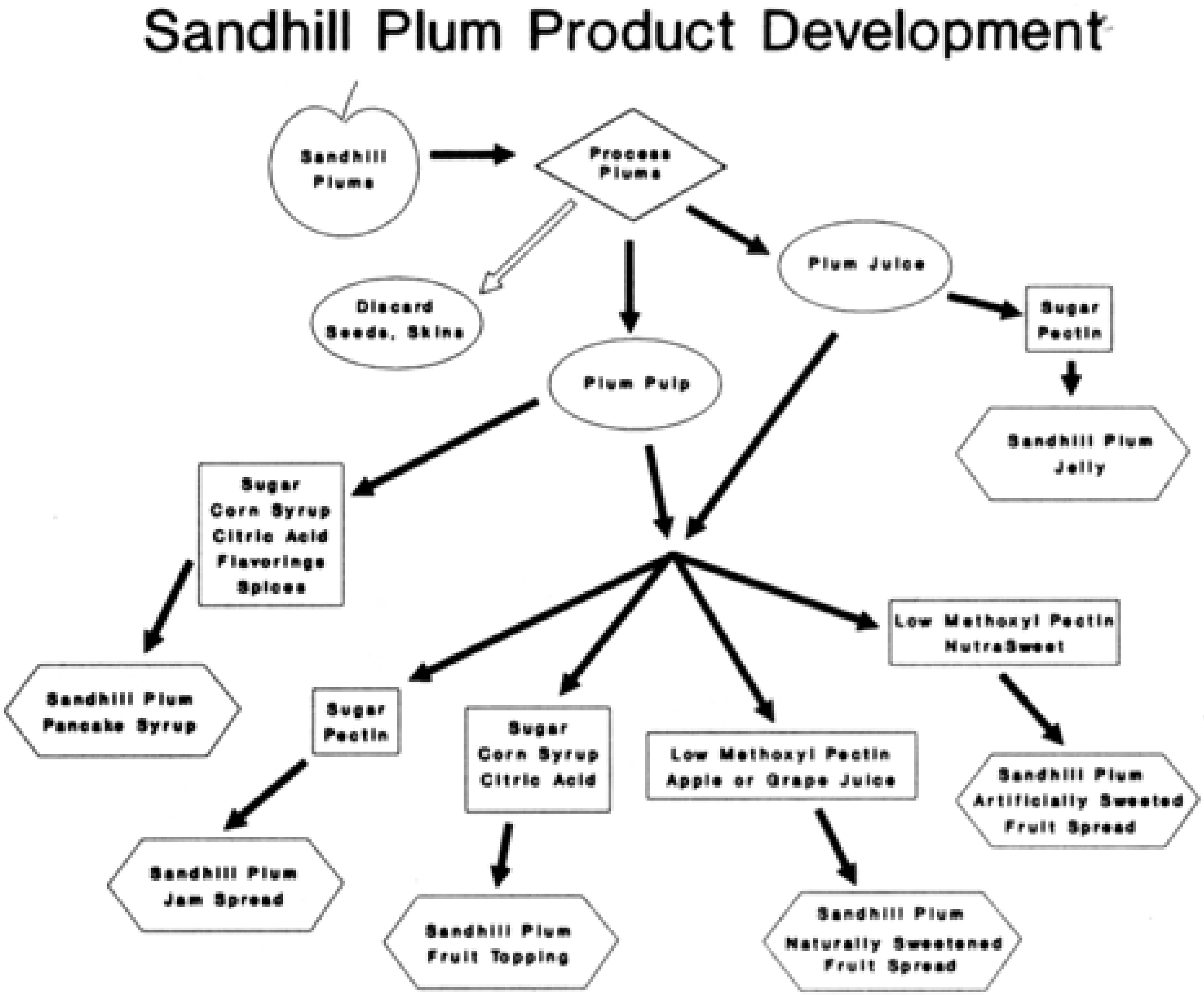

Fig. 5. A flow diagram for the manufacturing process of six sandhill plum products currently being produced in Kansas. Items enclosed in an oval represent ingredients derived from the sandhill plum. Additional ingredients are enclosed in rectangles, and final products are enclosed in hexagons.

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Singh, B.P. and Wayne F. Whitehead. 1999. Pointed gourd: Potential for temperate climates. p. 397–399. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Pointed Gourd: Potential for Temperate Climates

Bharat P. Singh and Wayne F. Whitehead

Pointed gourd (*Trichosanthes dioica* Roxb., Cucurbitaceae) is a tropical vegetable crop with origin in the Indian subcontinent. It is known by the name of *parwal*, *palwal*, or *parmal* in different parts of India and Bangladesh and is one of the important vegetables of this region. The fruit is the edible part of the plant which is cooked in various ways either alone or in combination with other vegetables or meats. Pointed gourd is rich in vitamin and contains 9.0 mg Mg, 2.6 mg Na, 83.0 mg K, 1.1 mg Cu, and 17.0 mg S per 100 g edible part (Singh 1989). It is purported that pointed gourd possesses the medicinal property of lowering total cholesterol and blood sugar. These claims are supported by preliminary clinical trials with rats (Chandra-Sekar et al. 1988) and rabbits (Sharma and Pant 1988; Sharma et al. 1988).

BOTANY

The plant is a perennial, dioecious, and grows as a vine (Fig. 1). Roots are tuberous with long taproot system. Vines are pencil thick in size with dark green cordate simple leaves. Flowers are tubular white with 16–19 days initiation to anthesis time for pistillate flowers and 10–14 days for staminate flowers. Stigma remains viable for approximately 14 hours and 40–70% of flowers set fruit (Singh et al. 1989). Based on shape, size and striation, fruits can be grouped into 4 categories: (1) long, dark green with white stripes, 10–13 cm long, (2) thick, dark green with very pale green stripes, 10–16 cm long, (3) roundish, dark green with white stripe, 5–8 cm long, and (4) tapering, green and striped, 5–8 cm long (Singh 1989).

Fig. 1. Pointed gourd trained on a fence wire trellis.

CULTIVATION

The pointed gourd is usually propagated through vine cuttings and root suckers. Seeds are not used in planting because of poor germination and inability to determine the sex of plants before flowering. As a result, crop established from seed may contain 50% nonfruiting male plants. To propagate from root suckers, tuberous roots of pointed gourd are dug in the early spring, subdivided, and replanted. Both pre-rooted and fresh vine cuttings are used for propagation. Vine cuttings made in the fall of previous year and rooted during winter are planted when danger from frost is over in the spring in order to obtain a crop in the same year. Current year vine cuttings are also planted to establish the crop during the summer, but optimum plant yield is only obtained during the next year. Fresh vines used for field planting should have 8–10 nodes per cutting and should be partially or fully defoliated to check transpiration. The distance between plants is kept between 1.5–2.0 m × 1.5–2.0 m depending on the method of training of vines (Singh 1989; Yadav 1989). A female:male ratio of 9:1 is optimum for ensuring maximum fruit set (Maurya et al. 1985).

Pointed gourd prefers a well-drained sandy loam soil with good fertility. Das et al. (1987) reported maximum early as well as total yield at N:P rates of 90:60 kg/ha, while Kumar et al. (1990) obtained maximum number of fruits/plant when both N and P were applied at the rate of 60 kg/ha.

Vines require training on some form of aerial support system to achieve maximum fruit production (Prasad and Singh 1987; Yadav et al. 1989). Singh (1989) reported 14% higher yield on vines trained on bower system compared to those growing on the ground. In tropics, pointed gourd produces maximum yields for 3–4 years, after which yielding potential gradually declines (Samalo and Parida 1983).

To determine whether pointed gourd can be grown successfully in temperate climates, a study was initiated in 1994 at the Fort Valley State University in Georgia. Cuttings of male and female vines were obtained from the Department of Vegetable Crops, Narendra Deva University of Agriculture and Technology, Faizabad, India with the assistance of National Bureau of Plant Genetic Resources, New Delhi, India, and National Germplasm Resources Laboratory, Beltsville, Maryland. Cuttings were first multiplied in the greenhouse under mist. Rooted cuttings were planted in the field in six 12 m long rows during April 1995. Planting distance was 1.52 m in the row and 1.83 m between rows. Thus, planting density amounted to 3,595 plants/ha, of which 3,236 were female and 359 male (female:male ratio 9:1). Vines were trained on trellises made of 1.52 m high fence wire. Plants were cut back to the ground level before frost and roots covered with straw to safeguard from cold during winter. Vines sprouted from over-wintered roots during subsequent years in spring when the average soil temperature reached above 12.5°C.

HARVESTING AND YIELD

Pointed gourd vines produced limited number of fruits during 1995, however, full scale fruiting only began in 1996. Fruits were produced for harvest from the beginning of July and continued to the middle of October. There was a continuous increase in the number of fruits produced during the first 4 weeks, thereafter, variation among weekly fruit numbers was dependent on the environmental conditions (Fig. 2). Plants produced fruits for harvesting for 15 weeks in 1996 and 17 weeks in 1997. Harvesting was carried out twice a week to obtain fruits at proper maturity for cooking. Over matured fruits developed hard seeds, rendering them less desirable. It took approximately 15 days for fruits to reach the marketable size from fruit-set. Seasonal pattern for the fresh and dry fruit yield /plant was similar to the fruit number/plant. Total fruit number, fresh and dry yields on per plant basis were higher in 1997 than 1996 (Table 1). Fresh fruit yields/ ha for 1996 and 1997 were 16.2 and 21.0 t, respectively. These yield levels compare favorably to those reported from the Indian subcontinent (Singh 1989).

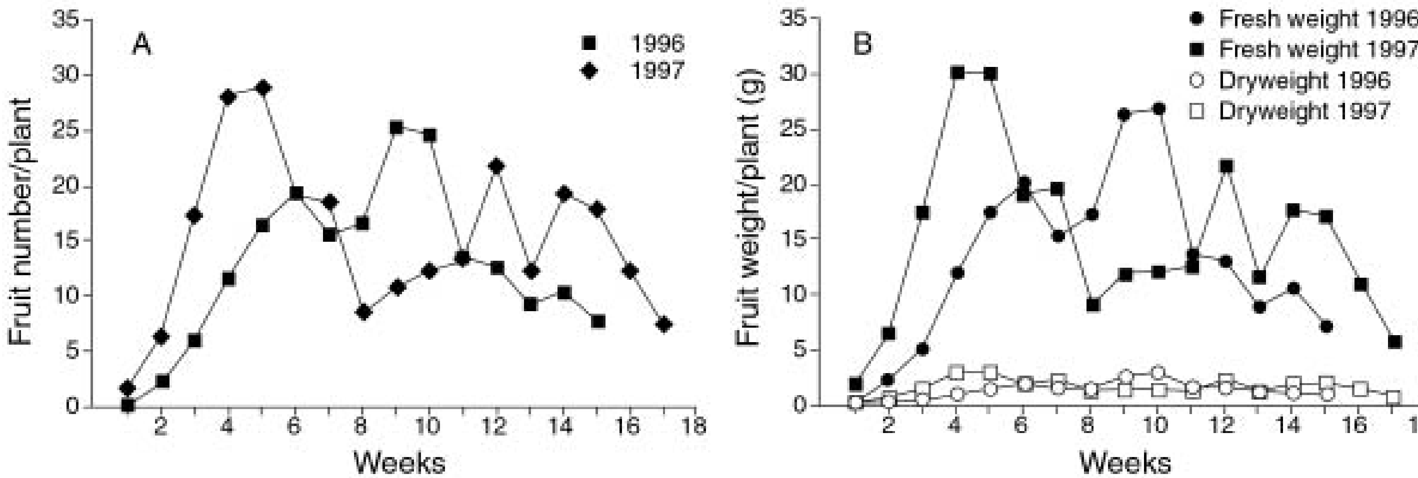

Fig. 2. (A) Per plant fruit number, and (B) fresh and dry weight of pointed gourd on a weekly basis in Georgia during 1996 and 1997.

Table 1. Total fruit number, fruit fresh and dry yields of pointed gourd in Georgia during 1996 and 1997.

Year	Total fruit number		Fresh fruit yield		Dry fruit yield	
	Per plant	Per ha	Per plant (kg)	Per ha (t)	Per plant (kg)	Per ha (t)
1996	190	614,840	5.0	16.2	0.5	1.6
1997	254	821,944	6.5	21.0	0.7	2.3

PROSPECT FOR THE CROP IN THE UNITED STATES

Two main factors will determine the prospect of pointed gourd in the United States: (1) the ability of the plant to adapt to the temperate climate, and (2) market demand for the crop. Research conducted in Georgia clearly demonstrate that pointed gourd can overwinter successfully and produce fruit for approximately 16 weeks during summer with yield comparable to that reported from India. The demand for this vegetable from ethnic minorities from the Indian subcontinent is also high and occasional imports are sold for US $9–10/kg in International Farmers Markets and ethnic grocery stores. However, since fruit harvest is spread over a long period, pointed gourd appears only suited for production on small areas. Price of this commodity produced locally would probably be similar or higher than the imports. The labor employed in manually harvesting these small sized fruits will have to be paid at a higher rate in the US than the exporting countries offsetting any transportation cost advantage from producing the crop locally. Therefore, pointed gourd provides most opportunity to small farmers living close to metropolitan cities where it can be grown as U-Pick or for supply to International Farmers Markets and ethnic grocery stores. The crop also has potential for production in home gardens where it can provide a nutritious vegetable for an extended period.

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Seneca-Snakeroot

Polygala senega L.

Other common names.—Senega snakeroot, Seneca root, rattlesnake-root, mountain flax.

Figure 94.—Seneca-snakeroot (*Polygala senega*)

Habitat and range.—This native p]ant is found in rocky woods and hillsides from New Brunswick and western New England to Minnesota and the Canadian Rocky Mountains, and south along the Allegheny Mountains to North Carolina and west to Missouri.

Description.—The root of this plant sends up a number of smooth, slender, erect stems (as many as 15 or 20 or more), sometimes slightly tinged with red, from 6 inches to a foot in height, and generally unbranched. The lance-shaped, stemless leaves are thin in texture and from 1 to 2 inches long. The flowering spikes are borne in May and June on the ends of the stems and consist of rather crowded, small whitish, insignificant flowers. The lower flowers develop first and have already fruited when the upper flowers open.

A modified form of Seneca-snakeroot occurring in the North Central States is distinguished by its taller stems and broader leaves.

Part used.—The root, collected in autumn.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Pomarrosa Malay

Malay apple, Pomarrosa Americana

Myrtaceae *Eugenia malaccensis* L.

Source: Magness et al. 1971

Tropical evergreen tree to 35 feet in height. The fruits are pear-shaped, 4 inches long, 3 inches wide and are reddish pink with longitudinal stripes and splashes of darker red. The fruit flesh is thick, white, dry and surrounds a large seed. The fruits may be eaten fresh or used to make jelly, but are usually stewed with some flavoring material such as cloves.

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Populus deltoides Bartr. ex Marsh.

Salicaceae
Eastern cottonwood

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

The timber is used principally for lumber, veneer, pulpwood, excelsior, and fuel (Laver, 1981). Widely used in the US and Canada for shelterbelt and amenity plantings (Ag. Handbook 450). Recently, it has been championed as one of the leading potential species for silviculture biomass production. Salicylic acid, derivable from this species, is now synthesized and selling at ca $2.50 to $3.00 per kilo. Salicylic acid in technical form is used as a coupling agent in dye intermediates, in the foundry industry as a curing agent in the production of shell molding compounds, as an agent for retarding the vulcanization process in rubber, as a preservative for glues and leather goods, and in alkyl/alkyd resins and latex paints (CMR, Dec. 13, 1982).

Folk Medicine

The bark tincture has been used to treat rheumatism, gout, and scurvy and infections of the chest, kidneys, and stomach. The buds have been used as a vulnerary and pectoral. In Europe, the fresh flowers are steeped in cold water to purify the blood. Used by Amerindians as a folk cancer remedy. Ojibwa used aspen buds, stewed in bear fat, for earache, bronchitis, or cough. Bella Coola decocted the rotten leaves as an herbal bath for general body pain and used the buds in poultices for hip or lung pain. Carrier chewed the root to apply as a hemostat and decocted the buds for colds and respiratory problems. Chippewa decocted the buds for colds and respiratory problems; heart ailments, sprains, and strains, and the root for backache, female problems, metrorrhea, and weakness. Delaware used the bark for female ailments. Nanticoke used bark for sprains. Ojibwa used the down like cotton on wounds. Potawatomi cooked buds in tallow to make an ointment for eczema and sores. "Tacamahaca" was used by Amerindians for maturing tumors. Smoky Mountain settlers used the buds like the Indians to make a salve for myalgia and soreness (Duke, 1983c).

Chemistry

The bark contains salicortin, salicin, salicyl alcohol, pyrocatechin, α-salicyloylsalicin, grandidentatin, grandidentoside, populoside, trichocarposide, and 6-methyldihydroquercetin. Leaves contain salicortin, salicin, salicyl alcohol, pyrocatechin, 1-0-p-cumaroyl-β-D-glycoside, populoside, α-salicyloylsalicin, chrysin-7-glucoside, and deltoidin (2-0-salicyloylsalicin). Tremulacin, brenzcatechin, and quercetin-3,3'-dimethyethes are also reported (List and Horhammer, 1969–1979).

Description

Large tree to 20–30(-50) m tall, diam. 0.5 to 2 m; bark grayish-green and smooth at first, later blackish and furrowed. Leaves broadly deltoid, 8–15 cm long, nearly as broad, glabrous on both sides, short-acuminate, dentate with incurved glandular or callous tipped teeth; bases truncate to subcordate, with 2–3 basal glands; petiole strongly flattened laterally. Bracts of aments fringed or fimbriate, the divisions narrow. Staminate aments 7.5–12.5 cm long, thick, stamens ca 60 or more, anthers red. Pistillate aments green and slender, 2–3 dm long; ovaries glabrous; stigmas 3 or 4. Capsules ovoid, 6–10 mm long, glabrous, green, the peduncle 3–10 mm long; seeds cottony (Brown and Brown, 1972).

Germplasm

Reported from the North American Center of Diversity, eastern cottonwood, or cvs thereof, is reported to tolerate frost, heavy soil, sand, slope, and waterlogging. Because of its intolerance to competition and the absence of suitable seedbeds under existing stands, it does not usually succeed itself (Laver, 1981).

Distribution

Quebec to North Dakota, south to Florida and Texas (Ag. Handbook 450).

Ecology

Estimated to range from Warm Temperate Dry to Moist through Cold Temperate Dry to Moist Forest Life Zones, eastern cottonwood is reported to tolerate annual precipitation of 6 to 15 dm, annual temperature of 8 to 14°C, and pH of 4.5 to 8. Said to persist on infertile sands, fine sandy loams, and fairly stiff clays, but thrives on moist well-drained, fine sandy loams or silts close to streams (Laver, 1981).

Cultivation

Seeds are microbiotic, but,with proper drying and cold storage in sealed containers, their viability can be maintained for several years. Natural seed regeneration can be obtained on moist sites with exacting site preparation. Seed should not be covered nor pressed into the soil of the seedbed. Young seedlings are very susceptible to drying out, and the seedbed must be kept water-saturated for germination and at least one month thereafter (ca 1 oz seed per 100 ft^2 seedbed; or about 300 seeds per sq ft) for broadcast, 100 seeds per linear foot for drilling. About 4 weeks after germination, beds should be thinned to 20 plants per square foot. Nursery beds are often stream sterilized or fumigated with methyl bromide to help control damping off. Finely divided sphagnum moss is a good medium for culturing poplar seedlings in the greenhouse (Ag. Handbook 450).

Harvesting

In the Lower Mississippi Valley, seed ripening and dispersal takes place from mid-May through late August, while in the Northeastern US, it occurs slightly later. Cottonwoods produce large seed crops nearly every year.

Yields and Economics

Geyer studied two provenances of cottonwood germplasm, one from Missouri, the other from Nebraska. At Tuttle Creek, Kansas (Eudora soil series, silty-clay loam, pH 7.5, 2.0% organic matter, 146 kg available P/ha, 560 kg exchangeable kg/ha; annual precipitation 838 mm, annual mean temperature 13°C) the Missouri germplasm produced 24,000 kg/ha ovendry biomass over four years spaced at 0.3 by 1.2 m, 29,400 kg/ha spaced at 0.6 by 1.2 m, and 27,100 kg/ha spaced at 1.2 by 1.2 m. This averages out to annual biomass production of 6 MT/ha at 0.3 by 1.2, 7 MT/ha at 0.6 by 1.2, and 7 MT/ha at 1.2 by 1.2 m. At the sandier Milford site (cass fine sandy loam, pH 7.7, 0.6% organic matter, 22 kg P and 336 kg K; annual precipitation 787 mm, the Missouri germplasm produced 22,000 kg/ha ovendry biomass spaced at 0.3 by 1.2 m, 20,600 kg/ha spaced at 0.6 by 1.2, and 21,100 kg/ha spaced at 1.2 by 1.2. Annual biomass production (aboveground) thus averages out to about 6 MT/ha at 0.3 by 1.2, 5 MT/ha at 0.6 by 1.2, and 5 MT/ha at 1.2 by 1.2 m. Biennial harvests were made in December when no leaves were on the trees. The stumps sprouted vigorously the following spring. Bark accounted for about 28% of the small parts of the tree on a dry weight basis, 16% of the large parts, running about 19% for the whole tree. The heat of combustion for the small parts was 4,695 cal/g, 4,416 for the large parts. At Tuttle Creek, the Nebraska germplasm produced 27,400 kg/ha ovendry biomass over four years spaced at 0.3 by 1.2 m, 25,800 kg/ha spaced at 0.6 by 1.2 m, and 28,000 kg/ha spaced at 1.2 by 1.2 m, averaging 7 MT/ha/yr at 0.3 by 1.2, 6 MT at 0.6 by 1.2 and 7 MT at 1.2 by 1.2 m. At the sandier Milford site, the Nebraska germplasm produced 28,200 kg/ha ovendry biomass spaced at 0.3 by 1.2 m, 28,500 kg/ha spaced at 0.6 by 1.2, and 24,000 kg/ha spaced at 1.2 by 1.2 averaging out to about 7 MT/ha/yr at 0.3 by 1.2, 7 MT at 0.6 by 1.2, and 6 MT at 1.2 by 1.2 m. Bark accounted for about 41% of the small parts of the tree on a dry weight basis, 23% of the large parts, running about 28% for the whole tree. The heat of combustion for the small parts was 4,385 cal/g, 4,288 for the large parts. Average annual of several species tested in eastern Kansas ran from 3.6 to 6.7 ovendry MT/ha, with close spacings producing the greatest tonnage, greater than those reported from similar studies in southeastern and northeastern US. Geyer compares these studies with similar studies in Pennsylvania, spaced at 0.6 by 0.6 m, yielding 0.6 MT/ha in year 1, 3.7 in year 2, 6.0 in year 3, and 6.2 in year 4. Another Kansas study showed 5.8 MT/ha/yr in 3 year old Populus 'Tristis No. l' (Geyer, 1981). Henry and Salo (1981) calculate the energetic cost of a silvicultural biomass farm as 1.67 billion (10^9) Btu for supervision, 0.53 for field supply, 7.87 for harvesting, 8.78 for handling the biomass, 17.32 for transport of the biomass, 112.48 for irrigation, 128.33 for fertilizaton and cultivation for a total consumption of ca 277 10^9 Btu, returning 4,250 x 10^9 Btu as energy, for a net gain of 3,972 x 10^9 Btu. (For a farm designed to have an annual production of 250,000 ovendry tons of biomass, enough to support an electric power plant of ca 50 MW.)

Energy

According to the phytomass files (Duke, 1981b), annual productivity in *Populus* ranges from 3 to 22 MT/ha. Fast growing poplars in Sweden, harvested young, have given biomass yields of 14–28 MT/ha. The maximum possible production of fast growing poplars, with optimum fertilization and moisture, is 44 MT/ha in the Netherlands, but normal production levels are closer to 6 (Palz and Chartier, 1980). The MAI of ca 22 MT DM/ha have been reported for hybrid poplars in Sweden, Henry and Salo (1981) assume that silvicultural energy farms in Louisiana will generate 15.3 times as much energy as they consume, compared to 10.6 times in Wisconsin. Here we see the 10:1 ratio we saw also in oilseeds, much higher than the average energetic yields for conventional crops.

Biotic Factors

Agriculture Handbook No. 165 lists the following as affecting this species: *Agrobacterium tumefaciens, Cercospora populina, C. populicola, C. reducta, Ciborinia confundens, Cryptodiaporthe salicina, Dothichiza populea, Fomes applanatus, F. igniarius, Graphium rubrum, Hypoxylon* spp., *Marssonina populi, Melampsora abietis-canadensis, M. medusae, M. occidentalis, Melanconis occulta, Mycosphaerella macularis, M. populifolia, M. populorum, Nectria* sp., *Phoradendron flavescens* var. *macrophyllum, Phyllosticta intermixta, P. maculans,* *Phymatotrichum omnivorum, Physalospora obtusa, Pleurotus ostreatus, Polyporus* spp., *Septoria populi, S. populicola, Steccherinum ochraceum, Stigmina* sp. *Taphrina aurea, T. johansonii, Trametes hispida, Uncinula salicis, Valsa nivea, V. sordida, Venturia tremulae*. In addition, Browne (1968) lists the following as affecting this species: Bacteria: *Aplanobacter populi*. Fungi: *Armillaria mellea, Cladosporium subsessile, Cryptodiaporthe populea, Drepanopeziza populorum, D. punctiformia, Fomes fomentarius, Ilypoxylon pruinatum, Leucostoma niveum, Melampsora laricipopulina, M. populnea, Mycosphaerella populorum, Nectria coccinea, N. ditissima, N. galligena, N. haematococca, Neofabraea populi, Oxyporus populinus, Pezicula populi, Phellinus igniarius, Phyllosticta populina, Septotinia populiperda, Trametes sauveolens, Venturia macularis. Coleoptera: Capnodis miliaris, Chrysomela interrupta, C. scripta, Tragocephala variegata, Zeugophora abnormis, Z. scutellaris.* Diptera: *Phytagromyza populicola*. Hemiptera: *Pemphigus populitransversus, Phloemyzus passerini.* Hymenoptera: *Pontania bozemani, Trichiocampus viminalis.* Lepidoptera: *Acronicta lepusculina, Choristoneura conflictana, Leucoma salicis, Nymphalis antiopa, Paranthrene tabaniformis, Sesia tibialis.* Mammalia: *Capra hircus, Oryctolagus cuniculus* (Browne, 1968). Adults and larvae of the cottonwood leaf beetle (*Chrysomela scripta*) feed on the foliage and succulent stems of seedlings, killing or retarding growth in plantations and nurseries. Equally injurious are cottonwood twig borers (*Gypsonoma haimbachiana*) and cotton root and stem borers (*Paranthrene dollii*). Borers of the southern and central states (*Plectrodera scalator*) and the poplar borer (*Saperda calcarata*), found principally in the northern part of the range, cause lumber defects (Laver, 1981).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update January 8, 1998 by aw

Portulaca oleracea L.

Portulacaceae

Cuban spinach, Miner's-lettuce, Miner's-salad, Pigweed, Purslane, Pussley, Winter purslane

We have information from several sources:

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

Effect of Nitrate: Ammonium Nitrogen Ratio on Oxalate Levels of Purslane—Usha R. Palaniswamy, Bernard B. Bible, and Richard J. McAvoy

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Solanum tuberosum L.

Solanaceae

Potato

We have information from several sources:

Root Vegetables: New Uses for Old Crops—Wanda W. Collins

Plant Nutrient Composition Altered With Controlled Environments for Future Space Life-Support Systems—S. Suzanne Nielsen, Martha A. Belury, Kwangok P. Nickel, and Cary A. Mitchell

New Crops for Canadian Agriculture—Ernest Small

Midwest Vegetable Production Guide for Commercial Growers 2000

Potatoes production links

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Potatoes HO-62 Purdue University Cooperative Extension Service

Outside links

Potatoes can be found in Lost Crops of the Incas from National Academy Press

Pouteria sapota

(Jacq.) H.E. Moore & Stearn

Sapotaceae

Sapote

We have information from several sources:

Sapote —Julia Morton, Fruits of warm climates

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.).

Prickly-Ash

(1) *Zanthoxylum americanum* Mill.; (2) *Z. clava-herculis* L.

Synonyms.—(1) *Xanthoxylum fraxineum* Willd.; (2) *X. carolinianum* Lam.; *Fagara clava-herculis* (L.) Small.

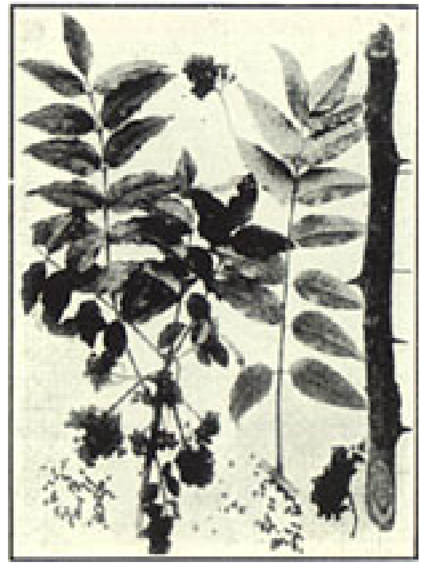

Figure 87.—Southern, prickly-ash (*Zanthoxylum clava-herculis*)

Other common names.—Common prickly-ash, northern prickly-ash, toothache tree, toothache bush, yellowwood, angelica tree, pellitory-bark, suterberry; (2) southern prickly-ash, Hercules-club, toothache tree, yellow Hercules, yellowthorn, yellowwood, yellow prickly-ash, prickly yellowwood, West Indian yellowwood, sea ash, pepperwood, wild orange.

Habitat and range.—The common, or northern, prickly-ash is common in woods, thickets, and along river banks from Virginia, Missouri, and Kansas northward to Canada, while the southern prickly-ash grows along streams from southern Virginia to Florida and west to Texas and Arkansas.

Description.—(1) The common or northern prickly-ash is generally a shrub from 10 to 12 feet high, rarely exceeding 25 feet. Its leaflets are from 5 to 11 in number and from 1 1/2 to 2 inches long. The greenish-yellow flowers appear about April or May, before the leaves are borne in dense, stemless clusters from the axils of the branches. The branches have brown, cone-shaped prickles, and the bark, leaves, and pods are highly aromatic.

(2) The southern prickly-ash is taller than the northern species, but seldom attains a greater height than 45 feet. Its leaves consist of 5 to 17 leaflets from 1 1/2 to 3 inches long, and its small, greenish flowers appear in June after the leaves are out, borne in large clusters at the ends of the branches. The entire tree is furnished with sharp spines or prickles.

Part used.—The bark of both species.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Jatropha curcas L.

Euphorbiaceae
Physic nut, Purging nut

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

According to Ochse (1980), "the young leaves may be safely eaten, steamed or stewed." They are favored for cooking with goat meat, said to counteract the peculiar smell. Though purgative, the nuts are sometimes roasted and dangerously eaten. In India, pounded leaves are applied near horses' eyes to repel flies. The oil has been used for illumination, soap, candles, adulteration of olive oil, and making Turkey red oil. Nuts can be strung on grass and burned like candlenuts (Watt and Breyer-Brandwijk, 1962). Mexicans grow the shrub as a host for the lac insect. Ashes of the burned root are used as a salt substitute (Morton, 1981). Agaceta et al. (1981) conclude that it has strong molluscicidal activity. Duke and Wain (1981) list it for homicide, piscicide, and raticide as well. The latex was strongly inhibitory to watermelon mosaic virus (Tewari and Shukla, 1982). Bark used as a fish poison (Watt and Breyer-Brandwijk, 1962). In South Sudan, the seed as well as the fruit is used as a contraceptive (List and Horhammer, 1969–1979). Sap stains linen and can be used for marking (Mitchell and Rook, 1979). Little, Woodbury, and Wadsworth (1974) list the species as a honey plant.

Folk Medicine

According to Hartwell, the extracts are used in folk remedies for cancer. Reported to be abortifacient, anodyne, antiseptic, cicatrizant, depurative, diuretic, emetic, hemostat, lactagogue, narcotic, purgative, rubefacient, styptic, vermifuge, and vulnerary, physic nut is a folk remedy for alopecia, anasorca, ascites, burns, carbuncles, convulsions, cough, dermatitis, diarrhea, dropsy, dysentery, dyspepsia, eczema, erysipelas, fever, gonorrhea, hernia, incontinence, inflammation, jaundice, neuralgia, paralysis, parturition, pleurisy, pneumonia, rash, rheumatism, scabies, sciatica, sores, stomachache, syphilis, tetanus, thrush, tumors, ulcers, uterosis, whitlows, yaws, and yellow fever (Duke and Wain, 1981; List and Horhammer, 1969–1979). Latex applied topically to bee and wasp stings (Watt and Breyer-Brandwijk, 1962). Mauritians massage ascitic limbs with the oil. Cameroon natives apply the leaf decoction in arthritis (Watt and Breyer-Brandwijk, 1962). Colombians drink the leaf decoction for venereal disease (Morton, 1981). Bahamans drink the decoction for heartburn. Costa Ricans poultice leaves onto erysipelas and splenosis. Guatemalans place heated leaves on the breast as a lactagogue. Cubans apply the latex to toothache. Colombians and Costa Ricans apply the latex to burns, hemorrhoids, ringworm, and ulcers. Barbadians use the leaf tea for marasmus, Panamanians for jaundice. Venezuelans take the root decoction for dysentery (Morton, 1981). Seeds are used also for dropsy, gout, paralysis, and skin ailments (Watt and Breyer-Brandwijk, 1962). Leaves are regarded as antiparasitic, applied to scabies; rubefacient for paralysis, rheumatism; also applied to hard tumors (Hartwell, 1967–1971). Latex used to dress sores and ulcers and inflamed tongues (Perry, 1980). Seed is viewed as aperient; the seed oil emetic, laxative, purgative, for skin ailments. Root is used in decoction as a mouthwash for bleeding gums and toothache. Otherwise used for eczema, ringworm, and scabies (Perry, 1980; Duke and Ayensu, 1984). We received a letter from the Medicial Research Center of the University of the West Indies shortly after the death of Jamacian singer Robert Morley, "I just want you to know that this is not because of Bob Morley's illness, why I am revealing this ... my dream was: this old lady came to me in my sleep with a dish in her hands; she handed the dish to me filled with some nuts. I said to her, "What were those?" She did not answer. I said to her, "PHYSIC NUTS." She said to me, "This is the cure for cancer." We found this Jamaican dream rather interesting. Four antitumor compounds, including jatropham and jatrophone, are reported from other species of Jatropha (Duke and Ayensu, 1984). Homeopathically used for cold sweats, colic, collapse, cramps, cyanosis, diarrhea, leg cramps.

Chemistry

Per 100 g, the seed is reported to contain 6.6 g H_2O, 18.2 g protein, 38.0 g fat, 33.5 g total carbohydrate, 15.5 g fiber, and 4.5 g ash (Duke and Atchley, 1983). Leaves, which show antileukemic activity, contain α-amyrin, β-sitosterol, stigmasterol, and campesterol, 7-keto-β-sitosterol, stigmast-5-ene-3-β, 7-α-diol, and stigmast-5-ene-3 β, 7 β-diol (Morton, 1981). Leaves contain isovitexin and vitexin. From the drug (nut?) saccharose, raffinose, stachyose, glucose, fructose, galactose, protein, and an oil, largely of oleic- and linoleic-acids (List and

Horhammer, 1969–1979), curcasin, arachidic-, linoleic-, myristic-, oleic-, palmitic-, and stearic-acids are also reported (Perry, 1980).

Toxicity

The poisoning is irritant, with acute abdominal pain and nausea about 1/2 hour following ingestion. Diarrhea and nausea continue but are not usually serious. Depression and collapse may occur, especially in children. Two seeds are strong purgative. Four to five seed are said to have caused death, but the roasted seed is said to be nearly innocuous. Bark, fruit, leaf, root, and wood are all reported to contain HCN (Watt and Breyer-Brandwijk, 1962). Seeds contain the dangerous toxalbumin curcin, rendering them potentially fatally toxic.

Description

Shrub or tree to 6 m, with spreading branches and stubby twigs, with a milky or yellowish rufescent exudate. Leaves deciduous, alternate but apically crowded, ovate, acute to acuminate, basally cordate, 3 to 5-lobed in outline, 6–40 cm long, 6–35 cm broad, the petioles 2.5–7.5 cm long. Flowers several to many in greenish cymes, yellowish, bell-shaped; sepals 5, broadly deltoid. Male flowers many with 10 stamens, 5 united at the base only, 5 united into a column. Female flowers borne singly, with elliptic 3-celled, triovulate ovary with 3 spreading bifurcate stigmata. Capsules, 2.5–4 cm long, finally drying and splitting into 3 valves, all or two of which commonly have an oblong black seed, these ca 2 x 1 cm (Morton, 1977; Little et al., 1974).

Germplasm

Reported from the Central and South American Centers of Diversity, physic nut, or cvs thereof, is reported to tolerate Slope. There is an endemic species in Madagascars *J. mahafalensis*, with equal energetic promise. ($2n = 22$)

Distribution

Though native to America, the species is almost pantropical now, widely planted as a medicinal plant which soon tends to establish itself. It is listed, e.g., as a weed in Brazil, Fiji, Honduras, India, Jamaica, Panama, Puerto Rico, and Salvador (Holm et al, 1979).

Ecology

Ranging from Tropical Very Dry to Moist through Subtropical Thorn to Wet Forest Life Zones, physic nut is reported to tolerate annual precipitation of 4.8 to 23.8 dm (mean of 60 cases = 14.3) and annual temperature of 18.0 to 28.5°C (mean of 45 cases = 25.2).

Cultivation

Grows readily, from cuttings or seeds. Cuttings strike root so easily that the plant can be used as an energy-producing living fence post.

Harvesting

For medicinal purposes, the seeds are harvested as needed. For energy purposes, seeds might be harvested all at once, the active medicinal compounds might be extracted from the seed, before or after the oil, leaving the oil cake for biomass or manure.

Yields and Economics

According to Gaydou et al (1982), seed yields approach 6–8 MT/ha with ca 37% oil. They calculate that such yields could produce the equivalent of 2,100–2,800 liters fuel oil/ha (see table under Energy). In Madagascar, they have ca 10,000 ha of purging nut, each producing ca 24 hl oil/ha for a potential production of 240,000 hl (Gaydou, et al, 1982).

Energy

The clear oil expressed from the seed has been used for illumination and lubricating, and more recently has been suggested for energetic purposes, one ton of nuts yielding 70 kg refined petroleum, 40 kg "gasoil leger" (light fuel oil), 40 kg regular fuel oil, 34 kg dry tar/pitch/rosin, 270 kg coke-like char, and 200 kg ammoniacal water, natural gas, creosote, etc. In a startling study, Gaydou et al. (1982) compare several possible energy species with potential to grow in Malagasy. Oil palm was considered energetically most promising.

	Crop production MT/ha	Fuel production /ha	Energetic equivalent kwh/ha
Elaeis guineensis	18–20	3,600–4,000	33,900–37,700
Jatropha curcas	6–8	2,100–2,800	19,800–26,400
Aleurites fordii	4–6	1,800–2,700	17,000–25,500
Saccharum officinarum	35	2,450	16,000
Ricinus communis	3–5	1,200–2,000	11,300–18,900
Manihot eaculenta	6	1,020	6,600

Biotic Factors

Agriculture Handbook No. 165 lists the following as affecting *Jatropha curcas*: *Clitocybe tabescens* (root rot), *Colletotrichum gloeosporioides* (leaf spot), and *Phakopsora jatrophicola* (rust).

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Wednesday, January 7, 1998 by aw

Spondias purpurea L.

Anacardiaceae

Purple Mombin, Red Mombin, Spanish Plum

We have information from several sources:

Purple Mombin—Julia Morton, Fruits of warm climates

South American fruits deserving further attention.—Richard J. Campbell

Neglected Crops: 1492 from a Different Perspective.—J.E. Hernándo Bermejo and J. León (eds.).

Last update Wednesday, March 3, 1999 by ch

Purple Trillium

Trillium erectum L.

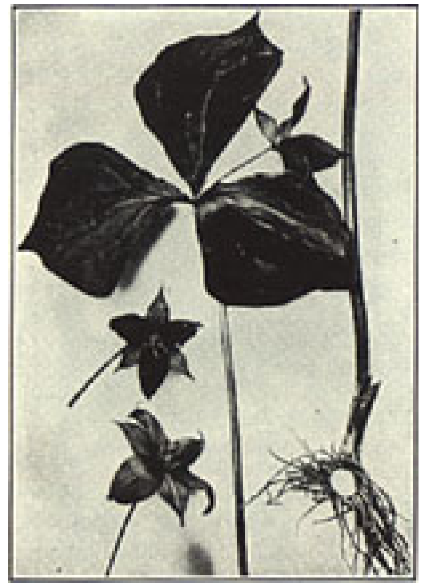

Figure 90.—Purple trillium (*Trillium erectum*)

Other common names.—Bethroot, trillium, red trillium, purple trillium, ill-scented trillium, birthroot, birthwort, bathwort, bathflower, red wake-robin, purple wake-robin, ill-scented wake-robin, red-benjamin, bumblebee root, daffy-downdilly, dishcloth, Indian balm, Indian shamrock, nosebleed, squawflower, squawroot, wood lily, truelove. Many of these names are applied also to other species of trillium.

Habitat and range.—This is a native plant growing in rich soil in damp, shady woods from Canada south to Georgia, Alabama, and Missouri.

Description.—Purple trillium is a low-growing plant from 8 to 16 inches in height, with a rather stout stem having three leaves arranged in a circle near the top. These are from 3 to 7 inches in length and of about the same width and are practically stemless. The flower, which appears from April to June, is borne singly at the end of the stem on a slender stalk. Its parts are arranged in threes which feature serves to identify the plant. The three petals, which are 1 1/4 inches long and one-half inch wide, are dark purple pink, greenish, or white. The flower has an unpleasant odor. It is followed by a reddish berry.

Part used.—The root, collected toward the close of summer.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

White Oak

Quercus alba L.

Other common names.—Stone oak, stave-oak.

White oak

Figure 116.—White oak (*Quercus alba*)

Habitat and range.—The white oak is found in woods from Maine to Minnesota and south to Florida and Texas but is most abundant in the North Central and Middle Atlantic States.

Description.—This tree is usually from 60 to 80 feet high, but in dense woods it sometimes reaches a height of 150 feet. The trunk attains a diameter of 3 to 4 feet with many wide-spreading branches. The leaves are red and hairy when young, becoming smooth and thin when older. In autumn they turn a beautiful red. The leaves are 4 to 7 inches long, borne on short stems, and are usually divided into five to nine lobes. When the leaves appear the very small greenish or yellowish flowers are produced. The male flowers are borne in slender, usually drooping spikelike clusters and the female flowers singly. The acorns mature in the autumn.

Part used.—The bark, preferably that from trunks or branches 10 to 25 years old, which should be collected in the spring. The outer layer is first scraped off.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Raphanus sativus L.

Cruciferae, Brassicaceae

Radish, Clover radish

We have information from several sources:

Asian Vegetables—Mas Yamaguchi

Midwest Vegetable Production Guide for Commercial Growers 2000

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Potential of Sugar Beet Nematode-Resistant Radishes and Mustard for Use in Sugar Beet Rotations—James M. Krall, David W. Koch, Fred A. Gray, and Li Mei Yun

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Daikon
Winter radish

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Samanea saman (Jacq.) Merr.

Mimosaceae
Rain tree

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

With a checkerd nomenclature, under *Enterolobium* in the Wealth of India, *Pithecellobium* in Common Trees of Puerto Rico, and Samanea in Woody Plants of Ghana, the rain tree is apparently widely traveled. Perhaps one of its most important uses in Latin America is as a shade tree, especially in parks, pastures, and roadsides. Improved growth, nutritive quality, protein content, and yield have been demonstrated by *Axonopus compressus*, a tropical forage grass, grown under *Samanea*. "The benefit by association was presumptively attributed to nitrogen made available in the soil by excretion or decomposition of the leguminous nodules." (Allen and Allen, 1981). The tree house in Walt Disney's "Swiss Family Robinson" was built in a rain tree 60 m tall with a canopy 80 m in diameter. Simon Bolivar is said to have encamped his entire liberation army under the "saman de guerra" near Maracay, Venezuela. In Malagasy, it is grown as shade tree for cacao, coffee, patchouly, and vanilla. In Indonesia, it is recommended for nutmeg but not for tea. In Uganda, it is considered good for coffee, bad for tea. According to NAS (1980a), "Grass grows right up to the trunk because this species' leaflets fold together at night and in wet weather, allowing the rain to fall through." Like *Acacia, Ceratonia, Prosopis,* and *Tamarindus*, this produces copious pods with a sweet pulp, attractive to children and animals alike. Pods can be ground up and converted to fodder or for that matter alcohol as an energy source. A lemon-like beverage can be made from the pulp. The wood is soft, lightweight (spec. grav. 0.44; 720–880 kg/m^3) of medium to coarse texture, fairly strong, takes a beautiful finish but is often cross-grained and difficult to work. It is used for furniture, general construction, and interior trim, for boxes and crates, panelling, plywood, and veneer. Central American oxcart wheels are made from cross sections of trunks. It is used for boat building in Hawaii, where it is also famous for making "monkeypod" bowls. Shavings from the wood are used for making hats in the Philippines. The tree yields a gum of inferior quality which could be used as a poor man's substitute for gum arabic. Like most other mimosaceous trees, this is an important honey plant. Rain tree is one host of the lac insect, which, however, produces a poor quality lac, reddish and rather brittle (C.S.I.R., 1948–1976).

Folk Medicine

According to Hartwell (1967–1971), the root decoction is used in hot baths for stomach cancer in Venezuela. Rain tree is a folk remedy for colds, diarrhea, headache, intestinal ailments, and stomachache (Duke and Wain, 1981). The alcholic extract of the leaves inhibits *Mycobacterium tuberculosis* (Perry, 1980). The alkaloid fraction of the leaves is effective on the CNS and PNS. In Colombia, the fruit decoction is used as a CNS-sedative. The leaf infusion is used as a laxative (Garcia-Barriga, 1975). In the West Indies, seeds are chewed for sore throat (Ayensu, 1981).

Chemistry

Per 100 g, the green leaf is reported to contain 47.8 g H_2O, 10.2 g protein, 2.1 g fat, 22.2 g insoluble carbohydrate, 15.7 g fiber, and 2.0 g ash. On an oven-dry basis, the leaves contain ca 3.2% N. Gohl, 1981 tabulates as follows:

		As % of dry matter						
	DM	CP	CF	Ash	EE	NFF	Ca	P
Fresh twigs, late vegetative, Malaysia	38.9	24.7	22.1	4.4	2.8	46.0	0.55	0.26
Fresh leaves, Thailand	39.1	22.1	29.4	6.0	7.0	35.5	1.42	0.21
Fresh leaves, Trinidad	34.4	30.0	29.0	3.5	3.5	34.0		
Pods, Jamaica	79.5	12.8	14.5	2.4	0.7	69.6	0.29	0.32
Pods, fallen, Trinidad	85.0	18.0	10.9	4.6	1.4	65.1		
Seeds, Jamaica	86.5	31.6	14.0	4.3	6.0	44.1	0.16	0.34

Whole pods contain: moisture, 15.3; ash, 3.2; fat, 2.1; protein, 12.7; 11.4; and carbohydrates, 55.3%. Kernels contain: moisture, 16.1; ash, 3.0; fat, 1.3; protein, 10.6; CF, 10.8; and carbohydrates, 42.0%. The bark contains two alkaloids—$C_8H_{17}ON$ and $C_{17}H_{36}ON_3$ (pithecolobine; LD_{50} in mice 40–225 μg/kg)—and a saponin (samarin), which yields on hydrolysis an aglucone of the formula $C_{23}H_{36}O_4$, arabinose, glucose and rhamnose. Samarin is an irritant to isolated intestine. Other constituents identified in the bark are gallic acid, glucose, sucrose, fatty acids and a phytosterol. Wood contains: lignin, 30.44; cellulose, 50.89; α-cellulose, 38.35; and ash, 0.27% (C.S.I.R., 1948–1976). Hager's Handbook (List and Horhammer, 1969–1979) reports hexacosanol, lupeol, α-spinasterol, octaconsanolic acid, α-spinasterol-β-D-glucoside, α-spinasterone, and lupeone from the rind, hentriacontane and octacosanol from the leaves; α-spinasterol, and its β-D-glucoside, palmitic, and stearic acid from the seed kernel, three flavonoids and kaempferol from the testae, and α-spinasterol and octacosabolic acid from the wood.

Description

Large umbraculiform tree to as much as 60 m tall, the crown to 80 m broad, covering 1/5 hectare, trunk to 1.5 m DBH, unarmed, with gray rough furrowed bark. Leaves alternate, evergreen, bipinnate, 25–40 cm long, with 2–6 pairs of pinnae, each of which bears 6–16 paired stalkless leaflets, with a glandular dot between each pair. Flower heads clustered near the end of twigs, each cluster on a green hairy stalk 7–10 cm long, with many small tubular pinkish-green flowers, calyx and corolla 5-toothed. The many stamen united to form a tube near their bases, seed pods oblong, flat, arcuate, black, 20–30 cm long, with a raised border, each with several oblong reddish-brown seeds ca one cm long.

Germplasm

Reported from the South American Center of Diversity, rain tree, or cvs thereof, is reported to tolerate drought, poor soils, waterlogging and weeds. ($2n = 26$)

Distribution

Native from the Yucatan Peninsula and Guatemala to Peru, Bolivia, and Brazil. Widely planted and naturalized elsewhere in continental tropical America from Mexico southward, throughout the West Indies (except Bahamas), and in Old World tropics. Grown also in southern Florida (Little and Wadsworth, 1964).

Ecology

Ranging from Subtropical Very Dry to Moist through Tropical Dry to Moist Forest Life Zones, rain tree is reported to tolerate annual precipitation of 6 to 25 dm (mean of 49 cases = 14.0), annual temperature of 21.6 to 28.5°C (mean of 36 cases = 25.8), and pH of 6 to 7.

Cultivation

Easily propagated from seeds and cuttings. Young specimens transplant easily.

Harvesting

Lopped for forage or timber at any time, it can be maintained at any height by periodical pruning.

Yields and Economics

A full grown tree 15 years old is said to yield ca 200–275 kg pods per season, which translates to 10 MT/pods, if we can crowd 50 productive trees to the hectare. A single tree 5 years old has been said to yield nearly 550 kg green forage (assuming 50% moisture = ca 275 kg DM). Assuming 50 trees to the hectare, that translates to nearly 14 mT forage in leaves.

Energy

According to figures in the Wealth of India, 10 MT pods would yield 1150 liters of absolute alcohol, roughly 5–10 barrels ethanol/ha/yr. It is reportedly used as an alcohol source in Colombia. Use of the wood as a fuel is not often reported. In the Philippines, Quisumbing (1951) reports the branches and trunk are used as firewood.

Biotic Factors

Browne (1968) lists: Fungi. *Fomes annularis, Ganoderma australe, Ganoderma lucidum.* Coleoptera. *Anomala antiqua, Apate monachus, Lepropus chrysochlorus, Oncideres tessellata.* Hemiptera. *Ferrisia virgata, Hemiberlesia lataniae, Icerya aegyptiaca, Icerya formicarum, Kerria lacca, Ptyelus flavescens, Rastrococcus iceryoides.* Isoptera. *Coptotermes amanii*. Lepidoptera. *Attacus atlas, Homona coffearia, Indarbela quadrinotata, Melisomimas metallics.* Mammalia. *Callosciurus caniceps.* Also occuring on *Samanea saman* are *Hypomyces haematococcus;* root knot nematodes, *Meloidogyne* sp.; and the leaf spot *Microstroma pithecolobii.*

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Complete list of references for Duke, Handbook of Energy Crops

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Rauvolfia serpentina

Contributor: Pankaj Oudhia

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Scientific Name: *Rauvolfia serpentina* (L.) Benth. ex Kurz. (Syn. *Ophioxylon sepentinum* L.)

English Name: Rauvolfia root, serpentine

Trade Name: Serpentine Roots

Common (Indian) Names:
Assamese: Arachoritita
Bengali: Chandra
Hindi: Chandrabhaga, Chota-chand, Sarpagandha
Canarase: Sarpangandha, Sarpagandhi, Shivanabhiballi, Sutranavi, Patalagandhi
Malyalma: Churannavilpori, Suvapavalporiyam
Marathi: Harkaya: Harki
Oriya: Patalagarur, Sanochado
Sanskrit: Sarpagandha, Chandrika, Patalguruda
Tamil: Chevanamalpodi
Telugu: Patalaguni, Patalagaruda, Sarpagandha

Family: Apocynaceae

Habitat: Moist forests shady places near rain-forest.

Status: The natural reserves of this plant are declining, especially after reports of its medicinal properties appeared in literatures. International Union for the Conservation of Nature and Natural Resources (IUCN) has kept this plant under endangered status.

Distribution: The snake-weed genus includes about 50 species, this has fairly wide area of distribution, including the tropical part of the Himalayas, the Indian peninsula, Sri Lanka, Burma, and Indonesia.

Related Species

Rauvolfia tetraphylla L. (Syn. *R. canescens* L.; *R. heterophylla* Roem. and Schult.). In Hindi, it is named Barachandrika. Found in Bihar, Orissa, Chhattisgarh, Madhya Pradesh, West Bengal, Andhra Pradesh, Tamil Nadu, and Kerala states of India. Native to West Indies. Its roots are often used as an adulterant of *R. serpentina*.

Rauvolfia vomitoria Afzel. and *R. caffra*. Both are African species. Having medicinal properties similar to R. serpentina but with low total alkaloid content and also low in serpentina.

Botany: An erect perennial shrub with a long, irregularly, nodular, yellowish root stock.

Leaves: In whorls of 3, thin, lanceolate, acute, bright green above and pale beneath.

Flowers: in irregular corymbose cymes, white, often tinged with violet.

Fruit: Drupe, single or didymous, shining black, the inflorescenece with red pedicels and calyx and white corolla.

Flowering Time: March to May in Indian conditions.

Natural Components: The root contains ophioxylin (an alkaloid having orange colored crystalline principle), resin, starch and wax. The total alkaloid yield is 0.8%. Five crystalline alkaloids isolated are ajmaline, ajmalicine, serpentine, serpentinine, and yohimbine.

Useful Parts: Roots and leaves.

Medicinal Properties and Uses: According to Ayurveda root is bitter, acrid, heating, sharp, pungent and anthelminic. Drug Rauvolfia consists of air-dried roots. Rauvolfia preparations are used as antihypertensive and as sedative. It is also used for the treatment of various central nervous system disorders associated with psychosis, schizophrenia, insanity, insomnia, and epilepsy.

Ayurvedic Preparations: Sarpagandha ghanavati, sarpagandha yoga, Sarpagandha churna, Mahesvari vati etc.

Cultivation: This plant is under cultivation in India, Sri Lanka, and Java. Experiments on cultivation are in progress in the United States.

Climate: it grows luxuriantly well where the rainfall is 2500 mm or more. The areas having more equable climatic variations seem to be more suited than the areas having higher climatic variations.

Soil: It prefers soil with plenty of humus and rich in nitrogenous and organic matter with good drainage. Alkaline soils are not suitable for commercial cultivation.

Propagation: Can be propagated both through seeds and vegetatively, but propagation by seed is preferred.

Seed Rate: 10 kg/ha.

Nutrients: Generally organic cultivation is practiced. Initially before sowing 10–15 tonnes of farm yard manures/ha are used.

Spacing: 45 × 30 cm.

Plant Protection: Serious and major infestation of any insect of diseases have not been reported.

Maturity Period: 3 Years. At this time the subaerial parts dry and main root reach a depth of 0.9

meters.

Average Yield: 2700 to 3300 kg dried roots/ha and 8–10 kg seed.

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Rhizophora mangle L.

Rhizophoraceae
Red mangrove

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Timber of the mangrove is used for cabinetry, construction, piling, poles, posts, shipbuilding, and wharves. Duke (1972) notes that in Panama it is being studied for its telephone pole potential. In the Choco it is being exploited for the pulp industry. Cattle will eat mangrove leaf meal after $CaCO_3$ has been added to raise the pH. Morton (1965) even describes a wine made from mangrove leaf and raisin. Amerindians ate the starchy interior of the fruit and hypocotyl during hard times (Morton, 1965). Dried hypocotyls have been smoked like cigars. Dried leaves have been used in Florida as a tobacco substitute. African children use the dried fruits as whistles (Irvine, 1961). In Costa Rica, concentrated bark extracts are used to stain floors and furniture, a habit shared with Africa's Ashantis. Cuna Indians make fishing lines from the brown branches. Although some have speculated that Rhizophora plantings can be used to extend or preserve precarious shores. Hou resurrects a quote suggesting the contrary "mangrove follows the silting up of a coastal area rather than precedes and initiates the accumulation of mud or other soil...it establishes itself merely on accrescent coasts" (Hou, 1958). Morton (1965), however, notes that the American Sugar Company introduced it in 1902 as a soil retainer on the mud flats of Molokai. According to Garcia-Barriga (1975) Kino de Colombia, resin from the red mangrove, has several medicinal uses.

Folk Medicine

One Cali doctor reports a cure of throat cancer, with gargles of mangrove bark (Garcia-Barriga, 1975). Reported to be astringent, emmenagogue, expectorant, hemostat, styptic, and tonic, red mangrove is a folk remedy for angina, asthma, backache, boils, ciguatera, convulsions, diarrhea, dysentery, dyspepsia, elephantiasis, enuresis, epistaxis, eye ailments, fever, filariasis, hemoptysis, hemorrhage, inflammation, jaundice, leprosy, lesions, leucorrhea, malignancies, scrofula, short wind, sores, sorethroat, syphilis, tuberculosis, uterorrhagia, and wounds (Duke and Wain, 1981; Morton, 1981).

Chemistry

Per 100 g, the leaf is reported to contain, 10.7 g protein, 3.4 g fat, 77.0 g total carbohydrate, 14.5 g fiber, and 8.9 g ash (Duke and Atchley, 1983 in ed). Per 100 g, the leaf meal is reported to contain 5.6 g H_2O, 7.5 g protein, 3.6 g fat, 59.3 g NFE, 13.9 g fiber, 10.1 g ash, 1.350 mg Ca, 140 mg P, 15.2 mg Fe, 650 mg K, 600 µg β-carotene equivalent, 88 mg Mg, 30 mg Mn, 3.5 mg Cu, 0.52 mg Co, 4.3 mg Zn, 54 mg I, 13 mg thiamine, 19 mg riboflavin, 240 mg niacin, 32 mg folic acid, 5.3 mg pantothenic acid, and 46.0 mg choline (Morton, 1965). I suspect that the vitamins are off by a magnitude or two. Something is wrong with the amino acid figures as well, but perhaps the proportions are worth repeating, arginine 1.1 : lysine 0.9 : methionine 0.421 cystine 0.301 : glycine 0.801. Another analysis of the leaf tablets shows, per 100 g, 790 mg S, 8.3 mg Cu, 920 mg Na, 8.3 mg B, 224 µg chlorophyll, 0.68 µg folic acid, 5.2 ppm cobalt, and 144 ppm F (Morton, 1965). Fresh leaves contain 65.6% moisture and ca 0.1% chlorophyll. Dry bark contains 10–40% tannin, aerial roots ca 10.5%.

Description

Tree 5–20(-30) m tall, 20–50(-70) cm in diameter with arching stilt roots 2–4.5 m high. Bark gray or gray-brown, smooth and thin on small trunks, becoming furrowed and thick; inner bark reddish or pinkish. Leaves opposite or elliptical, acute at tip and base, entire, without visible veins, thick, leathery, glabrous, 6–12 cm long, 2.5–6 cm wide, shiny green upper surface, yellow-green, black-dotted underneath. Petiole 1.5–2 cm long. Stipules paired, leaving ring scar. Flowers mostly 2–4 on forked stalk 4–7 cm long in leaf axil, pale yellow, ca 2 cm across. Bell-shaped hypanthium ca 5 mm long with 4 widely spreading, narrow, leathery, pale yellow sepals 12 mm long; petals 4, 1 cm long, curved downward, whitish but turning brown, cottony on inner side; stamens 8, stalkless. Ovary inferior conical, 2-celled with 2 ovules each cell; style slender; stigma 2-lobed. Berry, ovoid, 3 cm long, dark brown. Seed 1, viviparous, becoming cigar-shaped, to 25 cm long and 12 mm in diameter (Little, 1983).

Germplasm

Reported from the African, American, and Polynesian Centers of Diversity, red mangrove, or cvs thereof, is reported to tolerate diseases, insects, pests, salt, and waterlogging (NAS, 1980a, Little, 1983). ($2n$ = 36 in other species of Rhizophora)

Distribution

Tropical America from Bermuda through West Indies to Florida. Northern Mexico south to Brazil and Ecuador including Galapagos Islands and north-western Peru. Western Africa from Senegal to Nigeria; Angola, Melanesia, Polynesia (Little, 1983).

Ecology

Estimated to range from Tropical Moist to Rain through Subtropical Moist to Rain Forest Life Zones, red mangrove is reported to tolerate annual precipitation of 14.9 to 23.0 dm (mean of 7 cases = 18.8), annual temperature of 21.6 to 25.6°C (mean of 6 cases = 23.5), and estimated pH of 6.0 to 8.5. Mostly on brackish and saline silt of depositing shorelines.

Cultivation

Since natural regeneration is so good, this species is not often cultivated, but it has been planted, for example, to stabilize the banks of brackish aquaculture enclosures. Direct seeding yields ca 90% survival in Rhizophora and Avicennia. Air-layering and the planting of propagules have both been successful in Florida (NAS, 1980a).

Harvesting

No data available.

Yields and Economics

In Florida, red mangrove is said to fix 4 MT carbon/ha/yr (Murry and Benemann, 1981). Cannell (1982) cites data showing that *Rhizophora mangle* spaced at 1,100 trees/ha, averaged 7–8 m tall, and an LAI of 4.4. The stem wood and bark on a DM basis weighed 28 MT/ha, proproots 14.4 MT, the branches 12.7, the foliage 7.8, and the roots estimated at 50 MT/ha for a total standing biomass of ca 113 MT/ha. The current annual increment (CAI) of stem wood and stem bark was 3.07 MT/ha/yr, foliage 4.75 (Cannell, 1982). Litterfall was 0.84 g/m^2/day wood, 1.3 g/m^2/day leaves. Thus the annual foliage fall was close to 5 MT/ha/yr. These data were taken in a mangrove swamp in Puerto Rico. Standing biomass of the Pacific mangrove (*R. brevistyla*), from the more fertile Pacific side of Panama, was 280 MT/ha. (Duke, 1981b).

Energy

Following the phytomass files (Duke, 1981b), annual productivity is estimated to range from 5 to 20 MT/ha (with 9 reported in Puerto Pico). Wood (sp. grav. 0.9–1.2), an important source of charcoal, described as excellent for fuel and charcoal (Little, 1983).

Biotic Factors

Durable in the soil but susceptible to attack by dry-wood termites (Little, 1983). Morton (1965) reports a Cerospora (sic) leaf spot in Florida. Agriculture Handbook No. 165 notes *Anthostomella rhizomorphae* on leaves.

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Academy of Sciences, Washington, DC.

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Last update Thursday, January 8, 1998 by aw

Rheum spp.

Polygonaceae

Chinese rhubarb, Garden rhubarb, Pie-plant, Rhubarb, Wild rhubarb

We have information from several sources:

Midwest Vegetable Production Guide for Commercial Growers 2000

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Rhubarb—Cooperative Extension Service, Purdue University, West Lafayette, Indiana.

Smooth Sumac

Rhus glabra L.

Figure 98.—Smooth sumac (*Rhus glabra*)

Other common names.—Mountain sumac, upland sumac, scarlet sumac, sleek sumac, white sumac, Pennsylvania sumac, shoemake, vinegar tree.

Habitat and range.—Smooth sumac occurs in dry soil thickets and waste grounds from Nova Scotia to British Columbia and south to Florida, Mississippi, and Arizona.

Description.—Although sometimes attaining the height of a small tree, the smooth sumac is more frequently found as a rather handsome shrub 2 to 12 feet high, with smooth, brownish-gray trunk and branches. Its leaves are very long from 1 to 3 feet, and consist of from 11 to 31 leaflets, each leaflet being about 2 to 4 inches in length and about half as wide, lance-shaped, pointed, sharply toothed and whitened beneath. From June to August the plant bears greenish yellow flowers in dense pyramidal clusters at the ends of the branches. These are followed by roundish, flattened fruits or berries, covered with short, crimson hairs. Each fruit contains a smooth, 1-seeded stone.

Part used.—The leaves, bark, and berries, the latter being gathered while the downy covering ia still on them, which gives the berries their sour taste.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Zizania aquatica L.

Zizania palustris L.

Poaceae or Graminae

Wild rice, Indian rice, water oats

We have information from several sources:

Wild Rice: Domestication of a Native North American Genus—Ervin A. Oelke

Asian Vegetables—Mas Yamaguchi

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Wild Rice: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States. Interregional Research Project IR-4, IR Bul. 1 (Bul. 828 New Jersey Agr. Expt. Sta.).

Joublan, J.P., M. Berti, H. Serri, R. Wilckens, F. Hevia, and I. Figueroa. 1996. Wild rose germplasm evaluation in Chile. p. 584-588. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA.

Wild Rose Germplasm Evaluation in Chile*

Jean Paul Joublan, Marisol Berti, Humberto Serri, Rosemarie Wilckens, Felicitas Hevia, and Inés Figueroa

A number of *Rosa* species (Rosaceae) native to southern Europe and North Africa were introduced to Chile by Spanish colonizers. These species are now widely distributed in Chile from Santiago (33°S) to Aisen (45°S) and from sea level to 2000 m (Navas 1976; Hoffmann et al. 1992). Chile annually exports between 3600 to 4500 t of dehydrated rosehips to Europe.

Rose hips are the enlarged floral cups (receptacles) which surround numerous small, hard dry fruits (achenes) commonly called seeds. Rose hips are bright orange and oval and become fleshy but are not true fruits (Fig. 1). They are collected from the wild by peasants and their families. Rose hips are brought to the processing plant where they are dehydrated and seeds are removed; dry pulp is exported, mainly, to European countries. The dry pulp is used in herbal teas and marmelades and has been used as a pigment for laying hens and broiler chickens (Burgos 1976; Cortés 1976; Larraín 1978). It contains large amounts of vitamin C (1000-2000 mg/100g), riboflavin, pectins, nicotinic acid, and malic acid (Israel and Benado 1977). The vitamin C content varies with the site of collection, harvest date, and dehydration methods (Galeb 1976; Ziegler et al. 1986).

The achenes are a by-product of pulp extraction and have been used to feed pigs, hens, chickens, and chinchilla rabbits (Villagrán 1976; Moraga 1978; Peña 1978; Fuente et al. 1979; Seitz 1979; Barbet 1987; Voullieme and Hiriart 1978, 1980a, b). Achenes contain 8% oil composed by oleic, linoleic, linolenic, and transretinoic acids (Soto 1978). This oil is used in the cosmetic industry and is reported to accelerate the regeneration of damaged tissue, and promote wound healing (Valladares et al. 1985, 1986).

Information about the *Rosa* species that exist in Chile is scarce. "Rosa mosqueta" is the common name used for at least three species [*Rosa moschata*, *R. rubiginosa* (= *eglanteria*) and *R. canina*] which are collected from the wild. Morphological differences are evident in the wild material indicating that more than one species and probably several subspecies and ecotypes have developed since introduction. The objective of this study was to evaluate differences in characteristics, size, pulp thickness, and vitamin C of rose hips from wild material existing between latitudes 36° and 38°S where most processing plants exist.

METHODOLOGY

Rose hips and shoots were collected at 30 locations between Cauquenes (36°S) and Perquenco (38°S), Chile, and brought to the University of Concepción, Chillán. Locations sampled were at altitudes from 0 to about 2000 m. Forty hips were collected from each plant sampled and 20 hips were used to measured diameter, length, pulp thickness and the other 20 were used to determine weight, and industrial pulp yield. Vitamin C content was obtained from a sample of 20 hips, homogeneous in color. Samples were frozen and ascorbic acid content was measured according to the AOAC method (1969).

RESULTS

Preliminary results determined that rose hips were very variable among and within locations. All fruits collected from locations in the northern part of the sampled areas had thorns on fruit pedicels and some sparcely distributed thorns in the fruits. Clearly most plants South of Angol (42°S) did not have thorns in the fruit pedicel. Thorns in fruit pedicels have been used to classified species. According to Navas (1976), *R. canina* pedicels are glabrous and *R. rubiginosa* has thorns on the pedicels, and *R. moschata* has pubescent pedicels. Flowers are needed for a definitive classification.

Average hip length and diameter vary between 13 to 24 mm and 9 to 14 mm, respectively. Pulp thickness vary between 2.3 to 1.1 mm and mean fruit weight vary between 2.5 to 2.7 g (Table 1). Industrial pulp yield (kg of fresh fruit needed to produce 1 kg of dry pulp) vary between 2.7 to 5.3 kg. Neighboring plants differ significantly in their fruit length, diameter, pulp thickness, weight, and industrial pulp yield. Ascorbic acid content varied among locations, but this was related directly with the moisture content of the fruits (Table 1). Variability in data collected is influenced by the environment and the genetic background. Further evaluations will be performed to select plants with the desired characteristics for commercial planting, management, and industrial processing. Selection is an important goal for processing companies because they would receive a more uniform product that could have a better industrial yield.

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Mejoramiento de la calidad nutricional. Agro-Sur 8(1):18-20.

- Voullieme, A. and M. Hiriart. 1980b. Aquenio de rosa mosqueta (*Rosa eglanteria* L.) Alternativas alimentarias a nivel pecuario. 3. Digestibilidad in vitro y efecto del tamaño de partícula sobre su medición. Agro-Sur 8(2):104-105
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*Contribution from the Plant Production Department, Universidad de Concepción, Chillán, Chile. This project has been financed by Soc. Agrícola y Forestal Casino Ltda. and FONTEC-CORFO project No. 95-0491.

Table 1. Variability in rose hips collected at 60 different locations in Chile.

Location	Ascorbic acid (mg/100 g)	Length (mm)	Diameter (mm)	Fruit weight (mg)	Pulp thickness (mm)
Angol	1181	22	13	2170	1.8
Antuco	5289	20	14	1730	1.5
Antuco	2085	20	13	1378	1.5
Cabrero	1474	21	14	1642	1.6
Cabrero	2082	21	13	1342	1.5
Cauquenes	2534	16	11	1160	1.1
Cauquenes	4469	17	11	1065	1.4
Cerro Negro	1910	18	13	1553	1.7
Cerro Negro	3493	22	13	1613	1.7
Co Colorado	3916	19	14	1423	1.4
Colliguay	2129	20	13	1630	1.7
Collipulli	4254	21	13	1163	1.5
Collipulli	2752	19	14	1520	1.6
Florida	3447	20	13	1540	1.6
Florida	2157	21	13	1660	1.6
Hualqui	1825	20	13	1440	1.5
Huepil	3675	20	12	1448	1.5
Laja	2318	20	13	1395	1.4
Larqui	4151	18	13	1588	1.5
Las Rosas	3492	19	11	1388	1.8
Las Rosas	2064	24	13	1817	2.1
Las Rosas	3976	21	13	1875	1.9
Las Rosas	1300	20	15	2555	2.4

Lolenco	2397	20	14	1993	1.6
Lumaco	2503	17	10	793	1.4
Lumaco	4437	16	11	928	1.4
Lumaco	3013	20	12	1753	1.7
Lumaco	2666	21	11	1545	1.9
Millantu	3226	19	12	1268	1.5
Mininco	2566	19	12	1472	1.5
Mulchen	3624	20	12	1355	1.9
Nacimiento	4656	19	13	1470	1.5
Nereo	6694	18	14	1585	1.7
Nereo	3435	19	13	1510	1.6
Ninhue	2175	20	13	1630	1.5
Ninhue	2542	13	9	555	1.2
Paso Hondo	3110	21	13	1453	1.5
Paso Hondo	4156	21	13	1538	1.6
Pemuco	3835	18	12	1248	1.5
Perquenco	4097	23	14	1538	1.6
Portezuelo	1095	21	14	1698	1.6
Portezuelo	1389	19	13	1598	1.7
Puente Perales	3075	19	12	1253	1.4
Quilaco	2923	20	12	1438	1.5
Quilleco	2281	18	11	815	1.3
Quirihue	4221	21	14	1598	1.5
Quirihue	3091	19	14	1715	1.5
Rere	2677	22	13	1523	1.6
Rere	2699	22	14	1615	1.6
San Nicolas	2382	17	11	1065	1.5
San Nicolas	1968	19	13	1445	1.6
San Rosendo	2901	21	13	1623	1.5
Sn. Carlos Pur	3480	23	14	1660	1.8
Sta. Barbara	3391	22	11	1063	1.4
Tomeco	2680	18	13	1365	1.5
Traiguen	2681	21	13	1598	1.6
Trintre	2250	16	10	835	1.4
Yumbel	4438	20	14	1523	1.6

Yumbel	2537	21	13	1440	1.6
Yungay	--	19	14	--	1.5
Yungay	4072	20	13	1498	1.6
LSD (0.05)		1	1	33	0.1

Fig. 1. Rosehips fruits at harvest time in Chile.

Last update August 24, 1997 aw

Rosmarinus officinalis L.

Lamiaceae (Labiatae)

Rosemary

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Last update Monday, March 2, 1998 by aw

Rue

Herb of Grace

Rutaceae *Ruta graveolens* L.

ADDRESS>Source: Magness et al. 1971

The plant is a perennial herb, woody at the base, up to 2 feet in height. The leaves are much divided and have a very strong odor. In ancient times rue was much used as a flavoring and for medicinal purposes. It is now used to some extent by people who like bitter flavors in cookery and beverages. The volatile oil, distilled from the whole plant, is used in aromatic vinegar and toilet preparations.

Last update July 1, 1996 bha

Sorrel, Garden

Sourgrass

Polygonaceae *Rumex acetosa* L.

Source: Magness et al. 1971

Garden sorrel is a perennial plant, the roots of which persist for several years. It is grown to a limited extent for the leaves, gathered in early spring and used as greens or pot herbs. The stems are erect, reaching 3 or more feet in height. Rosette leaves are thin, light green and oblong. Stem leaves are narrow and pointed. All leaves are glabrous and have a tart flavor.

Season, start of growth to first harvest: About 4 weeks.

Production in U.S.: No data; very limited.

Use: As pot herbs. Part consumed: Young leaves.

Last update June 28, 1996 bha

Sorrel, French

Polygonaceae *Rumex scutalus* L.

Source: Magness et al. 1971

French sorrel differs from garden sorrel, which see, in that the stems are more branched and less upright. The leaves are somewhat fleshy. Rosette leaves have long petioles and are somewhat heart-shaped, while stem leaves are more pointed on short petioles.

Season, from start of growth to first harvest: 2 months, but harvested throughout the summer.

Production in U.S.: No data, very limited.

Use: As pot herb.

Part consumed: Leaves only.

Last update June 28, 1996 bha

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Secale cereale L.

Poaceae

Rye

We have information from several sources:

Handbook of Energy Crops—James A. Duke. 1983. unpublished.

Rye: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops for Canadian Agriculture—Ernest Small

Winter Cover Crops—Their Value and Management

Magness—J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Outside Links

ECP/GR Challenges in Rye Germplasm Conservation—by T. Gass, W. Podyma, J. Puchalski, S.A. Eberhart (compilers)—Link to the publication on the International Plant Genetic Resources Institute web site

Safflower seed oil

Carthamus tinctorius L.

Compositae or Asteraceae

Source: Magness et al. 1971

Production of sallower seed for oil has increased greatly in the U.S. during the past 20 years, from about 17,000 acres in 1949 to over 300,000 acres in 1968. The plant is a branching annual with spiny leaves that are nearly as broad as long. Seeds are borne partially exposed in globular heads, with 15 to 50 seeds per head and 1 to 5 heads per plant. Seeds are elongated, 0.25 to 0.33 inch long and a third as much in diameter. The seed contains 32 to 40 percent oil. The seed coats are fibrous, so seeds are decorticated before pressing or putting through expellers to obtain the oil. Most of the oil is used for edible purposes, but it is also comparable to linseed oil for industrial use. The press cake is a valuable high protein feed supplement for cattle, sheep and poultry.

See also:Safflower.

Last update July 1, 1996 bha

Salsify

Oyster plant, Vegetable oyster

Compositae, Asteraceae *Tragopogon porrifolius* L.

Source: Magness et al. 1971

Salsify is grown for its edible roots, which when cooked have a flavor resembling that of oysters. Although naturally a perennial, the crop is produced as an annual. The leaves are smooth and very long and slender. The roots are white, long and slender, about I inch diameter at the crown, 10 inches to a foot long, and tapering. Cultural conditions are similar to carrots, but plants have a smaller leaf surface and require a longer growing season than carrots.

Season, seeding to harvest: 4 months or more.

Production in the U.S.: 34 acres reported in 1954 census.

More in home gardens.

Use: As cooked vegetable. Part of plant consumed: Roots only.

Last update July 1, 1996 bha

Scorzonera hispanica L.

Asteraceae

Scorzonera, Black salsify

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Tuesday, June 16, 1998 by aw

Scolymus hispanicus L.

Asteraceae

Spanish salsify

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Tuesday, June 16, 1998 by aw

Elderberry

Caprifoliaceae *Sambucus* sp.

Eastern elderberry *S. canadensis* L.

Western elderberry *S. coerulea* Raf.

Source: Magness et al. 1971

Elderberry plants are large shrubs, or small trees, sometimes up to 20 feet, cultivated to a limited extent in the U.S. for the fruit. Leaves are large and compound. Stems are hollow or pithy. Fruits are produced in large flat clusters 6 to 9 inches across. Individual berries are small, about 0.16 to 0.25 inch diameter, globose, with prominent seeds. Colors vary from red to blue-black. Fruits are harvested from wild in considerable quantities. There are a few commercial plantings of a selected variety named Adams.

Season, bloom to harvest: 60 to 90 days.

Production in U.S.: No data. About 500 tons.

Use: Culinary, jelly, wine.

Part consumed: All in culinary, juice in jelly and wine.

Last update February 18, 1999 by ch

Sand dropseed

Gramineae, Poaceae *Sporobolus cryptandrus* (Torr.) A. Gray

Source: Magness et al. 1971

This is a tufted, native bunchgrass abundant in the Southern Plains and from Idaho and Oregon southward. It is most prevalent on sandy soil. Plants are 2 to 3 feet tall, with solid stems and rather numerous leaves up to 12 inches long and 0.25 inch wide. Roots are coarse and deep-penetrating. The plants produce a fairly large amount of foliage which is eaten readily by livestock while green, but sparingly when ripe. If not overgrazed, stands tend to increase in density. It produces seed in abundance and is useful for reseeding depleted range land. Its relatively low palatability, however, limits its overall usefulness.

Last update June 28, 1996 bha

Sassafras

Sassafras variifolium (Salisb.) Kuntze.

Synonyms.—*Sassafras officinale* Nees and Eberm.; *S. sassafras* (L.) Karst.

Other common names.—Ague tree, saxifrax, cinnamonwood, saloop, smelling-stick.

Habitat and range.—Sassafras is a native tree, growing in rich woods from southern Maine to Ontario, Michigan, and Kansas and south to Florida and Texas.

Figure 92.—Sassafras (*Sassafras variifolium*)

Description.—The sassafras occurs in the North as a shrub, but in the Southern States it sometimes attains a height of 100 feet. The leaves are variable in shape, some with three lobes and others with but one lobe on the side, shaped like a mitten. The yellowish green, fragrant flowers are borne in clusters which appear in early spring. Male and female flowers are borne on different trees. The fruit, which ripens in September, is about the size of a pea, dark blue, 1-seeded and is borne on a thick red stalk. All parts of the tree are aromatic

Part used.—The bark of the root, which is in reasonably constant demand collected in spring or autumn. The outer layer is discarded. The production of sassafras oil by distillation of the root and root bark is a small industry in the southeastern section of the country.*

*Information on the extraction of volatile oils from plants is contained in the following publication: Sievers, A.F. Methods of extracting volatile oils from plant material and the production of such oils in the United States. U.S. Dept. Agr. Tech. Bul. 16, 36 p. illus. 1928.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Satureja spp.

Lamiaceae (Labiatae)

Savory, Summer savory, Winter savory

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.
Summer Savory
Winter Savory

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.
Summer Savory
Winter Savory

Serenoa serrulata (Michx.) Hook. f.

syn: *Serenoa repens*

Palmae

Saw palmetto

We have information from several sources:

The Herb Hunters Guide—.Sievers, A.F. 1930.

Phytomedicines as a New Crop Opportunity— Loren D. Israelsen

Last update Thursday, July 09, 1998 by aw

Schisandra chinensis (Turcz.) Baill.

Schisandraceae

Wu wei zi, five flavor vine

We have information from several sources:

Chinese Medicinal Herbs: Opportunities for Domestic Production—Lyle E. Craker and Jean Giblette

Temperate Berry Crops—Chad Finn

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Selenicereus megalanthus K. Schum.

Cactaceae

Yellow pitaya, climbing cacti

We have information from several sources:

Climbing and Columnar Cacti: New Arid Land Fruit Crops—Yosef Mizrahi and Avinoam Nerd

New Crops as a Possible Solution for the Troubled Israeli Export Market —Y. Mizrahi and A. Nerd

New Fruits for Arid Climates—Yosef Mizrahi, Avinoam Nerd, and Yaron Sitrit

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Sesbania

Sesban

Leguminosae , Fabaceae *Sesbania exaltata* (Raf.) Rydb.

Source: Magness et al. 1971

This is an upright-growing annual legume reaching to 8 feet, grown only for turning under as a soil-improving crop. It produces a heavy tonnage for this purpose. On irrigated lands in the Southwest it is extensively grown as a summer crop and turned under prior to planting winter vegetables. It is grown mainly in areas of high summer temperatures.

Last update June 28, 1996 bha

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Akee, Seso Vegetal

Sapindaceae *Blighia sapida* Koen.

Source: Magness et al. 1971

Tropical evergreen tree of medium size. The flowers are produced laterally in racemes. The trivalved fruits turn yellow and red as they ripen. The mature fruit splits open along 3 sutures exposing the 3 large, shiny, black seeds attached to a white or milky-white aril. The firm and oily aril is the edible portion and is consumed fresh or is cooked and used as a vegetable. Only naturally opened fruits can be eaten. (unripe fruits are poisonous.)

Last update March 3, 1999 by ch

Sindora supa Merrill

Caesalpiniaceae
Supa

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Freshly cut trees are said to yield ca 10 liters of a nondrying, limpid, light yellow, homogeneous, aromatic, slightly fluorescent oil, probably a mixture of sesquiterpenes. The oil is valued for illumination, for making varnishes, paints, and transparent paper, and for the adulteration of other oils. The oil is also used for caulking boats. Supa, the wood of this species, is prized for interior house trim, naval construction, furniture, and cabinetmaking. The sap-wood is cream-colored or pinkish; freshly cut heartwood is yellow, aging upon exposure to reddish brown. Difficult to work, the heavy wood is valued for its durability and pleasant aroma (Allen and Allen, 1981).

Folk Medicine

Supa oil is a popular folk remedy for eczema, herpes, ulcers, and other skin diseases in the Philippines.

Chemistry

"The oil is ... probably a mixture of sesquiterpenes." (Quisumbing, 1951).

Description

Deciduous, straight, unbuttressed, unarmed, tree to 30 m tall. Leaves paripinnate, ca 15 cm long, with three pairs of leaflets, these elliptic, glabrous, coriaceous, 3.5–9 cm long, 2.5–5 cm broad. Flowers small, pedicellate in axillary or terminal panicles 10–15 cm long. Sepals 4, valvate; petal 1; stamens 9–10; anthers dorsifixed, longitudinally dehiscent. Pods broadly ovate, ca 4 cm long, 6 cm broad, opically beaked, basally rounded, with evenly spaced spinelike thorns. Seeds 1–3, black, shiny, with a large fleshy aril (Allen and Allen, 1981).

Germplasm

Reported from the Indochina-Indonesian Center of Diversity (endemic to Philippines), supa, or cvs thereof, is reported to tolerate slope. (x = 12 ?)

Distribution

Endemic to the Philippines, found in low- to medium-altitude forests in Albay, Carmarines, Nueva Ecija, and Quezon provinces in Luzon and in Mindoro (Quisumbing, 1951).

Ecology

Judging by its distributions I would guess that this is a species of the Tropical Moist Forest Life Zone.

Cultivation

The tree is not currently cultivated, apparently being harvested from the wild.

Harvesting

As Burkill (1966) puts it, the wood oil is obtained by the wasteful method of hacking the trunk and by cutting cavities in its base and subsequently firing them to increase the flow... The resin is formed in the wood at all depths, a circumstance which encourages the exploiter to destroy the tree more completely on account of his gain in going deeply.

Yields and Economics

Trees said to yield 10 liters oil each.

Energy

If the tree has been called the kerosene tree, perhaps this tree merits further study. If 100 trees per ha each yielded 10 liters "kerosene"/year renewably, the trees possibly merit as much attention as the "diesel" tree of Calvin, said to yield 40 liters a year.

Biotic Factors

Allen and Allen (1981) note that, so far, reports indicate no rhizobial nodules in these species, as might be expected in most caesalpinioids.

References

- Allen, O.N. and Allen, E.K. 1981. The Leguminosae. The University of Wisconsin Press. 812 p.
- Burkill, J.H. 1966. A dictionary of economic products of the Malay peninsula. Art Printing Works, Kuala Lumpur. 2 vols.
- Quisumbing, E. 1951. Medicinal plants of the Philippines. Tech. Bul. 16. Philippine Department of Agriculture and Natural Resources, Manila.

Complete list of references for Duke, Handbook of Energy Crops

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Last update Friday, January 9, 1998 by aw

Skirret

Umbelliferae, Apiaceae *Sium sisarum* L.

Source: Magness et al. 1971

Skirret is a vegetable grown for its edible roots. The plant grows to 3 to 4 feet high and bas compound, pinnate leaves. The roots grow in clusters, like sweet potatoes; but are longer, somewhat cylindrical, and somewhat jointed. They have a sweet taste and are tender if well grown, but have a woody, nonedible core. Plants are usually grown from seed, which may be started in beds and transplanted to the field, or may be field sown.

Season, seeding to harvest: 6 to 8 months.

Production in the U.S.: No data, very minor.

Use: As cooked vegetable.

Part consumed: Fleshy, tuberous roots.

Last update June 28, 1996 bha

Skunkcabbage

Spathyema foetida (L.) Raf.

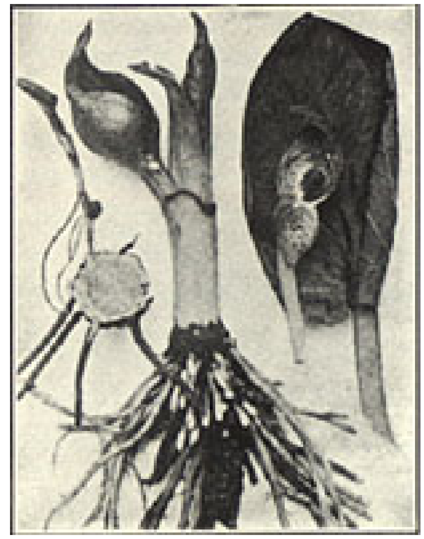

Figure 95.—Skunkcabbage (*Spathyema foetida*)

Synonym.—*Symplocarpus foetidus* (L.) Nutt.

Other common names.—Skunkweed, polecat weed, swamp cabbage, meadow cabbage, collard, fetid hellebore, stinking poke, pockweed.

Habitat and range.—Swamps and other wet places from Canada to Florida, Iowa, and Minnesota abound with this ill-smelling herb.

Description.—Skunkcabbage is a curious plant, the most striking characteristic of which is its rank, offensive odor. It is one of the very earliest of spring flowers appearing in February and March. The hood-shaped flower, which appears before the leaves, is oddly shaped and is not easily described, but its form is we]l shown in the illustration. The edges of the leaf are rolled inward, hiding the spadix inside, which is roundish and completely covered with numerous, dull-purple flowers. The leaves, which appear after the flower, are numerous and very large about 1 to 3 feet in length and about 1 foot in width. The rootstock and root when bruised have the characteristic odor of the plant.

Part used.—The rootstock with the roots, collected early in spring after the flower appears or after the seeds have ripened. It should be dried either in its entire state or deprived of its roots and sliced crosswise. It loses its value with age and should not be kept longer than one year.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Slippery Elm

Ulmus fulva Michx.

Other common names.—Moose elm, red elm, Indian elm, rock elm, sweet elm.

Habitat and range.—This tree is native in woods, along streams, and on hills from Quebec to North Dakota and south to Florida and Texas. It is more common in the western part of its range.

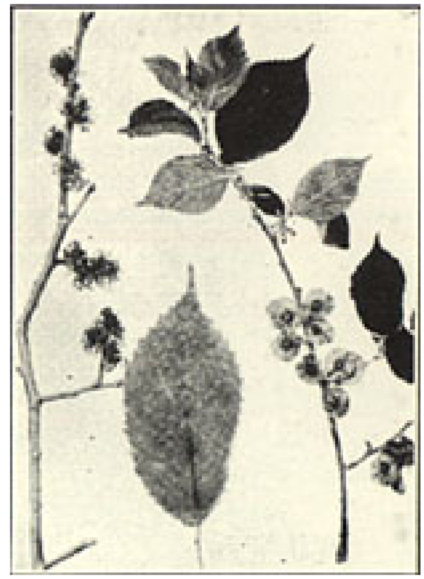

Figure 96.—Slippery elm (*Ulmus fulva*)

Description.—The usual height of the slippery elm is from 40 to 50 feet, with a trunk about 2 1/2 feet in diameter. In open woods and fields it is spreading and irregular in growth, but in dense woods it grows tall and straight, branching some distance from the ground. The bark is very rough, even the small branches are rough, and the twigs are furnished with rough hairs. The rather large leaves, which are from 4 to 8 inches long, are supported by short, downy stalks. The small, bell-shaped flowers appear in dense clusters in early spring, before the leaves, and are followed by flattened and circular winged fruits. Each fruit consists of a single seed surrounded by a thin, winged margin, which aids its dispersion by the wind.

Part used.—The inner bark. The whole bark is shaved from the tree, and after the outer bark is removed the inner portion is dried usually under pressure so that it will remain flat.

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

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Soybean oil

Soya

Leguminosae, Fabaceae *Glycine max* (L.) Merr.

Source: Magness et al. 1971

The soybean bas become the most important source of vegetable oil in the U.S. Quantity of beans crushed for oil averaged about 485 million bushels, 1964-66, producing 2,820,000 tons of oil. Production of oil has trebled in the past 20 years. The plant is a bushy, hairy annual herb up to 3 feet. The hairy pods grow in small clusters, axillary along the stem, and each contains 2 to 4 seeds. Seeds are variable in size, generally about 0.25 inch long. Pods are closed until seeds are threshed out. The seeds contain up to 25 percent of drying oil. The oil is extracted either with solvents, hydraulic presses or experers, the latter two methods involving heating. Much soybean oil is used as salad and cooking oil and for the manufacture of margarine. Large quantities are also used in industry. The press cake is a high protein feed. The beans and plants are also important livestock feeds.

Last update February 19, 1999 by ch
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Sphaeranthus indicus

Contributor: Pankaj Oudhia

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Sphaeranthus indicus L.

Common (Indian) Names
Sanskrit: mahamundi, mundi, hapus,
Hindi, Bengali, Marathi & Gujerati: mundi, gorkhmundi,
Telugu: boddatarupa, boddasoramu
Tamil: kottak aranthai
Malyali: mirangani
Riya: murisa, bokashungi
Punjabi: ghundi, khamadrus
Santal: belaunja
Undari: mundi

Family: Asteraceae

Habitat: Common rabi weed found in rice fields.

Distribution: Throughout India, Sri Lanka, Africa and Australia.

Related Species: *Sphaeranthus africanus* L. (Sanskrit-Sveta Hapusa; Malyali-Velutha adakkamaniyan)

Botany: A much branched, strongly-scented annual with winged stem and the wings toothed. Leaves obovate-oblong, narrowed at the base, dentate and serrate. Flowers compound heads, globose avoid, Flowering time November to January in Indian conditions; glandular hairy. Achene staled.

Useful Parts: Root, bark, leaves, flowers, and seeds.

Medicinal Properties and Uses: According to Ayurveda, this herb is hot, laxative, digestible, tonic, fattening, alterative, anthelmintic and alexipharmic. It is used in insanity, tuberculosis, indigestion, bronchitis, spleen diseases, elephantiasis, anaemia, pain in uterus and vagina, piles, asthma, leucoderma, dysentery, vomiting, hemicrania, etc. Methyl chavicol, α-ionone, d-cadinene, p-methoxy cinnamaldehyde as major constituents and α-terpinene,citral, geraniol, geranyl acetate, β-ionene, sphaerene as minor constituents of essential oil have been identified.

Ayurvedic Preparations: Mundi Churna, Mundi panchang swarasa, Mundi kvatha.

Other uses: Leaves eaten as pot-herb. The herb used as a fish poison and stuffed into hole of crabs to kill them. Aqueous extract is poisonous to American cockroaches. Plants yield an essential oil and a fatty oil. The plant is used as a soil fertility indicator.

Resource person

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Spinacia oleracea L.

Chenopodiaceae

Spinach

We have information from several sources:

Midwest Vegetable Production Guide for Commercial Growers 2000

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Spinach, New Zealand

Aizoaceae *Tetragonia tetragonioides* (Pall.) O. Kuntze

Source: Magness et al. 1971

New Zealand spinach is used in the same manner as spinach, but the plant is very different. It reaches a height of 1 to 2 feet, and is much branched, spreading to 3 to 4 feet across. In home gardens, tender shoots, tips, and leaves are cut and used throughout the summer. Commercially, whole plants are usually cut above the ground when small. New growth from the cut stem base will produce a later crop. The plant is adapted to warmer growing conditions than spinach, and will produce summer greens where spinach will not. Leaves are generally similar in appearance to spinach.

Season, seeding to first harvest: 2 months.

Production in the U.S.: No data. Minor as compared to spinach, Mainly in home gardens.

Use: As pot herb or greens.

Part consumed: Young leaves and stem tips.

Last update June 28, 1996 bha

Leszczyñska-Borys, H., M.W. Borys, and J.L. Galván S. 1999. *Spiranthes*: Terrestrial orchid with ornamental potential. p. 431–432. In: J. Janick (ed.), Perspectives on new crops and new uses. ASHS Press, Alexandria, VA.

Spiranthes: Terrestrial Orchid with Ornamental Potential

Helena Leszczyñska-Borys, Michal W. Borys, and J.L. Galván S.

Terrestrial orchids are rarely cultivated (Bailey 1914; Oszkinis 1991). The genus *Spiranthes* L.C. Rich. is represented by 150–200 species, mostly in the subtropical and tropical regions of the American Continent (Orpet 1914; Peña 1990). Some species are hardy and are found in the United States and Poland (Bailey 1914; Orpet 1914; Szafer et al. 1953; Peña 1990). None of the species has found horticultural application in Mexico, although the wealth of terrestrial orchids, their presence in a range of contrasting environmental conditions, and their esthetic values suggest various ornamental uses.

BOTANY

The genus *Spiranthes* (Orpet 1914), is characterized as "hardy native, easily transplated, flowering biennially, late summer and early autumn." Bailey (1914) concludes that "few species have any value; some of the hardy species are advertised by dealers of the native plants and by collectors." The name *Spiranthes* derives from Greek and refers to the twisted spikes (Bailey 1914), hence the common name "Ladies' Tresses." Martínez (1979) mentions a common name *ya áxchi* (Mayan) for *S. acaulis* (Sm.) Cog. and Rzedowski and Equihua (1987) report two names *coyol cimarrón* and *cutzis* for *S. aurantiaca* (Llave & Lex.) Hemsl from the Valley of Mexico. Peña (1990) describes 17 species of *Spiranthes* from the Valley of Mexico. Among them is *Spiranthes cinnabarina* (Llave & Lex.) Hemsl. [syn. *Dichromanthus cinnabarinus* (Lex.) Garay and

Stenorrhynchos cinnabarinus (Lex.) Lindl.]. *Spiranthes cinnabarina* (Llave & Lex.) Hemsl. occurs in the Valley of Mexico, in sod and in dry brush land, at 2250–2600 m above sea level (Peña 1990). The scape and inflorescence are attractive and suggest uses as a bedding plant, pot plant, or cut flower (Fig. 1).

Fig. 1. Flowering stem of *Spiranthes cinnabarina*.

Wild plants of *S. cinnabarina* were examined that were growing inside the property of the Universidad Popular Autonoma del Estado de Puebla, in Cholula, Puebla, Mexico (19°N 2100 m above sea level) where the Centro de Investigación Universitaria and the Germplasm Bank of Flowering Bulb Species are located. The climate is temperate, subhumid, with rainfall in the summer. Precipitation in the driest month is below 40 mm. The winter precipitation is less than 5% of the annual total (798 mm). The temperatures of the coldest month range from –3° to 18°C. The dry season has spells of precipitation, sometimes extending for three days. The wet season presents frequent spells of hot weather, lasting from two to three weeks. Rainfall is usually brief and intense. Evaporation rate exceeds precipitation almost three times, resulting in rapid development of soil water deficit due to sandy volcanic soils.

The first group of wild *S. cinnabarina* was found in partial shade accompanied by pasture plants, under *Eucalyptus* trees. The dry remains of grasses were burned yearly, leaving ashes and unburned remains, an old system of agriculture in Mexico, still commonly used by farmers and gardeners. The second group of wild plants, in the pasture in the open field at the same location, were growing in a layer of 5–10 cm of accumulated organic matter which contained residues from a steel factory. The third group, forming part of the collection in the Germplasm Bank, was situated in the same area, in beds, in the open field, in sandy, volcanic soil containing some added organic matter.

Spiranthes cinnabarina is an herbaceous, perennial plant that is adapted to a range of soil physical conditions. This species, when found in localities with frequent rainfall or where water accumulates, gave higher shoots, larger inflorescences and more brillant orange coloration. It is adapted to xerophytic conditions and extended spells of drought during the vegetative season, suggesting landscaping uses especially in urban areas. This species develops fleshy, fasciculated roots at a depth of 20 to 30 cm. The fleshy root system may explain the species tolerance to transplanting, characteristic of the genus (Orpet 1914).

CULTURE AND USE

The growing season is determined by the start of the rainy season, and the dormancy of the bud located upon a short, underground shoot. The dormancy period usually begins in the second half of October and lasts until May or June.

Trimmed bare root plants in the flower bud stage or with 30% of flowers opened can be air dried for 3 days, and then successfully transplanted. At the beginning of the growing season when plants were transplanted at the rosette stage (5–6 leaves) only one out of 108 plants was lost; when transplanted at the flowering stage bare root all 50 plants survived.

Plants grown in pots, flowered yearly for three years. The plant diameter at flowering stage ranges from 20–30 cm. The scape is covered with several bracts, being longer at their base. The inflorescence is a spike whose dimensions vary with the soil, water conditions, and solar radiation.

The plant can be grown in mass in parks, gardens, and urban areas in beds or pots. The medium height flowering scapes have orange flowers that turn to coffee-black starting at the base of the spike. Although this is a disadvantage for cut flowers, in group plantings the black flowers provide a contrast to the upper orange flowers which is attractive. At the end of the growing season the dead, above ground parts, should be trimmed.

The stems are resistant to winds. Both the "bud," and the open flower are attractive in color and form. The inflorescence, slowly opens from the base to the apex but its esthetic value is lost when more than 70–75% of the spike is opened. The remains of the flowers do not abscise but remain attached to the spike. Low scape height for group planting and, for use as a pot plant would be desired. A low scape genotype has been found and is currently under observation.

The stem can be used as a cut flower and for arrangements. The stem should be cut above the third leaf. The individual flowers opened continually. The stems held in water, without preservative, in a room of northern exposition (19°C day, 16°C night), lasted 10–14 days. Inflorescences wilted, after the stem was cut at noon, in full sun, but regained normal rigidity easily when the stem was placed in water within an hour. However, the inflorescence bent if the time from cutting to placing in a vase exceeded 1 h.

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Spondias mombin L.

Spondias lutea L.

Anacardiaceae

Yellow Mombin

We have information from several sources:

Yellow Mombin—Julia Morton, Fruits of warm climates

New crops from Brazil.—David Arkcoll

Last update Wednesday, March 3, 1999 by ch

Picea spp.

Pinaceae
Spruce

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Although the bruised shoots may be malodorous, those of some species have been used to make spruce beer, popular in the Canadian backwoods (Fernald et al., 1958). Millspaugh (1974) added one part of spruce essence to 76 parts water, boiling, straining, and allowing to cool; then he added 96 parts warm water, 7 parts molasses, and 1 part yeast. Another recipe for spruce beer (Can. Pharm. J. 13–14. 1878) recites 16.5 oz. double refined powdered sugar, 3 1/2 oz. bicarbonate of soda, 4 oz. citric acid, and 1 oz. concentrated spruce essence. Soda, acid, and sugar must be dried separately, the essence incorporated in the sugar, with small quantities of caramel. This represents an "instant" spruce beer, powdered, which was placed quickly in a dry bottle and corked. To serve, one teaspoonful was stirred into a glass of water. Amerindians also used the "balsam" as a chewing gum. Inner bark in spring and early summer might be eaten. Stripped young shoots can serve as nutritious emergency foods. According to Guenther (1952), commercial oil of spruce is usually not derived from one single well-defined species, but from mixed branches and leaves of spruce species (and hemlock species). The oil is used in pine and cedar blends for scenting deodorants, room sprays, etc. The resin is used for incense (Erichsen-Brown, 1979). In the days of the European invasion of North America, spruce beer was one of the favored remedies for scurvy, which plagued the immigrants after months on a diet of salt meat and dried legumes. A favorite drink of the admirals of those days was calabogus, made of molasses, rum, and spruce beer (Erichsen-Brown, 1979). The Indians were said to use the powder of spruce wood to keep their hair black. Splinters of the roots and/or bark, were used by the Amerindians in sewing their canoes.

Folk Medicine

According to Hartwell (1967–1971), the resin, seeds, and/or shoots are used in folk remedies for cancers, condylomata, excrescences, tumors, and ulcers. Reported to be anodyne, counterirritant, stimulant, and vulnerary, spruces are folk remedies for abrasions, arthritis, boils, burns, catarrh, consumption, cough, diarrhea, dyspepsia, dyspnea, headache, inflammination, nephrosis, ophthalmia, phthisis, renosis, rheumatism, scurvy, sores, sorethroat, stomach, stones, tumors, and wounds (Duke and Wain, 1981; Erichsen-Brown, 1979). Montagnai mixed the root decoction with sourgrass for lung and throat ailments (Duke, 1983c).

Chemistry

In comparison to fir needles (up to 427 mg ascorbic acid per kilogram), spruce was low, but spruce was higher (23 mg/kd) in carotene (Erichsen-Brown, 1979). d-Bornyl acetate, cadinene, d-camphor dipentene, dl-fenchyl alcohol, l-limonene, and β-pinene have been reported from the oil of *Picea*. From *Picea mariana* there was 2.5% santene, 1.0% tricyclene, 16.0% 1-α-pinene, and 6.5% 1-β-pinene, 10.0% 1-camphene, 3.5% myrcene, 5.0% d-delta^3-carene, 6.5% dl- and 1-limonene, 1.0% terpinolene, 1.0% 1-borneol, 37.0% 1-bornyl acetate, 1.0% dl-camphor. Oil from *Picea excelsa* contained 1-bornyl-acetate, cadinene, dipentene, 1-phellandrene, 1-α-pinene, and santene.

Toxicity

Woodworkers and those exposed to the "balsam" may show contact allergies. Of 1247 patients, 5.5% were sensitive to pine and/or spruce, the majority reacting to both. Asthma suffering may be aggravated by the sawdust or the needles (Mitchell and Rook, 1979). Plasters made from spruce balsam may cause redness, itching papules, and/or sensitive skin, even pustules and ulcers.

Description

Large, handsome, evergreen tree. Bark of trunk gray-brown to red-brown, with irregular, close scales; twigs more or less pubescent; buds small, outer scales with long hair-like points. Leaves 4-sided, somewhat curved, 10–15 mm long, spirally and thickly set on the branchlets, falling early on drying and leaving short, peg-like stubs. Male and female cones borne on the ends of previous year's growth; male sporangia opening longitudinally; female cones red-brown, pendent, 2–6 cm long, maturing by Oct. of 1st year, and usually falling soon after shedding seeds (*Picea rubens* from Radford et al., 1968).

Germplasm

Reported from the North American Center of Diversity, some American spruce species or cvs thereof are reported to tolerate bogs, frost, poor soils, and slopes (Duke, 1978). ($2n = 24$)

Distribution

Picea glauca occurs from Alaska to Newfoundland; northeastern and north central United States; also in Black Hills of South Dakota and small scattered areas in western Montana. *Picea mariana* from Alaska to Newfoundland; northeastern and north central United States, and *Picea rubens* from Nova Scotia, southern Quebec, New England, New York, and south in Appalachian Mountains to North Carolina (Ag. Handbook 450, 1974).

Ecology

Estimated to range from Cool Temperate Moist to Wet through Boreal Moist to Wet Forest Life Zones, eastern spruce are estimated to tolerate annual precipitation of 5 to 16 dm, annual temperature of 4 to 12°C, and pH of 4.5 to 7.5.

Cultivation

Seeds may germinate promptly without pretreatment, but cold stratification has been used for some species. When seeds of some species are chilled under moist conditions, light is not required for germination. Conversely, exposure of imbibed seeds to light during germination tests may overcome dormancy without stratification. Presoaking may increase germinative energy without influencing germinative capacity. Seeds may be treated with fumigants, fungicides, insecticides, and rodent repellants prior to sowing, but caution is advised (Ag Handbook 450, 1974). Seedling density targets are ca 300–1000/m^3. Outplantings are more effective with mulches.

Harvesting

Trees apparently should be harvested Jan.–Apr. when essential oils are highest. For seed, fruits should be harvested promptly at ripening to avoid seed shatter. Seeds may lose viability if left in the cone too long.

Yields and Economics

Oil yields mostly run 0.2–0.7%. Branches from isolated sun-exposed trees yielded 20% more oil than trees growing in dense bush. Branches from 25-year old trees gave twice as much as 45-year olds. The first period of maximum yield (Jan.–Apr.) precedes the period of strong cambial activity in the spring, the second follows formation of summer wood. In one Minnesotan study (Perala and Alban, 1982) in an area with annual rainfall ca 6 dm, annual temperature ca 4°C, pH 5–6, the annual litterfall was 5709 kg/ha organic matter on loam soil, (Glossic Eutroboralf), and 5253 on a sandy soil, both soil types located on a gently undulating till plain. On the loam soil, the litter contained 54 kg N/ha, 6.8 kg P, 16 K, 83 kg Ca, and 4.8 kg Mg/ha. On the sandy soil there was 41 kg N, 5.1 kg P, 12 K, 60 kg Ca, and 4.1 kg Mg/ha. It was concluded that harvesting entire above-ground trees would remove up to 3 times more nutrients than harvesting just the bole. On loam, stands of *Picea glauca* ca 39 years old, had 2187 trees/ha with a mean height of 14.4 m, a mean DBH (outside bark) of 15 cm, and a basal area of 41.1 m^2/ha. On the sandy sites, stands 41 years old had 2718 trees per ha, with mean hight of 13.7 m, a mean DBH of 14 cm, and basal area of 44.9 m^2/ha.

Energy

According to the phytomass files (Duke, 1981b), annual productivity of various spruces ranges from 2 to 14 MT/ha, standing biomass from 88–325 MT/ha. The stand of *Picea glauca* on the loam had standing biomass of 17.4 MT/ha in foliage, 35.8 in branches, 11.2 in bole bark, 91 in bole wood, 35 in root and stump, for an above ground total biomass of 155 MT, a total tree biomass of 190 MT/ha. There was a total of 0.2 MT in the understory and herbaceous biomass as well. The stand on the sandy soil had standing biomass of 11.7 MT/ha in foliage, 16.4 in live branches, 13.7 in dead branches, 12.0 in bole bark, 89 in bole wood, and 31 in stump and root for an aboveground total biomass of 143 MT/ha, a total biomass of 175 MT/ha. There was a total of 0.01 MT/ha in the understory and herbaceous layers as well (Perala and Alban, 1982). Ford (1982) reported a net annual aboveground DM of 26.7 MT/ha in Scotland, the total including roots of 35 MT/ha. One of the highest values reported for coniferous forest in the temperate zone. The needle area index was 10–11 at age 16, 7–8 at age 18. Branch area index was 3.6 and the ratio of main stem bark surface area to ground area was 0.4 at age 16. The standing crop of this 17 year old plantation contained 56.3 MT bole, 25 MT branches, 26.6 MT foliage, 4.9 MT fine roots, and 20.1 MT thick roots, for a total of ca 133 MT. The basal area was 26.6 MT/ha (Ford, 1982).

Biotic Factors

For extensive lists of pests and diseases affecting *Picea* spp. see Browne, 1968 and Agriculture Handbook 165. Nematodes include: *Criconema menzeli*, *Crconemella* spp., *Hemicycliophora similis*, *H.* sp., *H. uniformis*, *Hoplolaimus galeatus*, *Pratylenchus penetrans*, *P. pratensis*, *Rotylenchus robustus*, *Tylenchorhynchus maximus*, *T*. sp., and *Xiphinema americana*. (Golden, p.c., 1984)

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Pascual-Villalobos, M.J. 2002. Anti-insect activity of bufadienolides from *Urginea maritima*. p. 564–566. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA.

Anti-insect Activity of Bufadienolides from *Urginea maritima*

María Jesús Pascual-Villalobos

Squill [*Urginea maritima* (L.) Baker, Liliaceae] is a native medicinal and ornamental plant from the Mediterranean area. The bulbs were an ancient source of rodenticide products replaced later on by warfarin and modern anticoagulant raticides. Since rats have developed resistance to such products there is now renewed interest in the species.

In the 1950s, attempts were made in the United States to introduce this new crop for arid lands. A collection of bulbs are still maintained at Gentry Experimental Farm, Murrieta, California. Some limitations concerning variability in toxicity were previously discussed (Verbiscar et al. 1986a; Gentry et al. 1987). Scilliroside, a high toxicity bufadienolide glycoside, is the main active principle. Other glycosides and aglycones have also been isolated from the bulb (Verbiscar et al. 1986b).

We tested this plant in our research program to screen botanicals for insecticidal activity at “Centro de Investigación y Desarrollo Agroalimentario” in Murcia, Spain. In Spain squill is a wild plant of coastal areas (Fig. 1). Ethanolic extracts of bulbs have been active against stored product pests (Pascual-Villalobos and Fernández 1999), although such anti-insect effects could not be attributed to specific compounds in that study. The objective of this work was to test pure bufadienolides isolated from *U. maritima*.

Fig. 1. Wild *Urginea maritima* plants in “La Unión,” Murcia, Spain.

METHODOLOGY

Compounds

Five different bufadienolides (proscillaridin A, scillaren A, scillirosid, gammabufotalin, and scillirosidin) were obtained as pure substances (see previous work of Krenn et al. 1994) from *U. maritima* bulbs and they were provided by B. Kopp from the Institute of Pharmacognosy in Vienna (Austria).

Insects

The effects of compounds were studied on the stored product pest *Tribolium castaneum* (Coleoptera: Tenebrionidae). Larvae were obtained from same age cultures kept on an artificial diet of white wheat flour and beer yeast (95:5) at a constant temperature of 30°C in the dark.

Bioassays

Topical Application Bioassay. Substances (dissolved in acetone) were applied topically (using a micropipete) to 25 day old larvae at doses of 10, 20, 30, and 40 µg/insect. Larvae were placed singly inside glass tubes and kept at a constant temperature of 30°C in darkness; 24 replications per treatment. Mortality (%) was recorded after one and seven days. If a response to increasing doses of the products was obtained, probit analyses were performed and LD_{50} calculated when the fit was good.

Insect Growth Inhibition and Fertility Bioassay. Substances were incorporated into the standard insect diet at a dose of 2%. The experimental unit was a 4 ml glass vial with 100 mg of diet and one newly hatched larvae. Twelve replications were set up for each compound. The experiment was kept in the dark at a constant temperature of 30ºC. Length (mm) and mortality (%) of larvae were measured after 14 days. Emerged adults from each treatment were paired during 4 days on the same diet and the number of fertile laid eggs were counted. The comparison between treatments and control was done using the non parametric Mann-Whitney U test.

RESULTS

Proscillaridin A, scilliroside, and scillirosidin were active by topical application (Table 1). The aglycone, scillirosidin was more lethal, causing over 50% mortality in *Tribolium* larvae at 10 µg/insect, than its glycoside scilliroside. Scillaren A and gammabufotalin were less toxic on insects and a response to increasing doses was not obtained. Only data from scilliroside applications fitted to the probit model being LD_{50} of 25.5 and 17.1 µg/insect for mortality after one and seven days respectively.

Table 1. Mortality[z] (%) of *T. castaneum* larvae (25 day old) caused by topical application of bufadienolides (n=24).

Compound	Days after application	Dose (µg/larvae)				Probit fit χ^2(df=2)		LD_{50}
		10	20	30	40			
Proscillaridin A	1	41.7	29.2	41.7	70.8	23.9	poor	--
	7	45.8	50	87.5	91.7	17.3	poor	
Scilliroside	1	20.8	37.5	66.7	75	2.2	good	25.5
	7	29.2	62.5	83.3	83.3	3.0	good	17.1
Scillirosidin	1	54.2	41.7	58.3	95.8	47.1	poor	
	7	52.3	45.8	79.2	100	46.3	poor	
Scillaren A	1	33.3	25	4.2	41.7	--		--
	7	41.7	33.3	33.3	50	--		--
Gammabufotalin	1	20.8	25	41.7	29.2	--		--
	7	20.8	29.2	50	37.5	--		--

[z]Mortality of control (application of the solvent, acetone) was 0% at day 1 and 8.3% at day 7.

Intake of bufadienolides at 2% in the diet caused a statistically significant larvae growth inhibition and adult fertility reduction (Table 2). Ingestion of scillirosidin or proscillaridin A was most deleterious (larvae of 4.36 mm and 4.73 mm respectively in comparison with 6.9 mm of control); in these treatments a delay to reach pupae stage from 21 to 29.2 days was also obtained. The number of eggs laid per female was clearly reduced if the compounds were added to the diet. Again, scillirosidin and proscillaridin A were more active by completely inhibiting the fertility (Table 2). Also, scillirosidin, the aglycone appears to be more active than the glycoside (scilliroside).

Table 2. Insect growth inhibition and influence on fertility of bufadienolide intake (n=12).

Compound[z]	Larvae length[y] after 14 days (mm)	Mortality (%)	Fertility[yx] (no. eggs/pair)

Proscillaridin A	4.73 ***	25.0	0.0 ***
Scilliroside	6.00 ***	16.7	11.0 ***
Scillirosidin	4.36 ***	8.3	0.2 ***
Scillaren A	5.42 ***	8.3	6.3 ***
Gammabufotalin	5.96 *	25.0	5.8 ***
Control	6.9	0.0	26.1 ***

[z]Mixed at 2% in the diet.
[y]Mean values and significance of Mann-Whitney U test for comparison between treatment and control (ns=non significant, * 0.01<p<0.05, *** p<0.001).
[x]During 4 days.

We report for the first time that *Urginea maritima* bufadienolides induce anti-insect effects on *Tribolium castaneum*. This suggests that squill should be investigated for activity against other insects and pests.

REFERENCES

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St. Augustine grass

Gramineae *Stenotaphrum secundatum* (Walt.) Kuntze

Source: Magness et al. 1971

This grass, native to the West Indies, is now planted along the Southeastern Coastal Plain. It is an extensively creeping perennial with stolons that have rather long internodes. These stolons send up branches at the nodes, which are not over 12 inches high. Leaf blades are 4 to 6 inches long, glabrous and blunt. It will stand salt water spray so can be used along sea coasts. In the area of adaptation it is used for lawns, golf fairways and pastures. It forms dense sods which stand tramping well. As pasture it is grown mainly on muck soils in the Florida Everglades. It is not hardy north of central Georgia and central Alabama. It forms little seed and is propagated by planting the rooted runners. Ample fertilizer must be used to secure good growth.

Last update June 28, 1996 bha

Stevia rebaudiana Bertoni

Asteraceae, Compositae

Stevia, sugar-leaf, sweet-herb-of-Paraquay

We have information from several sources:

Seed Germination in *Stevia rebaudiana*—Jeffrey Goettemoeller and Alejandro Ching

New Crops from Brazil—David Arkcoll

Outside links:

Stevia Southern Crop Protection and Food Research Centre Agriculture & Agri-Food Canada

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Stokesia laevis Hill (Greene)

Asteraceae, or Compositae

Stokes' Aster

NewCROP has Stokesia information at:

Intercropping Stokes Aster: Seedling Growth under a Soybean Canopy—E.J. Callan and C.W. Kennedy

Stokes' Aster In: New Temperate Oilseed Crops. From Steve Knapp, 1990.

See: Stoke's Aster In: New Crops Research and Development: A Federal Perspective. Princen, L.H. 1990.

Photo of Stokes' Aster Dried Seed Head In: New Crops Research: Northeastern Region and National Federal Efforts. White, G.A. 1993.

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Cropping Systems for Stokes Aster—Elizabeth J. Callan and Charles W. Kennedy

And outside links to more Stokesia laevis info:

PICTURE OF STOKES ASTER FLOWER from the University of Kentucky

Tamarindus indica L.

Caesalpiniaceae (Leguminosae subfamily Caesalpinioideae)

Tamarind, Tamarindo, Tamarin, Indian Date, Sampalok, Tamar, Tamar-hindi

NewCROP has Tamarind information at:

Magness J.R. et al. 1971. Food and feed crops of the United States.

Tamarind—Julia Morton, Fruits of warm climates

And outside links to more Tamarind info:

TAMARIND "FRUIT FACTS"(Fruit Facts are a series of publications of the the California Rare Fruit Growers, Inc. that contain information on individual fruits, including botanical identification, description and culture notes based on California research, and characteristics of cultivars).

Bibliography of *Tamarindus indica* from Fruits for the Future.

Tamarinds from M. Grieve's Modern Herbal.

Chemical analysis from the FAO's Tropical Feeds Database.

Prosopis tamarugo F. Phil.

Mimosaceae
Tamarugo

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Tree produces abundant fodder, palatable to sheep, cattle and goats. It is said that older stands will support 26 sheep per hectare. The wood, though hard and difficult to work, is used for furniture and firewood. Man-made *tamarugo* plantations are being introduced in the Tamarugal Pampa which are transforming the absolute desert ecosystem into an agroecosystem. The result, is a noteworthy increase in overall productivity in one of the most inhospitable regions of the world (Habit et al., 1981). The potential value of the tamarugo was noted as early as 1918 when Maldonado, a forest inspector called for a tamarugo forest preserve, considering it most important for the Chilean desert (Burkart, 1976).

Folk Medicine

No data available.

Chemistry

Per 100 g, the fruit is reported to contain 3.34 g H_2O, 11.14 g protein, 1.62 g fat, 79.63 g total carbohydrate, 31.45 g fiber, 4.27 g ash, 280 mg Ca, and 1,440 mg P. Leaves were analyzed at 94.7% H_2O, 90.53% dry matter, 9.98% total protein, 10.72% crude fiber, 1.9% ether extract, 45.91% N-free extract, 22.02% ash, 2.82% Ca, and 0.91% P (Habit et al, 1981). By contrast Gohl (1981) reports:

		As % of dry matter						
	DM	CP	CT	Ash	EE	NFE	Ca	P
Browse, Chile	89.3	10.7	32.1	5.0	2.7	49.5	3.98	0.12
Leaves, Chile	88.5	9.9	15.8	20.3	2.0	52.0	6.21	0.11
Pods, Chile	91.1	11.7	41.5	4.6	1.6	40.6	0.33	0.13
Seeds, Chile	92.5	10.1	38.4	7.5	0.7	43.3	0.36	1.50

		Digestibility (%)				
	Animal	CP	CF	EE	NFE	ME
Browse	Sheep	55.0	25.0	47.0	38.0	1.32
Pods	Sheep	55.0	50.0	50.0	74 0	2.18

Felker and Bandurski (1979) report that the embryo and seed coat contain 27% protein.

Table 15. Average composition of various *tamarugo* components for cattle feed.

Plant component	DM (%)	CP (%)	EE (%)	CF (%)	NFE (%)	Ash (%)
Whole-fruit	94.40	13.30	1.40	34.20	44.80	6.40
Fruit without seed	87.25	13.27	0.95	31.67	44.83	9.28
Seed	90.77	27.30	5.33	10.84	50.45	6.08
Dry leaves without rachis	91.70	13.55	1.69	9.90	52.63	22.23
Dry leaves	91.43	9.04	1.77	22.25	55.41	11.53
Rachis of dry leaves	88.15	11.27	1.78	15.98	50.68	20.29
Green leaves	43.71	35.69	2.97	31.55	1.38	28.41
Dry leaves with rachis	90.53	11.02	1.09	11.84	50.73	24.32
Fruit	96.66	11.52	1.68	32.51	49.86	4.43

(Source: Habit et al., 1981)

Pak et al. (1977) present detailed nutritional analyses with comments also on potential toxicities:

Table 1. Chemical composition (g/100g dry weight) and caloric content (g/100g dry weight), of fruit, seeds and leaves of tamarugo *(Prosopis tamarugo)*

	Ash	Crude protien	Ether extract	Crude fibre	Soluble carbohydrate	Caloric content
Ripe fruit	4.57	9.2	1.4	29.9	55.0	408
Green fruit	4.54	12.9	1.3	30.4	50.9	n.d.*
Seed	3.34	27.1	3.7	9.5	55.4	446
Dry leaf	13.95	11.3	1.3	13.4	60.6	351
Green leaf	9.80	15.9	3.3	14.7	56.5	420

* n.d. = not determined.

Table 2. Calcium, phosphorus, magnesium, potassium and sodium concentrations (g/100 g dry weight) and Ca/P, K/Na ratios in tamarugo

	Calcium	Phosphorus	Magnesium	Potassium	Sodium	Ca/P	K/Na
Ripe fruit	0.22	0.27	0.10	2.09	0.05	0.8	41.8
Green fruit	0.24	0.26	0.13	2.20	0.08	0.9	27.5
Seed	0.19	0.21	0.26	1.11	0.03	0.9	37.0
Dry leaf	3.55	0.19	0.46	1.62	0.11	18.7	14.7
Green leaf	1.44	0.25	0.39	1.86	0.03	5.8	62.0

Table 3. Iron, copper, molybdenum, zinc, cobalt and manganese (parts/10^6 dry weight) and Cu/Mo ratio in tamarugo

	lron	Copper	Molybdenum	Zinc	Cobalt	Manganese	Cu/Mo
Ripe fruit	90	12	4.5	21	0.06	30	2.7
Green fruit	110	12	n.d.*	27	n.d.*	32	--
Seed	160	20	5.2	72	0.10	51	3.9
Dry leaf	460	17	2.5	24	0.03	369	6.8
Green leaf	230	24	13.4	42	0.12	136	1.8

*n.d. = not determined.

Cyanogenetic glucosides and alkaloids, were not detected in any of the samples, saponins were only found in green fruits and seeds, both in low percentages, 0.007 and 0.010% respectively. The seeds appeared to have simultaneous presence of antitryptic factor (2.3 trypsin inhibited units per milligiam of defatted dry sample) and haemagglutinins (6.0 units per milligram protein) (Pak et al., 1977).

Description

Deciduous open-crowned tree up to 18 m tall, the trunk to 80 cm in diameter; with a dense mat of lateral roots and deep taproot (to 6 m deep on tree 15 m tall). Flowers golden yellow, in long axillary cylindrical spikes. Stipules spiny, 5–38 mm long. Leaves unijugate, the pinnae 3–4 cm long or less, with 10–15 pairs of leaflets; leaflets linear obtuse or acutish, 4–8 mm long. Pod arcuate, turgid, brown or stramineous, 2–8 cm long, 2–3.5 cm in diameter with ca 6–8 seeds embedded in a brownish edible pulp, seeds ovate, 3–4.3 mm long, brown (Burkart, 1976). Calyx 1.5 mm long; corolla 4–5 mm long; ovary villous.

Germplasm

Reported from the South American Center of Diversity, tamarugo, or cvs thereof, is reported to tolerate drought, high pH, salt, and sand. ($2n = 28$)

Distribution

Native to that part of the Atacama Desert in northern Chile known as Pampa del Tamarugal, an island salt desert about 40 km wide and 300 km long. Also planted in Argentina and recommended for other saline deserts of the world.

Ecology

Found on salty-sandy or clay loam soils, occasionally with a 40-cm salt incrustation. In its native habitat the tree ranges from 1000–1500 m elevation. Ranging from Warm Temperate Desert to Thorn Steppe through Subtropical Desert toSubtropical Thorn Forest Life Zones, tamarugo, or cvs thereof, is reported to tolerate annual precipitation of (0-)3 to 5 dm, annual temperature of 12 to 20°C, and pH of 6.8 to 8.0. The desert ecosystem of the Tamarugal Pampa is highly specific. The climate is the normal desert climate; the most biologically significant factors are: high day-time temperatures, great day-to-night temperature range, almost total lack of rainfall, occasional mist, relatively low humidity and intense sunlight. The soils are composed of deposits of fluvial origin from the cordillera of the Andes, and have a surface salt crust ranging in thickness from 10–60 cm or more. Under certain conditions of atmospheric humidity, tamarugo absorbs water through its leaves, transporting it to the root system and depositing it in the micro-rhizosphere, whence it is reabsorbed along with the soil nutrients. This explains why measurements of mean annual evaporation show much higher rates outside than inside the forest area, where a mere fraction of the water is lost in evaporation. This is also why tamarugo trees are found in areas where the ground water table lies 40 m deep and has no contact with the roots of trees (Habit et al, 1981). According to Burkart (1976) the leaves absorb water through their stomata when the relative humidity of the air >95%. Variations in salinity of groundwater had little or no effect on growth rate but distance from water table. The greater the depth to groundwater the smaller the height growth of the trees, tending to minimize the importance of absorption of water from atmosphere (Felker, 1982).

Cultivation

For rooting cuttings a 34°C air temperature and vermiculite medium is recommended. N fixation in tamarugo may be limited. Since the leaf N content appears to be sensitive to phosphorus levels, there is hope that pod N levels may also be P-sensitive. Pods are generally 10% crude protein 3% short of the 13% crude protein level required for good animal growth. In N-fixing systems, phosphate has tremendous leverage over dry matter production. N:P levels are generally ca 10:1, and N:DM ratios ca 1.5:100. Thus every kg deficient P that is corrected has the opportunity to provide 600 kg DM. Habit et al. (1981) cite the following planting instructions: Use a 2:1 mixture of earth and guano. Plant in unperforated plastic bags, 12 cm in diameter, 30 cm long, filled with this mixture and placed in a carefully-levelled planting bed. Water to saturation. Sow three to five seeds a depth of 1.5 cm. First treat with sulfuric acid for 7 minutes, then wash and let dry in shade. Keep the surface, where the seeds are planted, wet, but do not accumulate water in the bottom of the bags, as this encourages fungus growth. Treat the soil with fungicide before sowing to avoid fungus attack. Once seeds germinate, give more water but at greater intervals, to ensure moisture for the downward-growing roots. Avoid excessive use of water. Keep seedlings in nursery 3 to 5 months, until they are 8 to 10 cm tall. Be sure the roots do not pierce the plastic. Plantation spacings in the Tamarugal Pampa are at 10 x 10 m and 15 x 15 m, taking into consideration the tree's growth and its function as fodder. A pit is dug in the ground and in it a hole is made 20 cm in diameter and 50 cm deep, abundantly manured with guano. Pit depth depends on terrain, usually 80 cm in diameter by 30–70 cm deep, varying according to depth of salt crust which must be penetrated before making the planting hole.. Before planting, water hole to saturate soil as far down as possible. Split the bottom of the plastic bags at planting so roots can pass through. Remove plastic bags with care to avoid breaking the cylinder of earth. There must be enough water to penetrate to the roots and keep them moist. It is most important to avoid excess watering, which shows up at the first stages of the seedlings as a "fall" due to fungi, and later as a yellowing of the leaves. Plants are established when they send out new shoots. When this occurs, watering can be spaced at intervals of 20 days, though care should be taken to ensure that the water penetrates properly. If there is moisture in the subsoil, it is advisable to determine whether the roots have reached it by suspending watering and observing the reaction of the plants.

Harvesting

Sheep and goats feed on fallen leaves and pods (fresh seed produced from October to January). Harvested for firewood as needed, the tree coppices readily.

Yields and Economics

In their tabulation, Felker and Bandurski (1979) list yields of 12 MT/ha leaves and pods. According to Habit et al. (1981), the average yield of fruit per tree is 2.1 kg/m^2 of crown projection, even higher with adult trees. With insecticides, single tree yield increased from 105 to 210 kg, translating to 10 MT pods/ha. Felker suggests 5 MT. Aerial application of insecticides was suggested. Chileans estimate cost of aerial application at $15–20(US)/ha and the heptachlor at $24 for the 4 liters required, for a total cost of $35/ha compared to $500/ha for ground application. High quality Prosopis wood retails for $6.00 per board foot ($2,540 per cu m) when cut, planed, and cured. Straight growing trees of algarobo occur in Argentina. One could get straight pieces 4 m long and 40 cm in diameter in 20 years. This wood, after being cut, planed, and dried would be worth at least $300 per tree, or $36,000 per ha (Felker, 1982).

Energy

Felker (1982) estimates that prunings from a tree would be 200 kg (not annually) suggesting 20 MT/ha. These could be converted to chips with a heating value of 18,000 BTU/kg. Felker (1982) suggests that trees should be pruned every 6–10 years, removing the lower branches which may preclude animals from eating the fallen pods. The 200 kg/tree prunings could be chipped and blown into a truck at a cost of ca $10/ton. The chips are estimated to produce energy at the rate of $1.47 per million Btu's, about 1/4 the cost of oil energy. Tractor driven chippers are available at $3,000 to $12,000 (US). If there were no market for chips, or charcoal were not available, a small wood-fired turbine could convert the wood to electricity. Felker notes that Aerospace Corporation of Virginia sells 3000 kilowatt wood fired gas generators for ca $2,250,000 (US). They consume ca 3 MT/hr generating 3,000 KWH at $0.15 KWH. At 15 trees per hour and 100 trees/ha, 1,314 ha would need be pruned every year to fuel the generator. Cross yearly electrical sales would be $4,000,000 (US) (Felker, 1982).

Biotic Factors

Habit et al. (1981) present detailed information on the insect pests of tamarugo, listing *Leptotes trigemmatus* (purple moth), *Tephrinopsis memor* (measuring worm), *Hemiberlesia rapax, Heteropysylla texana, Aphis* sp. (tamarugo louse), cecidomids, *Eriophyes tamarugae, Ithome* sp. (flower moth), *Leptotes trigemmatus, Tephrinopsis memor, Frankliniella rodeos* (tamarugo thrips), *Crytophlebia carpophagoides* (fruit moth), and *Scutobruchus gastoi* (tamarugo worm). Despite its anemophilous pollenization, insect participation seems important to fructification. The solitary bee *Centris mixta* is the most important insect pollinator. Imported *Apis mellifera* served as a good pollinator and honey producer (Habit et al., 1981). In addition to enumerating insect pests and control mechanisms, Habit et al. (1981) enumerate associated animals and plants. Marked increases in pod production were evident following insecticide treatment. Untreated tamarugo showed considerable abortion of young pods, much pod stunting, disfiguration, and insect holes (bruchid emergence holes). Rhizobia capable of nodulating tamarugo are being multiplied at INTEC (Felker, 1982). Hectares of dead tamarugo trees were suspected to be fungal infestations, transmitted through root graftings. Felker et al. (1981) review the pest infestations of their *Prosopis* plantings with suggestions for their control.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Thursday, January 8, 1998 by aw

Tanacetum vulgare L.

Compositae, Asteraceae

Tansy, bitter button, cow bitter, golden button, mugwort, tansey

We have information from several sources:

The Herb Hunters Guide—Sievers, A.F. 1930.

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Taxus spp.

Taxaceae

Yew

We have information from several sources:

The Search for New Pharmaceutical Crops: Drug Discovery and Development at the National Cancer Institute—Gordon M. Cragg, Michael R. Boyd, John H. Cardellina II, Michael R. Grever, Saul Schepartz, Kenneth M. Snader, and Matthew Suffness

Diversifying U.S. Crop Production—Jules Janick, Melvin G. Blase, Duane L. Johnson, Gary D. Jolliff, and Robert L. Myers

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Drug Discovery and Development at the National Cancer Institute: Potential for New Pharmaceutical Crops—Gordon M. Cragg, James E. Simon, Johnson G. Jato, and Kenneth M. Snader

last update October 21, 1997 by aw

Thymus spp.

Lamiaceae (Labiatae)

Thyme, common thyme, European wild thyme, French thyme, garden thyme, lemon thyme, serpolet

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Lowman, M.S. and M. Birdseye. 1946. Savory Herbs: Culture and Use. Farmer's Bulletin No. 1977. USDA, Washington, DC.

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Trachelium caeruleum L.

Campanulaceae

We have information from several sources:

New Herbaceous Ornamental Crops Research—Allan M. Armitage

New Flower Crops—Abraham H. Halevy

White clover

Ladino clover

Leguminosae *Trifolium repens* L.

Source: Magness et al. 1971

White clover, like red, is believed native to the eastern Mediterranean region. It was widely grown in Europe before America was colonized and was brought here by the earliest settlers. It is now grown in all areas of the United States except the Great Plains and the extreme South. The plants are perennials with a prostrate growth habit. They develop stolons which root at the nodes, resulting in thickening of the stands. They do not develop upright stems. Leaves grow at the crown and at the nodes of stolons. They are trifoliate and the leaflets vary in shape from broadly elliptical to obovate - generally about half an inch across. Flower beads are aenerally white, sometimes pink-tinted, and contain up to 100 florets.

Among many strains, Ladino white clover is now most widely grown. It differs from the common kinds in that it grows 2 to 4 times as large- otherwise, it is similar. White clovers are used primarily as pastures, often in combination with grasses. They are highly nutritious and palatable.

Last update October 27, 1997

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Triticosecale species

Poaceae or Graminae

Trictcale

NewCROP has WHEAT information at:

Triticale: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Alternative Wheat Cereals as Food Grains: Einkorn, Emmer, Spelt, Kamut, and Triticale—G.F. Stallknecht, K.M. Gilbertson, and J.E. Ranney

New Grains and Pseudograins—Duane L. Johnson

New Crops and the International Agricultural Research Centers—Robert B. Bertram

Wheat, durum wheat, winter wheat, spelt and triticale in New Crops for Canadian Agriculture—Ernest Small

Valeriana officinalis L.

Valerianaceae

Valerian, bitterroot, common valerian, tobacco-root

We have information from several sources:

Simon, J.E., A.F. Chadwick and L.E. Craker. 1984. Herbs: An Indexed Bibliography. 1971–1980.

Phytomedicines as a New Crop Opportunity—Loren D. Israelsen

Herbs Affecting the Central Nervous System—Varro E. Tyler

Vanilla planifolia Andr.

Orchidaceae

Vanilla, tlilxochitl

We have information from several sources:

Food and feed crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Outside Links:

Vanilla—FAO/IBPGR Technical Guidelines for the Safe Movement of Vanilla Germplasm—Link to the publication on the International Plant Genetic Resources Institute web site

Prosopis juliflora DC.

Prosopis chilensis (Mol.) Stuntz is often considered synonymous, but see Burkart, 1976.
Mimosaceae
Velvet mesquite

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Mesquite pods are among the earliest known foods of prehistoric man in the new world. Today flour products made from the pods are still popular, although only sporadically prepared, mostly by Amerindians. Pods are made into gruels, sometimes fermented to make a mesquite wine. The leaves can be used for forage. Providing good bee pasturage also, nectar from mesquite yields a superior honey. The wood is used for parquet floors, furniture, and turnery items, fencepost, pilings, as a substrate for producing single-cell protein, but most of all for fuel. Toasted seeds are added to coffee. Bark, rich in tannin, is used for roofing in Colombia. The gum forms an adhesive mucilage, used as an emulsifying agent. Gum is used in confectionary and mending pottery. Roots contain 6–7% tannin, which might discourage Rhizobia.

Folk Medicine

According to Hartwell (1967–1971), the juice is used in folk remedies for that cancerous condition he terms "superfluous flesh." Reported to be cathartic, cyanogenetic, discutient, emetic, POISON, stomachic, and vulnerary, mesquite is a folk remedy for catarrh, colds, diarrhea, dysentery, excrescences, eyes, flu, headcold, hoarseness, inflammation, itch, measles, pinkeye, stomachache, sore throat, and wounds (Duke and Wain, 1981). Pima Indians drank the hot tea for sore throat (Lewis and Elvin-Lewis, 1977). Aqueous and alcoholic extracts are markedly antibacterial.

Chemistry

Per 100 g, the flower is reported to contain (ZMB): 21.0 g protein, 3.2 g fat, 65.8 g total carbohydrate, 15.5 g fiber, 10.0 g ash, 1,310 mg Ca, and 400 mg P. Leaves contain 19.0 g protein, 2.9 g fat, 69.6 g total carbohydrate, total carbohydrate, 21.6 g fiber, 8.5 g ash, 2,080 mg Ca, and 220 g P. Fruits contain 13.9 g protein, 3.0 g fat, 78.3 g total carbohydrate, 27.7 g fiber, and 4.8 g ash. Seeds contain (ZMB) 65.2 g protein, 7.8 g fat, 21.8 g total carbohydrate, 2.8 g fiber, and 5.2 g ash. (FAO, 1981a). Another analysis of the fruit shows 14.35% water (hygroscopic), 1.64% oil, 16.36% starch, 30.25% glucose, 0.85% nitrogenous material, 5.81% tannin-like material, 3.5% mineral salts, and 27.24% cellulose. Mesquite gum readily hydrolyses with dilute sulfuric acid to yield L-arabinose and D-galactose and 4-o-methyl-D-glucuronic acid at 4:2:1. Owing to the high content of arabinose, the gum is an excellent source of sugar. Roots contain 6.7% tannin, bark 3–8.4%, and dry wood 0.9%. The alkaloids 5-hydroxytryptamine and tryptamine are reported from this species (Simpson, 1977).

Toxicity

According to Mitchell and Rook, the thorn from mesquite, on penetrating the eye, causes more inflammation than expected from the physical injury. The irritation may be due to waxes. Injection of cerotic acid is destructive to the eye. (Still Amerindians applied the leaves for conjunctivitis.) Using the wood in a fireplace has caused dermatitis, as has working with seasoned wood. The gum has irritant properties. Reports on cattle toxicity vary. Lewis and Elvin-Lewis (1977) report that ingestion over long periods of time will result in death in cattle. Further, they report that the pollen may cause allergic rhinitis, bronchial asthma, and/or hypersensitivity pneumonitis. Kingsbury (1964) goes into some detail on mesquite poisoning in cattle, including cases where autopsies showed pods and seeds in the rumen 9 months after the cattle could have ingested them. Mesquite poisoning may induce a permanent impairment of the ability to digest cellulose. Felker and Bandurski (1979) also provide interesting detail. If *Prosopis* pods are the sole food source for cattle, ca 1% become sick, and some die with a compacted pod ball in the rumen. Death is attributed to high sugar content repressing the rumen-bacterial cellulose activity. Mesquite feeding to pigs was promising during the first four weeks, deteriorating thereafter, perhaps due to phytohemagglutinins and trypsin inhibition. Feeding trials with sheep show a 15% higher protein digestibility coefficient for mesquite pods than for alfalfa hay. Trypsin inhibition has been demonstrated the TI content 1.4 TIU/mg (Del Valle et al., 1983). Contains isorhamnetin 11

3-glucoside, apigenin 6, 8-diglycoside, and traces of quercitin 3',3diOMe, leutolin 3'-OMe, and apigenin diglycoside (Simpson, 1977).

Description

Perennial deciduous thorny shrub or small tree, to 12 m tall; trunk to 1.2 m in diameter, bark thick, brown or blackish, shallowly fissured; leaves compound, commonly many more than 9 pairs, the leaflets mostly 5–10 mm long, linear-oblong, glabrous, often hairy, commonly rounded at the apex; stipular spines, if any, yellowish, often stout; flowers perfect, greenish-yellow, sweet-scented, spikelike; corolla deeply lobate. Pods several-seeded, strongly compressed when young, thick at maturity, more or less constricted between the seeds, 10–25 cm long, brown or yellowish, 10–30-seeded. Seed compressed and oval or elliptic, 2.5–7 mm long, brown (Reed, 1970).

Germplasm

Reported from the South American Center of Diversity, mesquite, or cvs thereof, is reported to tolerate drought, grazing, heavy soil, sand, as well as saline dry flats and weeds. Some Argentine germplasm tolerated mild frost at 40° S latitude. ($2n$ = 28, 52, 56, 112) (Zevin and Zhukovsky, 1975, Simpson, 1977).

Distribution

Originally Central and/or South American, the mesquite is now pantropically introduced and establishing, often as a weed. It is classified as a principal weed in Mexico, a common weed in the US (but does not naturally occur in the US, this report due to the long prevailing taxonomic confusion), and a weed in Australia, Dominican Republic, India, Iraq, and Venezuela. According to the NAS, the tree ranges from sea level to 1,500 m. According to the taxonomic work of Burkart (1976), neither *P. juliflora* nor *P. chilensis,* as now defined, occur in the US.

Ecology

Probably ranging from Tropical Thorn to Dry through Subtropical Thorn to Dry Forest Life Zones (with little frost), mesquite is reported to tolerate annual precipitation of 1.5 to 16.7 dm (mean of 29 cases = 9.9), annual temperature of 20.3 to 28.5°C (mean of 21 cases = 25.5), and pH around neutral (Ecosystematic Data Base) (NAS, 1980a).

Cultivation

Propagated, if need be (weeds rarely need be), by seed, root suckers, and hardwood cuttings. Hot water or acid treatment will expedite seed germination. In India, seeds collected in May–June may be sown right after collection, but September–October seed are not sown until April. For line fencing, seeds may be sown in two adjacent rows ca 50 cm apart, with a spacing of 30 cm between the sowings. Transplanting one-year olds in the rainy season is preferable to direct sowing. Root and shoot cuttings with minimum diameter 12.5 mm at the collar and 100 mm long are satisfactory (C.S.I.R., 1948–1976). Pot studies have shown water requirements of nearly 5,000 cm^3 per g of dry matter (Felker et al, 1981).

Harvesting

Bearing fruits in 3 to 4 years, the trees are usually harvested by hand, often after the fruits have fallen.

Yields and Economics

Felker and Bandurski (1979) estimate 2,000 kg/ha pods for such species as *Prosopis juliflora* in unmanaged Arizona desert, 4,000–20,000 kg/ha pods in arid Hawaiian savannas. Speaking of wood, the NAS (1980a) states that on a 15-year rotation, expected yields are 75–100 MT/ha, on 10-year rotation, 50–60 MT, suggesting wood yields of 5–7.5 MT/ha/yr over and above the fruit yields. According to TIME (March 12, 1984, p. 70), mesquite wood is selling for nearly $5.00 a kilogram. TIME quotes Joe Messina, founder of Mesquite Treat Enterprises, as saying that in Arizona mesquite costs about $100 a cord, which in dry wood approximates 3,000 lbs. In one instance, Messina cleared the mesquite off the land of a grateful farmer, free for the chopping. He sells the wood to restaurants in 50-lb. bags at $12.50 for logs, $17.50 for chunks, and $20 for chips. All this because "Mesquite grilling imparts a sweet smoky burnishing of flavor...an almost imperceptible flavor to fish, though a more pronounced and interesting one to shrimp." (TIME, Mar. 12, 1984). Galt et al. (1982) showed that a mesquite free pasture (annual precipitation ca 4 dm) produced 1,165 kg/ha forage compared to 818 kg/ha (17% mesquite) on the mesquite pasture. Burkart (1943) cites studies showing yields of 87 hectoliters/ha in the wild. He also cites Indian studies suggesting that bees can harvest nectar more than enough for 1 kg of honey.

Energy

Fast-growing, drought resistant, and with remarkable coppicing power, *Prosopis* is a natural fuelwood candidate. With specific gravity 0.70 or higher, the wood has been termed "wooden anthracite", because of its high heat content, burning slowly and evenly and holding heat well. This species provides >90% of the fuelwood in some Indian villages (Sharma, 1981). Although no direct data on N-fixation of *Prosopis* are available, Felker and Bandurski (1979) suggest that tree legumes (exclusive of Caesalpiniaceae) fix between 155 and 580 kg/ha/yr. Soils under the crowns of legumes in the desert usually have 10 times more N (0.3%) than those under non nitrogen fixers (0–03%).

Biotic Factors

Fungi reported on this or related species include *Agrobacterium tumefaciens, Cerospora prosopidis, Didymosphaeria cryptosphaerioides, Fomes everhartii, F. rimosus, Gloesporium leguminum, Leveilulla taurica, Napicladium prosopodium, Phoma* sp., *Phyllosticta juliflora, Phymatotrichum omnivorum, Physalospora mutila, Polyporus adustus, P. pinsitus, P. texanus, Ravenelia arizonica, R. holwayi, Schizophyllum commune, Scleropycnium aureum, Septoria prosopidis,* and *Sphaeropsis prosopodis.* Among the Coleoptera, *Amblycerus* sp., *Apate monachus, Bruchidius uberatus, Caryedon serratus, Celosterna scabrator, Oncideres putator, Rhipibruchus prosopis;* among Hemiptera, *Icerya formicarum,* and *Oxyrhachis tarandus;* among Isoptera *Anacanthotermes macrocephalus;* among Nematoda *Meloidogyne* sp. Galt et al. (1982) show the botanical composition of mesquite pastures on the Santa Rita Experiment Range. Felker et al. (1981) review the pest infestations of their *Prosopis* plantings with suggestions for their control.

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Complete list of references for Duke, Handbook of Energy Crops

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Last update Thursday, January 8, 1998 by aw

Vernonia galamensis (Cass.) Less.

Asteraceae, Compositae

Vernonia

We have information from several sources:

FactSHEET contributed by: David A. Dierig

Vernonia and *Lesquerella* Potential for Commercialization—David A. Dierig and Anson E. Thompson

Lesquerella and Vernonia: Oilseeds for Arid Lands—David A. Dierig, Terry A. Coffelt, Francis S. Nakayama, and Anson E. Thompson

Pest Survey of *Vernonia galamensis* in Ethiopia—Tesfaye Baye and Sileshi Gudeta

Vernonia: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

Underexploited Temperate Industrial and Fiber Crops—Richard J. Roseberg

High Value-Added Applications from Vernolic Acid—F. Petrus Cuperus and Johannes T.P. Derksen

New Industrial Crops: Northwestern Argentina Regional Project—Ricardo Ayerza (h) and Wayne Coates

Alternative Crops Research in Virginia—Harbans L. Bhardwaj, Andy Hankins, Tadesse Mebrahtu, Jimmy Mullins, Muddappa Rangappa, Ozzie Abaye, and Gregory E. Welbaum

New Crops Research and Development: A Federal Perspective—L.H. Princen

New Crops in the U.S. National Plant Germplasm System—Henry L. Shands and George A. White

Germplasm Use in Arid Lands Industrial Crops—Dennis T. Ray and David A. Dierig

Applications of Vernonia Oil in Coatings—D.L. Trumbo, J.C. Rudelich, and B.E. Mote

Variability in Oil and Vernolic Acid Contents in the New *Vernonia galamensis* Collection from East Africa—Ali I. Mohamed, Tadesse Mebrahtu, and Teklu Andebrhan

Vetches

Leguminosae *Vicia* sp.

Source: Magness et al. 1971

The vetches are weak-stemmed, semi-vining plants with pinnate leaves terminating in tendrils. Some 150 species are known, about 25 of which are native in the United States. However, the species grown agriculturally here are all introduced, being native to Europe or westem Asia. The vetches are extensively used as green manure for soil improvement, for hay, and in the South for winter pasture. Vetch seed is harvested from more than 100,000 acres annually (112,956 acres in 1959, census figure) in the United States - sufficcient to seed around 1,000,000 acres. Vetches may become troublesome weeds in grain fields but are readily controlled with herbicides. Tares as mentioned in the Bible are believed to have been common vetch.

Last update June 27, 1996 bha

Common vetch

Tares

Leguminosae *Vicia sativa* L.

Source: Magness et al. 1971

This vetch is less winter hardy than hairy. When fall seeded winter injury often occurs at temperatures below 100 F. The plants are sparingly pubescent with procumbent stems up to 3 or more feet. Leaves consist of up to 7 pairs of elliptic or oblong leaflets. Common vetch is sown both as a soil improvement crop and for hay. For hay or seed production it is usually planted with a grain crop, as oats or wheat, to support the vetch plants. Seeding is in the fall in mild climates, in spring in cold areas. Common vetch produces a palatable bay, especially for cattle. Good winter and spring grazing is provided in mild climates. Williamette, Warrior and Doark are important varieties of common vetch.

Last update February 18, 1999 by ch

Index | Search | Home

Vicia villosa Roth

Leguminosae

Hairy vetch

We have information from several sources:

Hairy Vetch: Alternative Field Crops Manual, University of Wisconson Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant & Animal Products

New Crops: Solutions for Global Problems—Noel Vietmeyer

Magness, J.R., G.M. Markle, C.C. Compton. 1971. Food and feed crops of the United States.

Hungarian vetch

Leguminosae *Vicia pannonica* Crantz

Source: Magness et al. 1971

This vetch is intermediate in winter bardiness between hairy and common. Its special virtue is tolerance to wet soils. It is mainly grown as a hay crop on heavy soils in western Oregon where winter precipitation is heavy. Plants are pubescent. Leaves consist of 4 to 8 pairs of linear to oblong leaflets. in Oregon it is commonly fall seeded with a grain crop for partial support. It produces a palatable and nutritious hay on soils poorly adapted for other vetches.

Last update February 18, 1999 by ch

Minor vetches

Leguminosae *Vicia* sp.

Source: Magness et al. 1971

Additional vetch species are crown to a limited extent in the United States.

Monantha vetch, *V. articulata* Hornem. can be grown under the same conditions as common vetch. Plants are smooth or nearly so. The light lavender colored flowers are borne singly. It is distinguisbable mainly by flat seeds.

Bard vetch, *V. monantha* Retz. is much restricted in adaptation. It is grown only in irrigated areas of southern Califomia and Arizona. It is very similar to monantha vetch in appearance, but seeds are oval to round.

Narrowleaf vetch, *V. augustifolia* L., is adapted to soil and climatic conditions like those of common vetch. It is early maturing, ripening seed from spring plants in the north and is characterized by the narrow leaflets. It is suitable for pasturage throughout the Cotton Belt. It may be a troublesome weed in spring wheat.

Horse bean, *V. faba* L., is grown as a feed crop in the United States only in coastal valleys in California, and now much less than formerly. The upright-growing, near glabrous plants have large leaves with broad, oval leaflets. Weevils infesting the seeds are responsible for reduced usage of horse bean as a feed crop.

Woolypod vetch, *V. dasycarpa* Ten., is quite similar to hairy or smooth vetch, *V. villosa*, but is slightly less winter hardy and grows at slightly lower winter temperatures. It is a valuable winter vetch for the Cotton Belt.

Last update February 18, 1999 by ch

Purple vetch

Leguminosae, Fabaceae *Vicia benghalensis* L.

Source: Magness et al. 1971

In general purple vetch resembles hairy vetch, with pubescent stems and pods. It is, however, the least winter hardy of the commonly grown vetches, and temperatures below 20 F. generally cause injury. It is grown mainly in milder sections of California where it is primarily a hay crop. Stems are up to 30 inches or more in length, prostrate or climbing. Leaves consist of 5 to 8 pairs of linear to oblong-linear leaflets. It is little grown in colder climates where spring seeding would be necessary.

Last update July 1, 1996 bha

Vetiveria zizanioides L.

Poaceae

Vetiver

We have information from several sources:

New Crops Era—Noel Vietmeyer

New Crops: Solutions for Global Problems—Noel Vietmeyer

Outside links: The Vetiver Network

Vicia monanthos (L.) Desf.

Leguminosae

Algarroba, one-flowered vetch

We have information from several sources:

Neglected Crops: 1492 from a Different Perspective—J.E. Hernándo Bermejo and J. León (eds.)

Food and Feed Crops of the United States—Magness, J.R., G.M. Markle, C.C. Compton. 1971.

Last update Monday, June 15, 1998 by aw

Tall wheatgrass

Gramineae, Poaceae *Agropyron elongatum* (Host) Beauv.

Source: Magness et al. 1971

Tall wheatgrass is a tall-growing, coarse-textured bunchgrass native to the Eastern Mediterranean Region, introduced from Russia in 1932. It is adapted to growing on wet, alkaline soils and has been used extensively for seeding such sites in the Northern Plains and Intermountain Regions. Clumps reach up to 6 feet and yield heavily with sufficient available moisture. It is less drought resistant and less palatable than crested wheatgrass, but is useful for both hay and pasturage on soils not suitable for other wheatgrasses.

Last update February 19, 1999 by ch

Yellowroot

Xanthorhiza simplicissima Marsh

Synonym.—*Zanthorhiza apiifolia* L'Her.

Other common names.—Shrub yellowroot, southern yellowroot.

Habitat and range.—Yellowroot grows in woods from southwestern New York to Kentucky and Florida, chiefly in the mountains

Description.—This slightly shrubby plant, 1 to 2 feet high, has compound slender-stemmed leaves 5 to 6 inches long clustered at the summit of the short stem. The leaves consist usually of five thin leaflets 1 to 3 inches long, with sharp, irregular teeth. The small, purplish-brown flowers are produced in spring, borne either singly or in clusters from terminal scaly buds. A characteristic of this plant is the bright-yellow color and bitter taste of its bark and long roots.

Part used.—The roots.

Figure 126.—Yellowroot (*Xanthorhiza simplicissima*)

Sievers, A.F. 1930. The Herb Hunters Guide. Misc. Publ. No. 77. USDA, Washington DC.

Last update Friday, April 3, 1998 by aw

Zoysia grasses

Gramineae *Zoysia* sp.

Manilagrass *Z. matrella* (L.) Merr.

Japanese lawngrass *Z. japonica* Steud.

Mascarene grass *Z. tenuifolia* Willd. ex Trin.

Source: Magness et al. 1971

All of these grasses are native to tropical or Eastern Asia. In this country they are used exclusively for lawns, golf courses, and occasionally for erosion control. They form excellent green turf, green in summer but becoming brown during the winter months.

Mascarene grass is the smallest, finest-leaved and least hardy of the three. It grows only 2 inches high, is shallow rooted. It is grown somewhat in southern areas.

Japanese lawngrass has a broad, coarse leaf and makes a dense sod. It is winter hardy as far north as Boston. It is tough, harsh, unpalatable to livestock. Once established, it is very persistent. Propagation is by inserting plugs of sod. Varieties are available, of which Meyer is best known.

Manilagrass has a general limit of hardiness at about 40 N. It appears best adapted to rather heavy soil but will thrive on other types. It is propagated by planting sod pieces and is rather slow to become established; but makes a dense, persistent sod.