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Canarium indicum, the Java Almond or Kenari nut (see page 32)

West Australian Nut and Tree Crop Association (Inc)

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Volume 17

1993

Note on Cover Date
All previous editions of the *Yearbook* have had a cover date for the year before the hear of issue, so that Volume 16, with a cover date of 1991, was actually issued in 1992

As this has led to confusion, in future the cover date on the *Yearbook* will be for the year of issue.

West Australian Nut and Tree Crops Association (Inc.)

PO Box 565, Subiaco, WA, 6008

Publications

The Association publishes a quarterly magazine *Quandong*, the *WANATCA Yearbook*, and the Australasian Tree Crops Sourcebook (ATCROS). Members receive all publications of the Association as part of their subscription.

Membership

For current details of membership contact the Secretary, WANATCA, P0 Box 565, Subiaco, WA 6008, Australia. Members are welcomed from within and beyond Western Australia, indeed about one third of the current membership is from outside Western Australia. Overseas members are encouraged, and pay only standard fees.

For further details of the Association, see Inside Back Cover

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POMEGRANATE CULTURE IN CENTRAL ASIA

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Introduction

The pomegranate (*Punica granatum* L.) is the only species in the genus *Punica*, and appears to be a relict of a much wider Mediterranean distribution of clear Gondwanan origin. The family has every indication of a tropical origin, but has evolved under natural selection and domestication, with the latter extending its range well beyond its native area.

Cultivation and selection has produced many cultivars, reflecting the internal polymorphism of the species. Within the former USSR, the pomegranate is native to Central Asia and the Caucasus, but in this area vegetative propagation has been common and a number of interesting local forms have been preserved.

N.I. Vavilov, after whom our Institute was named, showed great interest in the pomegranate. In a letter to A.D. Skrebskova he mentioned how much he liked the fruit, and suggested that the time was right to elucidate and describe the evolutionary path it had taken [Vavilov, 1987a]. In other letters to her he expressed the need to investigate pomegranate polymorphism and cytology, to extend its cultural range [Vavilov, 1987b], and to preserve its natural geneplasm resources [Vavilov, 1965].

The Plant

The pomegranate has the form of a shrub, 1.5-3m high, with perhaps 20-40 stems of varying age and diameter. Rozanov [1961] has noted a 5m plant. This had stems up to 6cm across, with dingy-grey, finely-fissured bark. Popov [1929] considered that pomegranates of the Pamir-Alai district were distinctive for their brownish-yellow stems, and on this basis classed them under the form *tadshikorum*.

Young pomegranate shoots are greenish-grey and spiny, one-year wood is yellowish green and bare but ends with a needle-like prickle. Buds are small (0.2cm), brownish-green, and turnip-shaped. Leaves on one-year wood are opposite-paired, on two-year wood they appear as leaf bundles, 3.8-4.0cm long and 1.3-1.6cm wide. They are broad-lanceolate with entire margins, narrowly wedge-shaped at the base, roundish at the top and always bare and shiny. Petioles are 0.7-0.8cm long, and bare.

Time of leafing-out depends on the local conditions, so that along the Piandzh River and

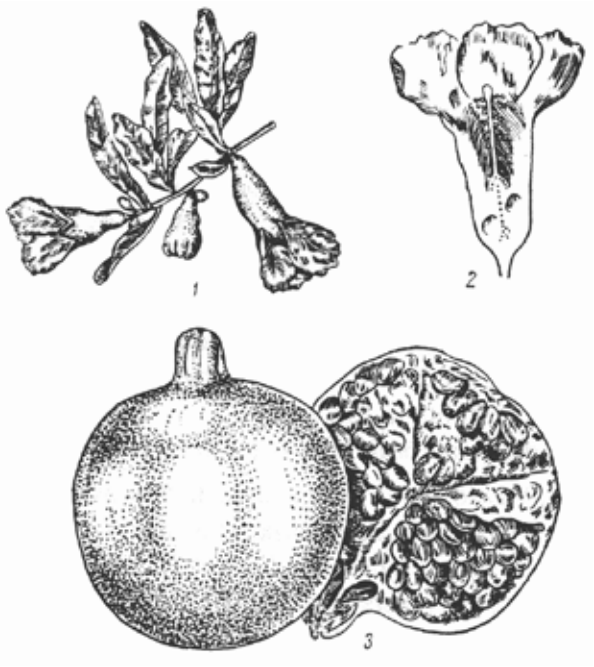
§ Member, WANATCA

on well-warmed southern slopes at 600-700m elevation, leaves appear as early as March. At the upper limits of its range, as in Pamir-Alai at an altitude of 1200-1300m, leaf-out starts in the first half of April and growth ceases in June. On the other hand, in the irrigated areas of the Gissar valley, pomegranates continue growth into late autumn.

In the wild, a period of intense growth precedes flowering. In Pamir-Alai pomegranates lose their leaves with winter, but in warmer areas such as Florida and South China, they may be evergreen. Rozanov [1961] considers that leaf-shed is an adaption to a dryer, more temperate climate.

Flowers appear in leaf axils of current-year shoots, they may be perfect, or more often single-sex, and have 7-8 crimson petals. The style is single, with a lobed stigma. Flowers may be large, jug-shaped, with well-developed ovary and style - 'long-pistilled'. The smaller, 'short-pistilled' flowers are bell shaped, with many developed stamens but an under-developed ovary.

Pomegranates are in flower from May till August, one flower lasting 2-3 days. The long-pistilled flowers open first, the short-pistilled ones follow 7-8 days later. In late May to early June the short-pistilled flowers drop, but the long-pistilled ones carry through. Late flowers lead to under-developed fruits. When in flower, pomegranates look very showy.



The pomegranate. 1) Flowering shoot; 2) Flower cross-sectdion; 3) Fruit and cross-section.

The Fruit

Pomegranate plants bear a distinctive, specialized berry-type fruit called a cenocarpium, with many seeds surrounded by juicy flesh and in a unique two-storied arrangement called a nidus, within a distinctive tough, pliable rind. Fruits of wild pomegranates are very varied, but are usually roughly spherical, somewhat flattened at the top, smooth, of a washed-out greenish- or orange-yellow colour. Some wild fruits are dingy green. The pulp is pink and sour, or very occasionally sour-sweet. Cultivated varieties are even more varied in shape and colour, the latter ranging from pink and crimson-red to blackish-violet and blue [Petrova, 1989].

According to B.S. Rozanov [1960, 1961], fruit characteristics can be used to distinguish two subspecies, *Punica granatum* subsp. *chlorocarpa*, which includes all wild forms and some cultivated forms, and *P. granatum* subsp. *porphyrocarpa*, which includes only some cultivated forms.

Fruits ripen in September and October. From a single shrub growing in the Darvaz Mountains, 100-200 fruits may be obtained, but their size and weight will vary greatly with conditions - drier conditions means smaller fruits. Wild plants growing along river banks or on well-exposed slopes may give fruits as good as orchard plants; the main difference then is in the size and flavour of the fruits. Generally, wild fruits are smaller and more sour than orchard fruits [Vavilov, 1929; Speranskii, 1936; Neubauer, 1954; Evreinoff, 1957].

Rozanov has shown that Tadzhikistan cu1tivars, such as 'Chuchuk-dona', 'Shaarsabzy', 'Oblik-Nardon' , and 'Achik-Anor' , are the closest to wild forms, and represent the first stages of domestication. Many cultivars found in the Darvaz, Gissar, and Karategin Mountains were originally selected from the wild, and have restricted areas of use, as little as one village. Evreinoff [1957] has pointed out that the pomegranate represents a classical example of domestication of a wild fruit tree. Introduction into culture did not occur at any one centre, but was a parallel process extending over the whole wild range. As with Central Asia, other countries within the natural range, such as Afghanistan and Iran, have their own local selections.

Pomegranate seeds are very small, with 250-300 seeds per fruit, and light brown. They germinate easily. Their composition is 6-35% water, 6-21 % fat, 12-20% starch, 22-34% cellulose, 9-10% nitrogenous compounds, and 1-2% ash. Some specimens have high seed oil content, including punic, lauric, palmitic, arachic, and linoleic oils. They may also have a high content of tocopherol, a natural auto-antimutagene. This may be one reason why this relict genus has persisted. There is no tocopherol in the vegetative organs, which may have a link to the increase in somatic variation in the north of the natural range.

Reproduction and Growth

In the wild, pomegranates reproduce by seed. Seedlings appear in April. Growth is slow at first, especially in dry conditions, then speeds up somewhat. On dry slopes, a seedling may take 10-12 years to reach a height of 1m; if irrigated it may reach the same height in 2 years. The plants are long-lived. Berezhnoi [1951] has found plants as old as 50-70 years, while Kuznetsov [1956] noted pomegranates as much as 300 years old in the Surkhan-Darinskii region of Uzbekistan.

Pomegranate roots may reach a depth of 170cm after 4-6 years, and after 8-9 years their surface roots extend well beyond the canopy limits, and so may have a major role in anchoring mountain slopes and soils, with their drought-resistance a major plus.

Even though pomegranates have good drought resistance, they will grow well in soils of high moisture content. Plants grow successfully in areas where winter temperatures do not fall below -l2°C, with long, hot summers, and a warm, dry, even autumn. If temperatures fall below -20°C, pomegranates may be killed back to the ground. Under conditions where the vegetative period is sufficiently long but temperatures may fall below -15°C, frost protection is needed for successful crops. Spring frosts are not usually a problem as the pomegranate is a late bloomer, but autumn frosts before harvest can be dangerous. Good fruit ripening needs a hot summer and a long, dry, and warm autumn.

Pomegranates will grow on rocky mountain slopes, on riverbank sands, and even on gravels and alkaline soils. Best growth is obtained on deep fertile well-drained loams and clay

loams. Plants will not withstand very salty or marshy conditions.

The plants have been used as hedges and boundary plants in orchards since ancient times, sometimes there is no distinction between the hedge and the orchard plant. In the wild, pomegranates are found associated with Bokhara almond, hawthorn, pistachio, Regal maple, sumach, and other local trees. More rarely, and mainly along the banks of the Piandzh River, pomegranates are found in small groves with plane trees, persimmons, grapes, and figs, at springs. These groves are protected as sacred places by the local inhabitants [Zapriagaeva, 1947].

Uses

Pomegranate fruits, including wild ones, have a very wide variety of uses. Their most important product is pomegranate juice, essentially the contents of the gigantic sarcotestal cells which form the integument around the seeds. The juice contains 76-78% water, 1.1-1.5% protein, 8-21 % sugar, 1-3% fat, and 0.3-5% acids. Wild pomegranate juice contains much the same amount of sugar as that from cultivated types, but the acid content is more than double, which detracts from the taste. Juice may be used in fresh drinks, syrups, extracts, seasoning in meat dishes, as well as in confectionary and ice-cream. Juice of wild pomegranates can be used for producing citric acid crystals.

The rind of the fruit is no less valuable than the juice. Wild pomegranates have thicker, tougher rind, containing more tannin, than cultivated ones. Tannin content may be 26-30% [Grossgeim, 1946; Sokolov, 1952], soluble matter up to 21.8%, gum 34.2%, and resin to 10.9%. Pomegranate tannins are used to treat the thinnest sorts of leather, including Morocco [Endin, 1944], and have also been used in dyeing cloth. Dark brown or beige colours are used with silk, green, khaki or browns with cottons, and yellow-greens in wool blends. Pomegranate rind has been locally used for centuries to get fast brown and black dyes.

Pomegranate rind extracts, containing substantial amounts of tannins, have been used medicinally to treat gastric disorders [Kushelevskii, 1891; Jayaweera, 1957; Parsa, 1960]. Alkaloids in the rind, especially pelleterine, have wide medical application. Extracts give a positive action with acute and chronic enterocolitis, and will usually cure diarrhea after 4 days [Rossiiskii, 1946]. Rind also contains isopeleterine, which is highly active against liver fluke [Wibaut, 1957]. Pomegranate bark from branches, trunks, and roots contains up to 32.7% tannins [Stankov, 1951], and root bark has been used as an effective vermifuge for many years in India, Britain, and European counties [Watt, 1892].

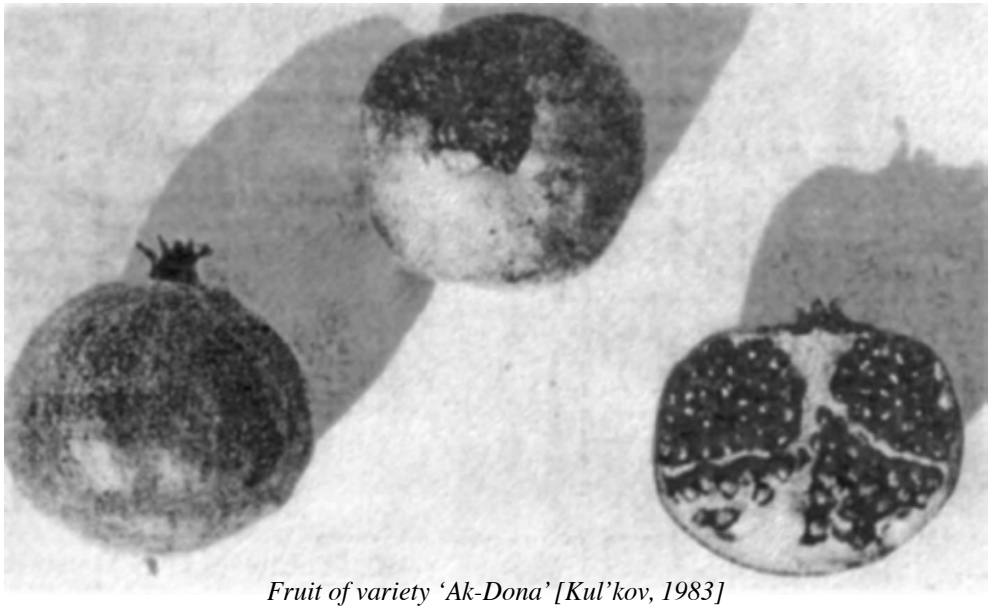
Ground pomegranate root is used in popular medicine to relieve injuries and fractures and reduce pain [Gammerman, 1957]. Watt [1892] notes it as the best remedy for chronic dysentery. Flower petals and buds also figure widely in folk medicine, with infusions used to stop bleeding [Abu-Ali Ibn-Sina, 1956], treat throat disorders [Medvedev, 1919] and dysentery [Watt, 1892], and as a febrifuge [Monteverde, 1927].

For the people of Central Asia, the pomegranate is a symbol of plenty, and a potent local medicine. Considered a sacred plant, the wood was not burned. In ancient times there was a considerable trade in pomegranate petals as a source of fast red dyes, but how these were prepared is not currently known. Pomegranate leaves have been used as a tea substitute [Sakhobiddinov, 1948]. Seeds have been used to prepare vinegar [Strebkova, 1931) and extract oils [Nesterenko, 1949], as well as a remedy for fever.

Although these days pomegranate is regarded mostly as a fruit-bearing plant, it can also serve as a beautiful ornamental. Especially valuable are forms with double flowers (*P. granatum* forma *multiplex*), with white flowers (*f. albescens*) and with yellow petals (*f. flavescens*) [Rehder, 1949].

Wild pomegranate ranges are found in the Transcaucasus, Asia Minor and Central Asia, Iran, and Afghanistan [Neubauer, 1954]. Within the former Soviet Union, disjunct ranges of wild pomegranate exist in the Transcaucasus [Voronov, 1925], Kopetdag [Popov, 1929], and Pamir-Alai [Zapriagaeva, 1964].

As regards Soviet pomegranate cultivation, this has been centred in the Central Asian republics, with about 3 million trees [Kolesnikov, 1973]. In Uzbekistan, pomegranate orchards are widespread in the Surkhandarin, Andizhan, Namangan, Fergan, and Bukhara regions. In Tadzhikistan pomegranates are grown in the north and north-west, with the main area (74 %) being the Vakhsh Valley, with many new plantings - this area does not need frost protection measures.



Fruit of variety 'Ak-Dona' [Kul'kov, 1983]

In Turkmenistan, pomegranates are grown in two places, in the Ashkhabad region near the Maryi oasis, with winter protection, and in the south-west, on open ground. The most technically advanced plantings in Central Asia achieve yields of 15-20 tonnes of pomegranates per hectare.

Selection and Varieties

Breeding and selection of pomegranate varieties on a scientific basis has been going on for about 40 years - very little compared to perhaps 50 centuries of local folk selection. Scientific techniques used have included selection from open-pollinated seedlings, varietal crossings, selection of sports, and all manner of interbreeding, backcrossing, and hybridization approaches, including introgression to the F4 generation. So the new cultivars do not exceed 3 or 4 decades in age, compared to 2- 5 millenia of folk selection and 5- 7 million years of natural selection of the species.

The most important breeding achievements during the Soviet period have been: 1) deriving a suite of soft-seeded, sweet-acid cultivars; 2) obtaining compact-habit cultivars, intended for intensive cultivation in modified environments; 3) selecting soft-seeded cultivars which ripen early and extra-early, with the aim of extending the regions over which pomegranates may be grown.

The following list includes the most important and widespread varieties.

Achik-Dona. An Uzbek selection. Fruits are large and spherical, with a pinky-gold skin. Seeds are large and long, the pulp is sweet and tasty. It produces high yields and ripens in mid to late October.

Bala-Miursel. A local Azerbaidzhan selection. Plants reach 3m in height. Fruits are large (400-500g), the rind is a deep crimson, and thick. Large-seeded, with red, sweet-acid juice, containing up to 16% sugar and 1.5% acids. Fruits ripen at the beginning of October and will keep for 3-4 months. Yield is 30-50kg per plant.

Giulosha Azerbaidzhan. Plants grow to 3m, fruits weigh 300-400g. Their skin is pinky red, thin, and shiny. Seeds are large, juice is bright pink and sweet-acid, containing about 20% sugar, 1.8% acids. Fruits ripen in early to mid October, and keep for 2-3 months.

Guilosha Pink. Another local Azerbaidzhani selection. Fruits are round, medium size (200-250gm), sometimes larger. Seeds are of medium size, juice yield is high (around 54%) and of excellent flavour. Sugar content is 15.6%, acids 1.3%.

Kazake-Anar. An Uzbek selection with large (300-400g) yellow-green fruits, medium thickness rind, and big seeds. Juice is crimson - red, sweet-acid and of good flavour, containing about 20% sugar and 1.85% acids. Juice yield is about 45%, this high-yielding cultivar ripens in the first half of October. A very widespread variety.

Kaim-Nar. An Azerbaidzhani variety with medium-size fruits (200-250g), greenish with a bright-red blush. The dark red juice is tasty and sweet-acid, fruits ripen mid-October.

Kai-Achik-Anar. An Uzbek- Tadzhik variety in which the plants grow quite large. Fruits are large (300-400g) and spherical, ripening in mid-October. They transport and keep well. Plants yield about 50kg each of fruit with 16% sugar, 1.4% acid.

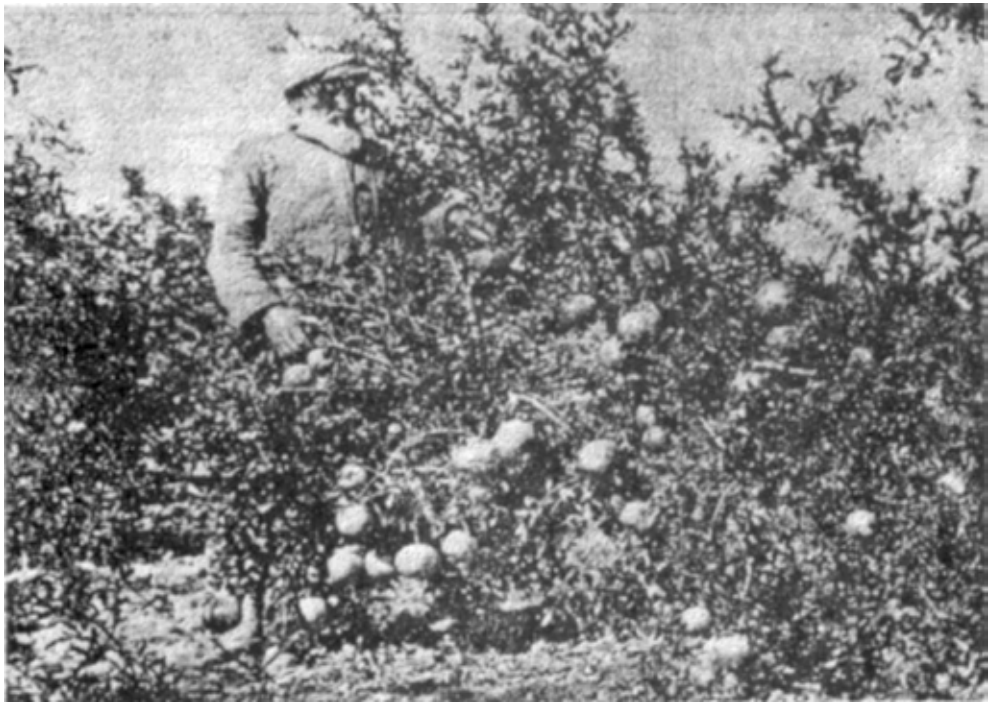
Kzyl-Anar. An Uzbek variety with medium round fruits. Their shiny green skin is of average thickness. Seeds are medium size. Juice yield is about 54%, sweet-acid with 15% sugar and 2.2% acid. Fruits ripen in early to mid October and keep for 4-5 months, but do not travel well.

Krmyzy-Kabukh. An Azerbaidzhani variety of exceptional quality. Plants are very tall (4 m), fruits are large (350-400g), bright red, and spherical. Medium rind, large seeds, yielding about 45% of red sweet-acid juice, with about 14.5% sugar, 2.1 % acids.

Nazik-Kabukh. An Azerbaidzhani selection which produces large (400g) dark red fruits on a tall (4m) plant. Fruits contain big seeds, yield about 49% sweet-acid juice, with about 12.3% sugar and 2.6% acids. Fruit ripens in early to mid October, keeps for 3-4 months, and is in high yield.

Shakh-Nar. An Azerbaidzhani selection growing on a small plant. The medium-size (300g) red fruits are round or pear-shaped, with average-thickness rind. Seeds are small, juice yield is around 50%, the sweet-acid juice has about 13.4% sugar and 2.1 % acids. Fruits are ripe in the second half of October, and keep for 6 months. Yields are good.

A great many other varieties exist as well as these. They include *Surkh-Anor, Kavadany, Iridane, Ak-Dona,* and *Shirin-Nar.*



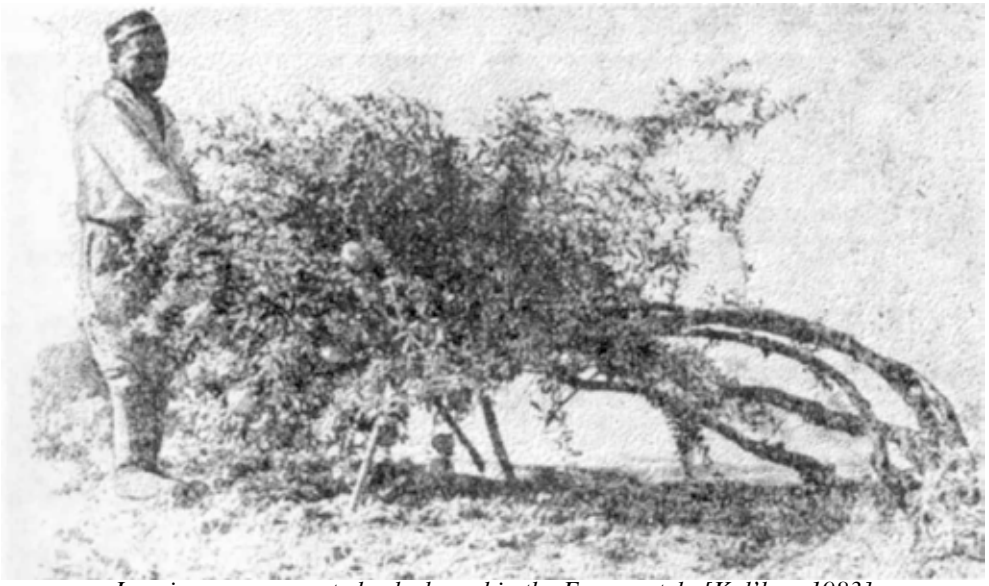
High-yield varety 'Achik-Dona' at the South Uzbek Experiment Station, Denau. Yield was 43kg at third year of fruiting [Kul'kov, 1983]

Further Development

The present aim in Central Asia is to increase the area under pomegranate production, and 10 specialist plantations of this fruit have been established, but the range of varieties in use is still very limited. This limits the season of fruit availability and puts pressure on harvesting and processing processes. There is a need to develop early varieties suited for intensive culture.

However, in practice breeding work has almost ceased. In Tadzhikistan a small amount of variety crossing is still being carried out, working with the gene bank assembled by Prof. B. S. Rozanov and T. A. Ivanova, all directed to obtain dwarfed cultivars suited to artificial shelter and producing soft-seeded, sweet-acid fruits. In Azerbaidzhan, many cultivars and promising selections have emerged from the gene bank collection of A.D. Strebkova and Prof. L. M. Akhund-zade.

One of the largest assemblies of pomegranate resource material is that of the Vavilov Institute's Turkmen Experiment Station - this numbers more than 1000 selections. A small amount of work on soft-seeded cultivars is still being carried out there. The climatic conditions of the Station, in the north of the open (unsheltered) pomegranate culture belt, has enabled some good selection work to be carried out. For example, in the 1950-60 period, N.L Zaktreger was able to select a series of promising cultivars and forms.



Leaning pomegranate bush shaped in the Fergan style [Kul'kov, 1983]

Selections with early or extra-early ripening features are of special interest. For example, fruits of the test variety 'Super-early' ripen at the beginning of August. Soft-seeded varieties which ripen between late August and early September include '6/49' (selected by Prof. Rozanov) , and 'Andalib', 'Kerogly', 'Siunt', 'Zelili', 'Anvari', 'Sumbar', and 'Shikhimderinskii' (selected by Zaktreger). All these, according to G. M. Levin [1990], are promising for testing in the northern, colder regions of pomegranate culture.

The soft-seeded varieties are of excellent eating quality. This group contains about 100 accessions with a range of ripening and taste characteristics. Varieties which reached the official testing and registration stage included 'Podarok', 'Shainakskii', 'Agat', 'Gissarskii Alyi', 'Gissarskii Krupnoplodnyi', 'Meskheti', and 'Azerbaidzhan'.

Good cold and frost resistance is found in the 'Kazake' strains, most of which have valuable cultural and biological traits. The seedling '57/12' is notably cold-resistant. For the modified-environment areas, the dwarf, soft-seeded and sweet-acid selections of Rozanov and Ivanova are promising, especially the variety 'Agat' .

Propagation

Pomegranate is normally propagated from cuttings, occasionally by grafting. One-year or two-year wood is used, with cuttings 20-25cm long and at least 0.5cm across. They may be taken between December and mid-April, and may be stored in a cellar in damp sand, or buried in trenches in the open ground.

Cuttings are set out after cutting across under a lower node with a sharp knife. They should be inclined rather than upright, with one bud exposed, at a separation of 16-2Ocm within the row and 90cm between rows. They can be transplanted from the nursery when 1-2 years old and with shoots 40-5Ocm long.

If grafting is used, wild or semi-cultivated pomegranate rootstock is recommended. Best results are obtained with bark or whip-and-tongue grafts. Grafting is done in spring, budding is best done with dormant buds early in September.

Culture

Best spacing for pomegranates is still not decided. Layouts from 3 x 3m to 8 x 8m have been recommended. However, the most widely-accepted spacings are 4 x 2m or 4 x 3m, corresponding to 1250 and 833 plants/hectare.

Soil treatments are as for normal orchards. Ploughing each year to a depth of 20-25cm, depending on the root system, is normal. The best fertilization method is to apply 30-40 tonnes of animal manure per hectare every two years, corresponding to N120-P90-K60. Irrigation is very important to obtain good plant growth conditions and ripen good fruit, the amount required equates to 900-1000 cubic metres per hectare. Pomegranate plantations are irrigated about 12 times during the vegetative period, usually once in April, twice in May and June, 3 times in July and August, and once in September.

Pomegranates can be grown as a multi-stemmed shrub with 3 or 4 stems, or as a small tree with 4-5 scaffold branches. On each of these, 4-5 secondary shoots may be left, each with their own tertiary shoots, and so on. Unwanted suckers and shoots are cut out systematically. It is specially important to see that root suckers and watershoots are not left, these should be cleaned out 3 or 4 times a year.

Pomegranates bear both on older wood, especially that 2- 3 years old, as well as on current season growth. Best fruit yield and quality is obtained from older wood. Because of this, it is desirable during early pruning, before blossoming, to remove about 50% of current-year shoots, and shorten the remaining half so that flower buds do not form on them [Arendt, 1973].

These shoots are shortened again in late July-early August, while main pruning is done in autumn. The aim of this is to thin the crown, leaving the strongest and best-formed branches.

Replacement of older (3-5 year) branches with new ones, plus timely removal of current-year non-fruiting shoots, are major requirements to maintain regular high yields.

Under protected-culture conditions, it is more reasonable to form a leaning shrub with three main branches, to reduce breaking of branches and rotting when this is covered dur-

ing winter. Shaping is commenced the second spring after planting. The aim in pruning is to attain precise and timely control of growth processes in the inclined branches to give optimum growth and fruiting. Correct pruning in protected culture can increase yields by at least 14%.

Fruit picking is an extended process, as all fruits do not ripen at the same time. The longer the fruits stay on the plant, the better their flavour and the higher their sugar content, so it is important to allow fruits to ripen on the tree as late as local climatic conditions allow.

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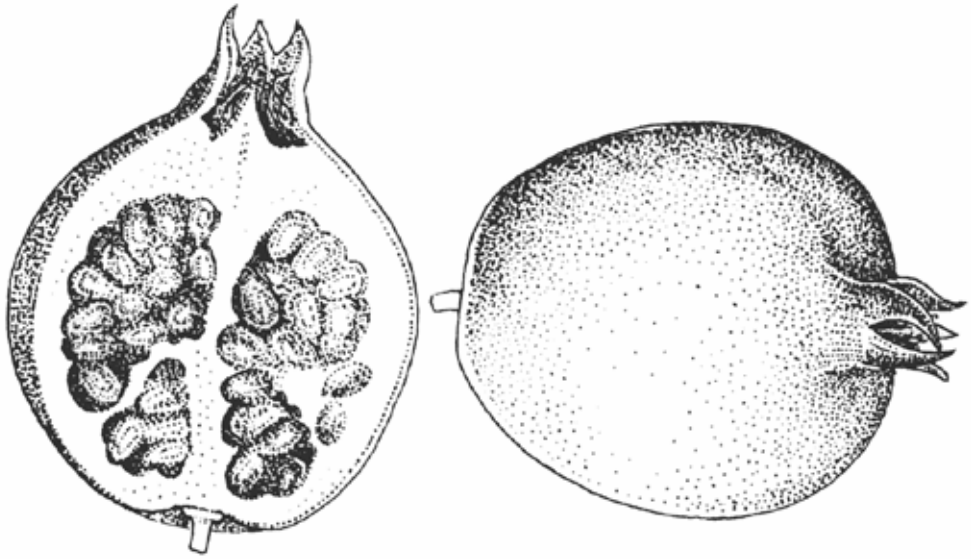

PECAN - AN EMERGING CROP

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Introduction

Pecan [*Carya illinoinensis* (Wangenh.) C. Koch, also known as *C. illinoensis*] is a relatively unknown and botanically undomesticated tree crop. It is mainly grown in its native North American range. Since it provides excellent nuts, good timber, and intercrops well with a variety of horticultural crops, it has a potential on other continents as well. In Latin America, Israel, Egypt and China it has already been introduced.

This report presents information pertinent to the use and adaptation of pecan.

Usage

Food: A fresh pecan nut is generally considered by many to be the best tasting of the various major tree nuts. Nutmeats (or kernels) are eaten raw, roasted, or salted and are commonly used in baked goods, ice cream, liqueurs, mixed nuts, and flavourings. Kernels are highly nutritious, being sweet and oily, comprised of about 74% fat, 13% total carbohydrate, 2.4% fibre, and 9.7% protein; they are an excellent source of P and K. The fats are highly polyunsaturated, containing primarily oleic (55 to 83%), linoleic (14 to 38%) and linolenic (3.3 to 7%) fatty acids.

Wood: The wood of pecan is relatively dense, attractive, and is valued as a timber tree for veneer and lumber for furniture and floorings. Under near optimum growing conditions young trees can grow over 5cm in trunk diameter each year. These trees have very high rates of carbon fixation under conditions of high moisture and sunlight. The prunings of trained trees and trees removed in the thinning process also present a source of firewood. Pecan wood is excellent for purposes of 'smoking' foods.

Agroforestry: Pecan potentially lends itself to diverse secondary uses such as alley cropping with grains, cotton, forages and many horticultural crops, perennial inter-cropping (peaches, plums, cherries, blueberries, brambles, etc.) and silvipasture. It is also potentially useful for erosion control because of its deep tap root and abundance of deep lateral and feeder roots. The large spreading leaf canopy is an excellent interceptor of rainfall. It can also function as windbreak or boundary planting while providing alternative forest products such as firewood and mushrooms.

The canopy gives abundant shade and wildlife habitat. The potential of pecan in agroforestry has not yet been investigated; however, its historical utilization in intercropping systems in the U.S. would indicate that it possesses considerable potential as an agroforestry component. It also has significant potential as a source of cooking oil (from nut meats) for regions where oil crops are scarce or expensive to grow.

Ecology

Native Habitat: The native range of pecan is the floodplains along the Mississippi, lower Ohio, lower Missouri, lower Red Rivers and their associated tributaries. In historical times, the range appears to have extended from about 42° 20' North latitude (Iowa-US) to that of about 16°30' North latitude (South Mexico). Since competition from other trees, shrubs, and vines in this environment is intense, pecan has evolved such that it rapidly reaches the status of a large overstorey tree. Trees in such habitats can reach heights of 60 m.

The species is only moderately shade tolerant. It is aggressive and highly competitive in its native habitat; however it does poorly if the site is so low as to allow the water table to be very near or at the ground surface during long periods of the growing season. The soils of pecan's native habitat are characterized by stratified and deep alluvials. The soil water table is typically high during late winter and early spring and low during the rest of the year.

Pecan [Carya illinoinensis (Wangenh.) C. Koch]

Native trees grow in regions ranging from no freezing weather (South Mexico) to about 170 freeze-free days (Iowa). Cool night or day temperatures suppress nut development.

Pecan is one of the last tree species in its natural habitat to break bud, hence cultivars have a high heat requirement for spring budbreak. As a deciduous tree crop, the number of hours below about 7°C (chilling hours) influences spring bud break.

While the native habitat of pecan is relatively humid, the crop does at least as well in arid environments if trees receive irrigation and day temperatures rarely exceed 46°C. Under humid conditions, its foliage and nuts are readily attacked by several disease pests (pecan scab, pecan anthracnose, brown kernel rot) which appear to have co-evolved with the species, whereas trees in arid climates are free of these diseases. On the other hand water stress can induce fruit abscission and vivipary, or premature germination.

Pollination: Trees generally require another cultivar to function as a pollinator. If flowering among trees fails to overlap, there will be very poor nut-set and kernel quality will be poor. Pecan is wind pollinated, pollen sources should be located appropriately for dispersal and uniform coverage of the orchard. Pecan is a copious pollen producer, however fertilization may not occur if pecan is grown in environment where relative humidity during flowering fails to drop below about 80%. This is because high humidity prevents the anthers of catkins from adequately releasing their pollen.

Commercial Production

Cultivars: Worldwide commercial production of inshell nuts is about 175,000 tonnes annually (see table). The vast majority is produced in the US, with Mexico ranked second and Australia third. Significant production also originates from Brazil, Israel, and South Africa, with minor production from Argentina, China, Egypt, Peru, and Uruguay. There are over 1000 named pecan scion cultivars in the US alone, with several dozen cultivars more when those developed in other countries are included. However, only about 30 of the total group are considered to be of commercial economical significance.

Unlike many other fruit or nut crops, there is no specific rootstock. Pecan rootstocks are from open pollinated seed of one of several scion cultivars. Seeds of 'Curtis' and 'Elliott' are frequently used for planting in acidic soils whereas seed of 'Riverside' or 'Apache' are often used for planting in alkaline soils. However, in practice almost any seed source is likely to be utilized as a rootstock. There are no clonal rootstock cultivars.

Harvest: Orchards for nut production are generally established at square or rectangular spacings ranging from 10x10m to about 20x20m, depending upon the grower's strategy. To avoid selfing, usually a pollinator is planted every 4-10 rows in the orchard.

Depending upon the cultivar or genotype utilized, trees generally begin producing nuts between their 4th and 8th growing season. Trees appear to be capable of remaining productive for 300 years or more. Nut production ranges from about 12 kg per tree for a 10-year-old tree to about 150 kg for those around 70 years old. Commercial orchards in the US typically yield between 700 and 2,000 kg of in-shell nuts per hectare.

Harvesting is done by using either mechanical shakers or long sticks. Nuts are commonly harvested from the ground as soon after dropping from the tree as practical, because kernel quality can rapidly deteriorate on a warm and/or wet orchard floor, and nuts are subject to predation by rodents and birds. Nuts can be stored for several years at -10°C and one year at -2°C. When the nut dehisces from its associated shuck (or involucre) it is fully ripe, and is at prime quality upon air-drying to 3.5-4.5% moisture.

Climatic Factors

Most commercial cultivars require 180-210 days to mature their nuts, although cultivars exist which will mature their nuts in 110-120 days. These cultivars with the shortest fruit development periods are also the most cold hardy, the best adapted to the northern extreme of its natural range, and generally have the smallest nuts (140-180 nuts/kg), whereas the southern adapted cultivars generally have large nuts (80-130 nuts/kg).

The major climatic limitation to cultivation is the length of the growing season (days between last freeze and the first freeze). Most commercial cultivars grown in the US are grown in areas receiving 240 or more freeze-free days, however substantial commercial production also comes from areas with as little as 210 freeze- free days (some from areas with 180 or fewer days).

A second temperature factor of substantial importance is that of the average temperature during the growing season, or rather growing season heat units [$\Sigma n(m-t)$ - where n = number of days in growing season; m=mean daily temperatures during the growing season; t=minimum growth temperature for pecan (about 10°C)]. Most commercial cultivars will perform poorly if the growing season is below about 4,000 heat units, even if the growing season is long (in excess of 220 days).

Darkened areas are regions of the planet where pecan appears to be adaptable for cultivation. Criteria are based on air temperature characteristics in relation to dormant and growing seasons and assume the use of appropriately adapted germplasm and the application of irrigation water whenever needed. An unaccounted factor potentially limiting cultivation within the darkened regions, especially desert sites, is the impact of strong winds on tree structure and fruit integrity.

In fact, most commercial pecan growing areas in the US have heat units ranging from about 5,000 to 7,000; hence, most pecan cultivars do better in areas with a very warm growing season than in one with a cool season such as that typically found at high elevations or latitudes. At the lower latitudes of Mexico pecan produces well at elevations up to at least 2,000 m. It appears that low heat units during the growing season can be partially offset if there are high levels of solar radiation. When all else is about equal, commercial orchards in sunny environments are more productive than those in environments with a lot of cloud cover. Heat, as related to budbreak, also plays a major role in adaptation. It is known that budbreak can be substantially accelerated (2 weeks or more) when trees receive hydrogen cyanamide treatments several weeks prior to anticipated budbreak. The vast majority of commercial cultivars do well when they receive chilling of 400+ hours.

Other Environmental Factors

Soil: Pecan thrives in a wide variety of soils over diverse climatic conditions. While it performs best in deep well-drained alluvial soils, it also performs well in less suitable soils if sufficient water and fertilizer are applied. It does best on soils with a pH between 6 and 7.0, but also does well on soils from pH 5 to 8. Trees are highly susceptible to zinc deficiencies,

especially if grown in soils with excessive alkalinity or acidity. Pecan is also susceptible to high levels of chlorine, sodium, boron, and soluble salts.

Pests: The most economically important insect pests are the yellow and black aphids, pecan weevil and hickory shuckworm, whereas the most important diseases are generally pecan scab, shuck dieback or anthracnose, and phytophthora shuck and kernel rot.

Because of the severity of these pests and the expense of controlling them, efforts to establish pecan outside of its natural range should encompass extreme quarantine measures to ensure that these pests are not co-introduced with the incoming pecan germplasm. The co-introduction of some of these pests with pecan by growers in some countries has resulted in these pests becoming the major biological and economic barriers to increased growth and popularity of the industry in those countries. For example, pecan aphids were accidentally co-introduced into South Africa and Israel, and pecan scab and anthracnose were co-introduced into Brazil.

Nut predation by ravens, crows and other large birds and by rodents, such as squirrels, can also be a major pest problem.

A significant abiotic 'pest' of pecan is lightning. Since these trees are often the tallest object around, they are frequently struck by lightning. This generally results in bark damage and limited trunk damage, but can also kill the tree.

Potential

This species exhibits a substantial ability to be productive in a wide variety of environments. Most cultivars are likely to be highly productive in several regions. These include the climate types of cool uplands of Tropical Savanna, Tropical and Subtropical Steppe, Mediterranean (or Dry Summer Subtropical), and Humid Subtropical (where pecan evolved). The potential commercial regions of the planet where pecan appear to be capable of being cropped are identified on the map. Some cold hardy cultivars can be cropped in Humid Continental climates with warm summers.

Pecans can be easily produced in most warm humid climates, however the best locations are probably sunny arid sites where plenty of water can be economically supplied. Northerly adapted cultivars are available that could be utilized in relatively cold climates.

There is a tremendous amount of genetic variability within the species, plus that in 19 other *Carya* (hickory) species. Hence as breeding efforts continue to improve both adaptability and important horticultural traits, pecan will undoubtedly be a crop of increasing worldwide importance.

Yearbook Editor's Note: From the map, Australia has a higher proportion of its land suitable for pecan production than any other continent. As stated, water availability is assumed. With this and the other requirements fulfilled, the potential production area is not unreasonably optimistic - certainly an eye-opener for the potential Australian nut producer.

[Based on an article in Chronica Horticulturae. Vo1.31. No.2. June 1991]

Table 1. Characterization of production and most significant cultural and pest problems of pecan from producing countries.

Characteristics	Country of cultivation								
	USA	Mexico	Australia	S.Africa	Brazil	Israel	Egypt	Peru	Uruguay
Prodn (mT)§	129,800	27,216	4,250	1,814	1,200	1,016	1000	500	<100
Main cultivars: first	Stuart	Western Schley	Western Schley	Bester	Mahan	Delmas	Seedlings	Mahan	Stuart
second	Western Schley	Wichita	Wichita	Barton	Desirable	Western Schley	Curtis	Stuart	
%crop exported	3	50	95	0	0	10	0	0	0
%production from arid sites	33	85	80	30	95	100	100	100	50
humid sites	67	15	20	70	5	0	0	0	50
Most limiting cultural problems	alternate bearing	irrigation	cultivars	irrigation	pruning	zinc deficiency	irrigation	irrigation	irrigation
Most limiting insect pest	Pecan weevil, Hickory shuckworm, Stinkbugs, Nut casebearer, aphids	Yellow aphids, Hickory shuckworm, Nut casebearer	Green vegetable bug, Tree moth borers	Yellow aphids	Yellow aphids	Yellow aphids	Yellow and black pecan aphids	*Oiketicus kirbyi, Anthonomus, Heliothis virescens*	Aphids
Significant endemic insect pests	many	many	Echiomima spp. *Dacus tryoni*	*Salagina spp Nezera spp*		none	none	none	*Oiketicus spp Heliothis virescens*
Significant disease pests	Pecan scab, Pecan anthracnose	Cotton root rot	Brown leaf rot	Pecan scab	Pecan scab	none	none	none	

§ Annual in-shell production in metric tonnes (does not include nuts sold at roadside markets and those consumed for personal use).

Information presented in this table was provided by the authors for the U.S.; Dr. George R. McEachern for Mexico; Dr. Leigh James and Mr. Dean Stahmann for Australia; Dr. Nigel Wolstenholme and Mr. Arthur Rowell for South Africa; Dr. Shaul Homsky for Israel; Mr. Klaus Bederski for Peru; Dr. Fatma Khalil for Egypt; Mr. Juan Darricarrere for Uruguay; Dr. Rodolfo Reichart for Argentina; and Mr. Oskar Unk for Brazil. Their input is gratefully acknowledged.

WILD FRUITS IN PUERTO RICO

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The Antilles, or West Indies, form an arc stretching east and south from the southern tip of Florida to Venezuela. They make up the eastern boundary of the Caribbean Sea, the whole area washed by the Caribbean being termed the Caribbean Basin, including Mexico, Central America plus northern Columbia and Venezuela.

The Greater Antilles comprise Cuba, Hispaniola, Jamaica and Puerto Rico, the Lesser Antilles include the rest of the island chain to the southeast of Puerto Rico.

Puerto Rico is a rectangular, very mountainous island measuring 166 x 68 km, located at roughly 18°N in the Caribbean Sea, the smallest of the Greater Antilles. It has an area of nearly 9000 sq km, including the offshore islands of Vieques, Culebra, Mona, Desecheo, Caja de Muerto and many other smaller ones.

Climate is humid on the northern coast, drier in the south, very wet in the eastern Luquillo mountains. The highest peak is slightly over 1,300 metres tall, and temperatures are usually between 25° and 30°C, depending on altitude.

The lowest recorded temperature in this century was 6°C in the western mountains, the highest, 41°C. The terms 'summer', 'fall', etc. are used in the text as a time reference only, for there are no seasons in the temperate sense in Puerto Rico, only wet and dry season, and the dry season is nearly nonexistent in the Luquillo mountains, where I live.

For purposes of this article, 'wild fruits' are defined as fruits not generally found for sale in markets or supermarkets on the island nor cultivated commercially. I've also excluded other fruits, both local and introduced but naturalized, which are probably familiar to Australian readers, in order to concentrate on really wild fruits.

Among the ones left out are *Chrysophyllum cainito* (starapple), *Manilkara sapota* (sapodilla), *Malpighia punicifolia* (acerola), *Phyllanthus acidus* (Otaheite gooseberry), *Syzygium jambos* (roseapple), *Spondias dulcis* (ambarella), *Chrysobalanus icaco* (cocoplum), *Annona squamosa* (sweetsop), *Melicoccus bijugatus* (Spanish lime) *Genipa americana* (genipap), *Hymenaea courbaril* (West Indian locust), *Mammea americana* (mammee apple) and others.

As in other places, the above mentioned fruits were formerly found in market stalls in many towns, but nowadays have been displaced as supermarkets push more expensive temperate and citrus fruits. Also, many of these fruits are strongly seasonal, perishable, or do not ship well. However, local gardeners still grow them and they are sometimes for sale in the

§ Member, WANATCA

smaller markets, so they are not really wild.

Edible wild fruit criteria for this article: - fruit 6mm across or larger.

- fleshy fruits, not dry (except nuts and palm fruits).
- Solanaceae, Cucurbitaceae and other annuals are excluded.
- fruit not seen for sale in markets.
- fruit not introduced, only native species.

The species in the following list are known to be edible. I have either tasted them personally, know first-hand someone who has or have a reputable printed source (see bibliography) who will vouch for their edibility. Remember, though, that edible does not necessarily mean palatable. Some taste very good and others are abominable.

As the local indians, the Taínos, were mostly exterminated in the 16th century, not much of their ethnobotanical knowledge has come down to us. Perhaps other species were eaten by them, but we shall never know.

The author wishes to state unequivocally that he is not recommending that anyone pick, use or consume the fruits listed and/or described nor will be responsible for any use given them.

He also wishes to acknowledge his indebtedness to Mr. Papa Vives and Mr. Frank Watlington for data and insights into several of the fruits listed.

Species are arranged alphabetically by family and scientific name. Spanish and English common names are given immediately afterwards.

Anacardiaceae

Spondias mombin L., jobillo, hogplum, yellow mombin

Ubiquitous tree up to 20m tall, the hogplum is very common in the humid areas of Puerto Rico because it was formerly used as a living fence. Cuttings up to 2m long and 10cm thick will root readily just by sticking them in the ground. The fruit is produced twice a year at low elevations in the Luquillo mountains, and is bright yellow, oblong, 30- 50mm long by 30mm wide, with a large white stone. Flesh is very juicy, somewhat acid but agreeable, good for jams, but often infested by fruit fly larvae. Production is enormous, fruits blanketing roads when in season. Pigs and wild animals are fond of them.

Arecaceae

Acrocomia media O.P. Cook, corozo, prickly palm (seed)

A stocky, very spiny native palm, the corozo bears a dry, yellow, fibrous round fruit, roughly 35mm across, with a white kernel from which an edible oil may be extracted. The kernel looks like a miniature coconut and tastes almost the same, and uncracked is used by local artisans to make rings. The palm has of late become fashionable for urban reforestation, with the lower spines removed. Other Acrocomias in America are also called *corozo*.

Aiphanes acantophylla (Mart.) Burret, palma de coyor (pulp, seed)

Another spiny endemic palm, the *coyor* is very thin, lofty species up to 13m tall. It bears abundant bright red, fleshy fruits somewhat resembling cherries up to 15mm in diameter. Pulp is floury and nearly tasteless, and the edible kernel, roughly 2mm across, resembles that of *Acrocomia media*. Both palms flower and bear fruit nearly year-round.

Roystonea borinquena O.P. Cook, palma real, Puerto Rican royal palm

This palm is one of our most used ornamental endemics, very common as a street tree in older neighbourhoods and also often seen in rural areas. It may grow to 18m and is readily recognizable by its trunk, which starts swelling some distance from the base. In this it differs from the better-known Cuban royal palm, *R. regia*, which has a trunk of uniform diameter. Fruits are elliptical, somewhat fleshy when fresh, light brown, about 13mm across. The pulp is considered fit only for pigs, though there are reports that the Taíno Indians ate it many centuries ago.

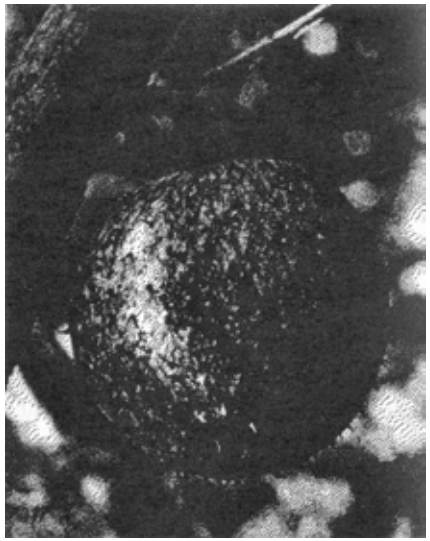
Annonaceae

Annona glabra L., corazón cimarrón, cayur, pond apple

The pond apple is externally much like a smooth-skinned cherimoya or custard apple, measuring 7 -13cm across, but inside is rather dry, mostly full of seeds and with scant, insipid orange pulp. The seeds are light brown and float, as does the wood. The tree is small and is common in swampy areas, resisting waterlogging very well. This has made it suitable for use as an annona rootstock for seasonally flooded terrains. Distribution is from southern Florida to Brazil and also coastal West Africa.

Annona montana Macfadyen, guanábana cimarrona, wild soursop

Similar to *A. muricata*, fruits are somewhat heart-shaped, up to 12cm across, but differ from soursop in that they are a greyish-green colour and the flexible spines are shorter. Also, they show some white coloration in the rind around the spines. Pulp is more stiff, yellowish and not very tasty. Some authors assert that there are palatable varieties, but we have yet to encounter them. Trees grow to 7m and flower all year long. Seedlings are sometimes used as rootstocks for other annonas. Grows best in dry areas.

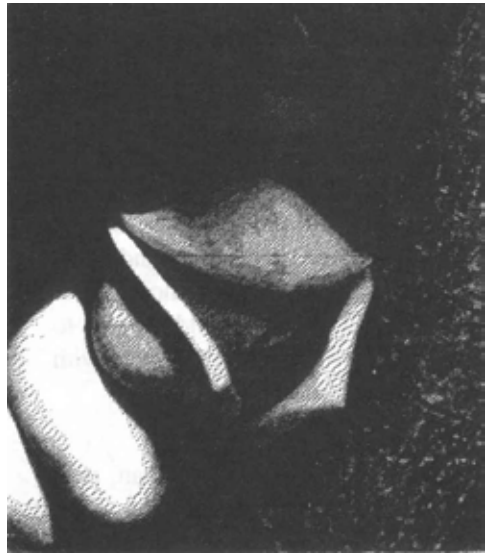


Fruit of Annona montana

Oxandra lanceolata (Sw.) Baill., haya prieta, lancewood

Reported from Cuba, Jamaica and Hispaniola, but rare in Puerto Rico, found only in the extreme western part of the island. It is a small tree, occasionally reaching 15m, and produces

one-seeded, 8 x 13mm reddish fruits, singly or very few per stalk. The fruits, contrary to those of other Annonaceae, are each produced from one flower. Pigs are known to relish it, but I have not located any human testimony sharing their enthusiasm.



Annona montana flower

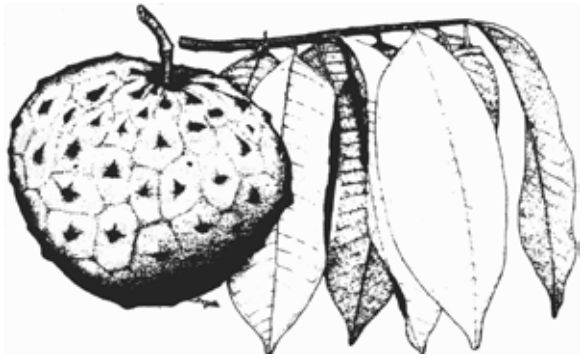
Rollinia mucosa (Jacq.) Baill., anón cimarrón, cachimán, wild sugar apple

Found mostly in the western Cordillera Central mountains, also in Hispaniola, the Lesser Antilles and northwestern South America. The local strain is very palatable, like a large sweetsop, up to 15cm diameter. In fact, the local name anon cimarron means wild sweetsop. It is smooth-skinned with spines resembling those of the soursop. Pulp is translucent, almost gelatin-like, with a subtler flavour than other annonaceae and absolutely no grittiness. Leaves are a darker green than the sweetsop's. Fruits are borne mainly in summer, but do so year-round, and turn greenish-yellow when ripe. Varieties in other countries mayor may not be of agreeable taste.

Bromelidaceae

Bromelia pinguin L., maya

Close relative of the pineapple, with spiny, succulent leaves I-2m long. The maya produces an upright panicle bearing many ovoid, somewhat acid yellow fruits 30-40mm long. The protein-digesting enzyme *pinguinain* has been isolated from the fruit, proven effective against intestinal parasites. Found all over tropical America, sometimes used as a living fence because of the spines.



Rollinia mucosa

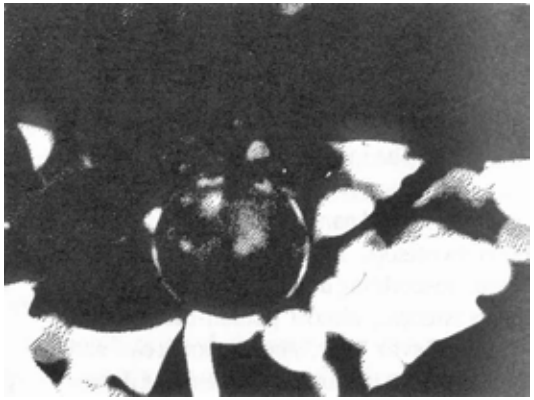
Cactaceae

Cereus hexagonus (L.) Mill., cacto columnar, tall columnar cactus

Large cactus, up to 15m, with egg-shaped red fruits, S-13cm long, with sweetish white pulp and small black seeds. It is native to the Lesser Antilles and naturalized in Puerto Rico, the other Greater Antilles and South America.

There are also native edible Hylocereus species, specially *H.*

undatus, but I have no solid data on these.



Reedia portoricensis

Canellaceae

Pleodendron macranthum (Baill.) v. Tiegh., chupacallos Extremely rare, endemic species found only in moist areas in the central mountains of Puerto Rico, it is a small to medium-size tree to 13m. The aromatic edible fruits ripen in summer, and retain their calyx at the base and a short style at the apex. They are round, purple to black and up to 25mm in diameter, with many seeds roughly 3mm long.

Clusiaceae

Rheedia portoricensis Urban, palo de cruz, guanabacoa, sebucán

Small tree or bush to 6m, though formerly trees up to 22m were recorded.

Slow growing, apparently dioecious, with very dense foliage, small leaves ending in sharp spines. Fruits are borne Jan.-Feb., with another crop in midsummer. These are bright yellow, oblate or elliptical up to 50mm diameter. Pulp is whitish/translucent, sweet, scant, surrounding a large seed. New growth is bright orange-reddish. Should be a fine ornamental suitable for privacy hedges, especially be cause of the sharp spines.

Diospyros sintenisii

Ebenaceae

Diospyros sintenisii (Krug & Urban) Standl., guayabota níspero, tabeiba, mucaro

Small endemic tree usually 10m high, uncommonly found in the western mountains, fruiting in summer. The hard walled, berry-like fruit is shiny green when unripe, turning brown or dark red on maturity. It is rounded, has 5-6 cells and is roughly 25-35mm across, with a peculiar large, three-lobed triangular calyx. The rare and similar *D. revoluta* Poir., found from Puerto Rico eastward to the Lesser Antilles, is poisonous, and readily distinguished by its four-lobed calyx. Older texts list both *D. revoluta* and the edible *D. digyna* Jacq., the Central American black sapote, as *D. ebenaster* Retz.

Juglandaceae

Juglans jamaicensis C. DC., nogal, palo de nuez, West Indian walnut

Previously believed extinct locally, but five adult specimens were rediscovered in the last decade in a mountain forest in the western Cordillera Central. Fast-growing, native to Puerto Rico, Hispaniola and Cuba, but not found in Jamaica despite the specific name. The tree may grow to 27m and produces nuts approximately 38mm across, with a large oily seed, edible and tasting like other walnuts.

Efforts are underway to save local germ plasm from extinction. It is not threatened in its other natural habitats.

Growing at 600m altitude and higher, it apparently is part of a group of genera (*Ilex, Buxus, Prunus, Magnolia* and others) left over from a colder era and still surviving in the mountains.

Juglans jamaicensis

Malpighiaceae

Byrsonima coriacea (Sw.) DC., maricao, doncella, hogberry, locust-tree

Found in the West Indies and neighbouring countries of the Caribbean basin, the *maricao* is very similar to its better known cousin, *B. crassifolia*, the nance or golden spoon. Fruits are slightly smaller, around 10mm diameter, and generally are a darker shade of yellow than the nance. The fruit has an aromatic aftertaste reminiscent of menthol, and will not spoil for nearly two months if kept submerged in water. The stone is large, rugged and contains several seeds which may take a year to germinate. Other local Byrsonimas may be edible, as well as other native Malpighias besides *M. punicifolia*.

Melastomataceae

Heterotrichum cymosum (Wendl.) Urban, camasey peludo

Endemic to open areas in the mountains of Puerto Rico, it is rarely taller than 5m. Twigs are covered with reddish hairs. Fruits are purple, juicy, sweetish berries roughly 12mm

across, produced nearly all year. They are flattened at the top, with many small, brown seeds.

Miconia prasina (Sw.) DC., camasey

One of the many Miconias in the island, it is a small tree with hairy twigs and round blue-purple fruits to 5mm They are somewhat insipid, a little acid, with many tiny seeds scarcely 1mm across. It is found all over the Caribbean down to Peru and Brazil.

Miconia sintenisii Cogn., camasey

Known only from high mountains in Puerto Rico, this shrub bears 12mm light blue berries with sweetish, juicy flesh and 5 calyx lobes at the apical end. Fruits have many small seeds and are borne throughout the year. Probably other species of the 19 Miconias found here are edible, but they are seldom encountered near urban areas.

Myrsinaceae

Ardisia obovata Desv., mameyuelo, bádula, Guadeloupe marlberry

Shrub or small tree to 7m. The black fruits are borne in great racemes, each measuring 6- 8mm with a single seed. *Mameyuelo* pulp is dark red, and fruiting takes place year-round. The species belongs to the lower strata of trees in forests at middle and low elevations in karstic (limestone) areas. It's found from the western Bahamas down to St. Lucia in the Lesser Antilles.

Mouriri domingensis (Tuss.) Spach, caimitillo, guasávara, murta

Known locally and from Hispaniola, St. Croix, Antigua and Guadeloupe, it is a tree of moist coastal forest. Fruit is oblate, sweetish, orange, with a peculiar remnant calyx ring on its side, and measures 16-32mm. Bears fruits in spring and summertime. The more common *M. helleri* Britton, the mameyuelo, has smaller fruits and is also edible (not to be confused with related *Ardisia* species, which also share the common name *mameyuelo*).

Myrtaceae

Calyptranthes pallens Griseb., tapón blanco, pale lidflower

Small tree with juicy, pubescent, dark purple berries to 13mm across, with a small cup at the apex. Fruits mature in summer and contain 2-4 small seeds. Found from southern Florida to the Lesser Antilles and coastal Mexico and Guatemala.

Eugenia axillaris Willd., grajo, krum berry, white stopper

The species is a bush/small tree to 8m. Fruit is sweet and juicy, though small, 10-13mm across, black or sometimes yellowish, with one seed. Apparently fruits often sustain insect damage. Fruiting from spring through summer. Found from southern Florida to the Lesser Antilles.

Eugenia biflora (L.) DC., hoja menuda, pitangueira, black rodwood

Much branched tree to 10m, found in both dry and humid limestone areas of the island, with reddish berries to 8mm across. Range is the Caribbean Basin and northern South America.

Eugenia domingensis DC. (syn. *E. aeruginea* DC.), guasábara, serrette guava

10-20m tall tree known from local mountains up to I,000m, the guasábara also grows in Cuba, Hispaniola and some of the Lesser Antilles. Fruits are produced year -round and are

dark purple, rounded, 10-16mm across, retaining the sepals at the apical end.

Eugenia eggersii Kiaersk., guasábara, guayabacón

Edible, rare, endemic and found only at higher elevations (more than 750m) in the Cordillera Central and the Luquillo rainforest. Usually 5m tall, formerly reported to 20m, fruiting in summer, with warty, round fruits 12mm across. The fruits retain 4 rounded sepals at the apex.

Eugenia haematocarpa Alain, uvilla

Another endangered endemic known only from the Luquillo mountains in eastern Puerto Rico, this peculiar small tree is cauliflorous, bearing flowers and fruits directly from the trunk. Fruits are dark red to purplish, round, 20mm across, have scant pulp and a large seed. Very rare, slow growing. Reported to fruit in May, the species was fIrst discovered in 1963.

Eugenia ligustrina (Sw.) Willd., granadillo, palo de muleta, birchberry, privet stopper

Bush or small tree to 8m, growing at lower and medium elevations in the Antilles down to Brasil. Fruits are reddish to black, globose, approximately 8mm across, with sweet and edible flesh and few small seeds. They also have medicinal uses. Wax may be extracted from the fruit.

Eugenia pseudopsidium Jacq., quiebrahacha, bastard guava, Christmas cherry, wild guava

Coastal shrub, also found in several offshore islands, the quiebrahacha (literally, ax breaker) bears shiny red or yellow 10-16mm fruits with one seed. Fruits are available irregularly through the year.

Eugenia stahlii (Kiaersk.) Krug & Urban, guayabota

Endemic known only from the mountains of Puerto Rico, usually found between 500-I,000m, slow-growing. Tree to 20m, bearing small guava-like fruits 19-25mm across, with 4 unequal sepals at the apex. The fleshy fruits have one large irregular-shaped seed and are borne year-round except at springtime.

There are 26 Eugenias recorded from Puerto Rico, several of them endemic. Many have fruits probably edible to some degree.

Myrcia splendens (Sw.) DC., hoja menuda, birchberry

The Spanish name means 'small leaf'. This small tree is found in the Caribbean and northern South America. The elliptical or round fruits are dark blue or black, 6-8mm long, with a large seed and a ring at the apex formed by persistent sepals.

Myrciaria floribunda (West ex Willd.) Berg, murta, guavaberry

The *murta* bears aromatic red or yellow berries some 10mm in diameter, used in the neighbouring Virgin Islands to make a delicious guavaberry rum. The tree may grow to 16m, and has flaking bark similar to that of the related jaboticaba. Fruits are available from Christmas through April, and have 1-2 seeds. The species prefers rather dry habitats and is found in the whole Caribbean Basin.

Psidium amplexicaule Pers., mountain guava

Known only from eastern Puerto Rico, the Virgin Islands and Nevis in the Lesser Antilles, this wild guava relative has rounded berries 20mm in diameter, which retain calyx lobes at the apex. Fruits borne from spring to autumn. There are other lesser-known wild Psidiums on the island but I have been unable to locate more data on them.

Siphoneugena densiflora Berg, hoja menuda

Known only from Puerto Rico, Guadeloupe, Martinique and Venezuela, this shrub from the mountains of western Puerto Rico bears black shiny berries with insipid, juicy, pink flesh. Fruits are 10mm across with 1-2 seeds, and are produced in spring and summer.

Olacaceae

Ximenia americana L., limoncillo, tallowood, purge nut

Acid, yellow, fleshy fruit up to 4cm in diameter, native to the American tropics but also found in the Old WorId tropics. The large kernel is also edible in small quantities when roasted, and edible oil may be extracted from it. Usually found near the sea, uncommon in Puerto Rico.

Passifloraceae

Passiflora laurifolia L., parcha, water lemon, bell apple

The water lemon resembles the common yellow passionfruit but is a softer, ochre yellow and seems to be covered by a soft down (though it is not). Pulp is translucent, with slightly lemony taste, sweet and very agreeable, does not need to be diluted like *P. edulis*. The pulp can be eaten as is from the fruit and is rich in vitamin B-5 (pantothenic acid).

The are at least 15 native Passifloras in Puerto Rico, several of which are edible, such as *P. foetida, P. maliformis, P. rubra, P. serratodigitata*, etc., but I've been unable to locate much information on local uses/names.

Polygonaceae

Coccoloba diversifolia Jacq., uvilla, doveplum

Similar to the pantropical *C. uvifera*, it is a small tree with roundish/teardrop-shaped, dark red or purplish fruits up to 1.3cm long, sour and rather astringent. It is sometimes used for jellies, fruits all year, is found in the Greater and Lesser Antilles and has been introduced in Florida, where it is planted as an ornamental.

Coccoloba venosa L., calambreña, chicory-grape

Small tree to 9m, with leaves smaller than those of other Coccolobas. Fruits are sweet, oval, white or pink, 15mm long, borne in racemes similar to those of the seagrape, ripening in October. Grows from Hispaniola east and south through the West Indies down to Venezuela. Grows in arid areas and is found in our dry coastal forest. Locally there is a beautiful variegated cultivar.

There are 14 Coccolobas found on the island, including the pantropical *C. uvifera*, the seagrape. Most probably have edible fruits, though of rather small size, sour and/or astringent and with scant pulp.

Rhamnaceae

Krugiodendron ferreum (Vahl) Urban, bariaco, black ironwood, leadwood

Small tree no taller than 5m, new leaves are reddish. The one-seeded fruits are produced profusely several times a year in Puerto Rico (in Florida the season is Sept.-Nov.). The elliptical fruit is dark brown or black, 6-10mm long, sweet, good-tasting but with scant pulp. It is found from southern Florida down to Curacao and in the Caribbean coast of Central America down to Honduras.

Reynosia guama Urban, guamá, guamaberry

Not to be confused with the Ingas (Leguminosae-Mimosoideae), generically called guamas in Puerto Rico. Shrub or small tree to 6m, known from dry limestone forest in Puerto Rico and the neighbouring Virgin Islands. Fruits are elliptic,10mm long and retain a cup (calyx remnant) at the base. Ripe fruits are aged in rum in the Virgin Islands to make guamaberry 'wine'.

Reynosia uncinata Urban, cascarroya, chicharrón, sloe

Similar to *R. guama*, but native from Cuba down to Anguilla in the Lesser Antilles. The blackish 16mm fruits have juicy, scant, dark red flesh. Leaves have a hooked short spine hidden beneath the apex. Fruits borne irregularly year round.

Ziziphus rignonii Delponte, saona, thorn

Spiny small tree, rare, native to dry limestone forest from Hispaniola eastward down to Anguilla. It is related to *Z. jujuba* and *Z. mauritiana*, the Chinese and Indian jujubes, respectively. Fruits available from summer through fall, and are rounded or elliptic, dark brown, up to 13mm across.

Rosaceae

Prunus occidentalis Sw., almendrón, West Indian laurelcherry

One of two Rosaceae found naturally in Puerto, the *almendrón* locally is a rare large tree, to 25m, in the upper mountains. It grows slowly and does not do well at lower elevations. Fruits are cherry-like, purplish-green, elliptic, up to 30mm long and astringent but liked by wild fowl. They are often attacked by what seem like fruit fly worms. The single seed resembles an almond and is surrounded by thin, edible flesh. Locally it fruits profusely in June. Seeds germinate readily. Known from the West Indies, Guatemala, Venezuela and Panama. The few specimens left here are buttressed, with beautiful, furrowed, lichen-covered brown bark.

Sapindaceae

Hypelate trifoliata Sw., cigua, melcocha, inkwood

This small tree is found from southern Florida to Anguilla in the Lesser Antilles, rarely in Puerto Rico, and then only in dry areas. Fruiting in summer, it has black, oval drupes roughly 7mm across, with thin, sweet flesh.

Sapotaceae

Chrysophyllum argenteum Jacq., lechecillo, milky iron, wild kaimit

A small tree to 8m, producing oval dark blue fruits 10-20mm long. The seed occupies most of the fruit, which is produced most of the year. Found throughout the West Indian chain down to Venezuela. The specific name alludes to the silvery underside of the leaves. *C. bicolor* Poir. has been merged into this species by Sapotaceae specialist T.D. Pennington.

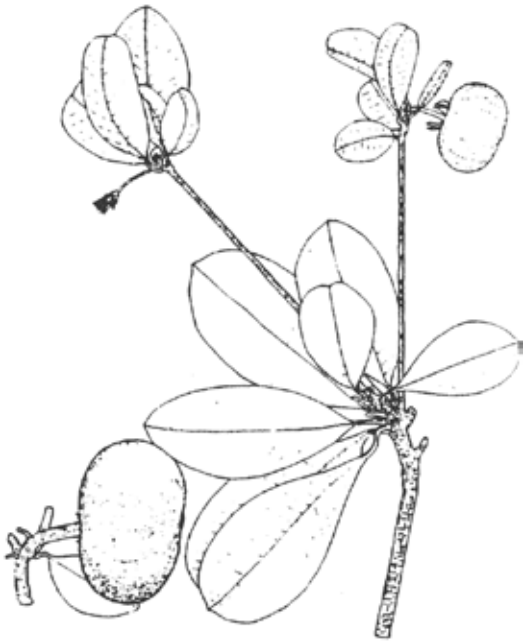
Chrysophyllum oliviforme L., caimitillo de perro, satinleaf, saffron-tree

Very similar to the caimito, *C. cainito*, with the same coppery tinge in the under side of the leaves, but fruits are one seeded, elliptical, and smaller, 20-32mm in diameter and dark purple. Fruits resemble olives, hence the name oliviforme, with sweet pulp. The rind exudes a milky latex that sticks to the lips. Fruits are known to mature in February. It is

known from southern Florida to Puerto Rico, apparently the southernmost limit of its natural range.

Manilkara bidentata (A. DC.) Chev., ausubo, balata

Large tree to 33m, formerly the most important wood logged locally, found also throughout the Caribbean and northern South America. It is closely related to the sapodilla or chiku, *M. zapota*, and yields a similar but smaller round or ovate fruit 25-32mm across. Pulp is sweet but gummy if not fully ripe, with a single seed. Fruits are produced irregularly all year long.



Manilkara pleeana

Manilkara pleeana (Pierre) Cron., ausuba, mameyuelo, sapote de costa

Known only from coastal limestone forest in Puerto Rico and the Virgin islands, this tree with milky sap bears relatively large, globose fruits up to 7cm across. They have pinkish, insipid flesh and an objectionable gummy latex.

Micropholis guyanensis (A. DC.) Pierre subsp. *guyanensis* (syn. *M. chrysophylloides* Pierre), caimitillo, leche prieta

Puerto Rico is the northernmost limit of this species, found throughout the Lesser Antilles, Costa Rica and Panama down to Bolivia and Brazil. Fruits ripen Nov.-Jan. in the Caribbean. Leaves have bronzed undersides similar to the caimito's. Local specimens occur at elevations higher than 400m

Pouteria multiflora (A. DC.) Eyma, jácana, bully tree

A large tree of humid forests in the West Indies, the *jácana* may grow to 25m and produces a fruit similar and related to the canistel (*P. campechiana*), but rounded and with relatively scant pulp. Fruits are up to 5cm in diameter, bright yellow, smell delicious but flesh is thin and floury, somewhat sweetish. It usually has 1, sometimes 2, large seeds.

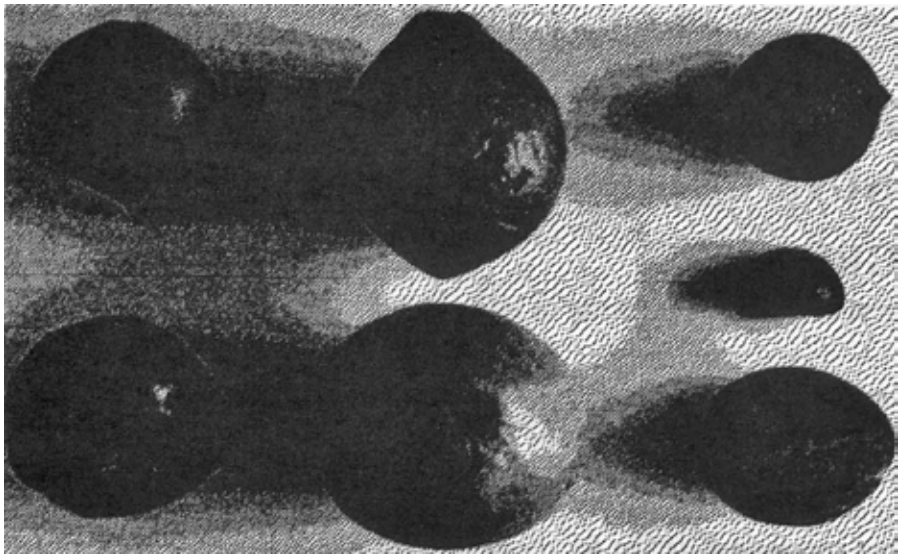
Sideroxylon foetidissimum Jacq. (syn. *Mastichodendron foetidissimum* (Jacq.) H.J. Lam), tortugo amarillo, false mastic

Large tree up to 25m with roundish yellow fruits 19-26mm across, having white, acid, juicy flesh. Latex in the fruit rind is somewhat objectionable. The large seed is about 12mm wide.

Vitaceae

Vitis tiliifolia H. & B., parra cimarrona, bejuco de agua, West Indian grape

Climber growing up to 12m long, with stems to 12cm thick. The small (6-8mm), purple/black, very acid grapes are eaten by wildfowl. The plant has figured in local trials seeking a suitable rootstock on which to graft temperate grapes.



Fruits and seeds of Pouteria multiflora

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CANARIUM:
PILI NUTS, CHINESE OLIVES AND RESIN

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The genus *Canarium* is a member of the Burseraceae, an important tropical family of trees, and comprises some 75 species confined mainly to the old world tropics (Mabberley, 1987) but with at least one economically important species extending into southern China and as far as Okinawa and the Ryuku Islands (Walker, 1976). Tanaka (1976) lists 29 species with edible nuts and other species are grown for their commercially exploited resins, pharmaceutical derivatives, tannins, and timber.

In a phytochemical analysis of the family Pernet (1972) stressed the fact that most species exude an oleoresin which contains a rich mixture of triterpenes and which underlies the potential economic value of many hitherto unexploited species.

The most complete account of the genus is that of Leenhouts (1959) who examined all known species from the point of view of their morphology, geographical distribution and taxonomy. This author subdivided the geographical limits of the genus into 11 regions; he subdivided the genus into 3 sections and described 75 species as being typical. In a chemotaxonomic analysis of the Burseraceae, Umadevi et al. (1988) suggest that the family is however homogenous and that the three tribes enumerated by Leenhouts (1959) are not chemically identifiable. They also suggest that based on the presence of various flavonoid compounds, the family is closely related to the Anacardiaceae and represents one of the primitive families of the Rutales.

The species enumerated in this paper refer to Leenhouts classification and synonyms are given where necessary.

The importance of some species as a source of food has long been known and, for example, *C. zeylanicum* has been found as identifiable, charred fragments from a cave site in Sri Lanka (Kajale, 1989) dating from the Mesolithic period (i.e. 10,000 - 8,000 BC). The Chinese olive, *Canarium* album Raeusch, was described in the Nan-fang ts'ao-mu chuang - a fourth century Flora of East Asia - while Burkill (1966) mentions the use of the edible nuts in Malaysia from the early recorded history of the region.

Cover picture (from Leenhouts [1955]):

Canarium indicum. a,female specimen; b, male specimen; c, part of cross-section of branch let; d, petiole cross-section; e, female flower; f, female flower longitudinal section; g, male flower; h, male flower longitudinal section; j, part of infructescence; k, fruit cross section

The Java Almond or Kenari Nut, Canarium indicum

The fruits and nuts derived from the various species of *Canarium* have not yet become important items in world trade, and in his wide-ranging survey of cultivated tropical and subtropical plants, Rehm and Espig (1984) consider them to be restricted to local (or in the case of *C. album*, regional) trade while their economic potential is also considered low. The exception is again *C. album* - the Chinese Olive - which is now exported to other regions of S.E. Asia and can also be found in speciality shops in Europe and the North America.

The edible derivatives of *Canarium* are of two types. Some, such as *C. album* are eaten as an olive i.e. it is the fleshy part that is eaten and not the very hard, difficult to crack, nut. This species is referred to as a Chinese olive and is eaten in S. China and Indo-China; in Malaya they are normally pickled before eating. In the other species e.g. *C. ovatum* - the Pili nut of the Philippines - and *C. indicum* - the Java almond, Kenari nut - it is the nuts that are eaten

Extension of Canarium species across the Indian Ocean [Leenhouts, 1959]

for their oil and protein content.

In this paper I describe some of the more important species of *Canarium* and offer information on their importance as food producing trees which may, in time, be usefully grown in Australia.

1. *Canarium ovatum* Engl. - Pili Nut, Philippine Nut.

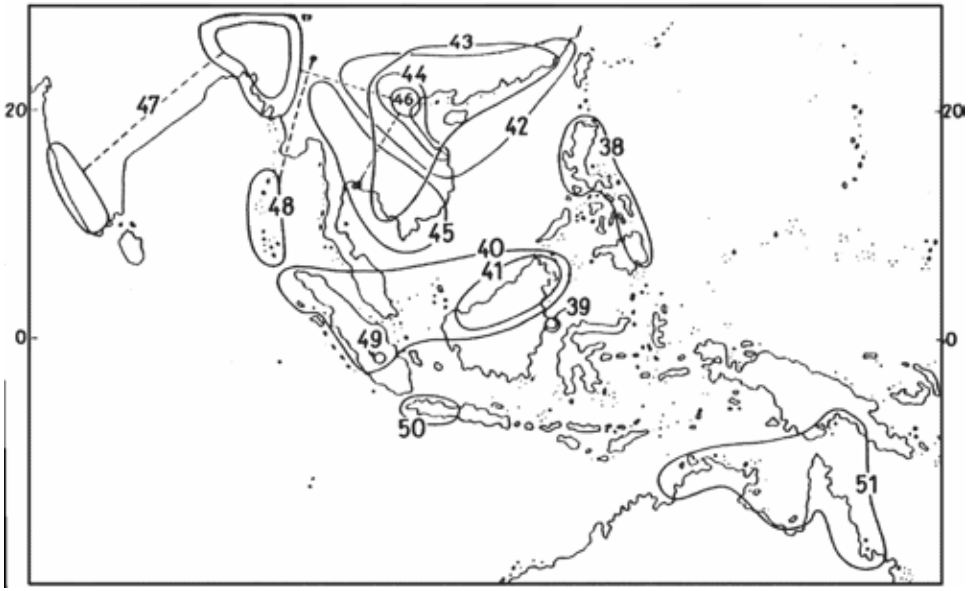
A very important nut crop in the Philippines and considered by Menninger (1977) because of its wide use in this very populated part of the world, as "The most important of all the nuts in the world to the millions of people who depend on it for food, is the PILI NUT of the Philippines and its relatives. Seventy-five kinds of these nuts grow in enormous quantities from Africa through India to northern Australia, Malaya and on the Pacific islands."

C. ovatum is a large, buttressed tree reaching about 20m in height with a girth (DBH) of 40 cms. The compound leaves are alternate and bear 5-7 leaflets, each 15-20 cms long. Leaflets are smooth, rounded at the base with pointed tips. Inflorescences many-flowered with 1 cm long, yellow, fragrant flowers. Fruits ellipsoid, greenish turning black when ripe, they contain a single seed with a hard shell and also a thin oily pulp. The tree is common in the primary forests of Luzon but, according to Campbell (1984), is comparatively little known.

Canarium ovatum, the source of Pili Nut Oil [Brown, 1921]

The nuts of *C. ovatum* are an important part of the diet of the native Philippine people and play an important role in the country's economy. Burkill (1966) claims that each tree can produce 70 lb of nuts per season and this figure confirms the yields of 33 kg recorded by Brown (1921) who also noted that in 1913 more than 1.1 million kg of nuts were exported. The nuts are considered a delicacy and Brown (1921) describes them thus:

''The nuts of this species are very rich in oil, and when roasted have a delicious flavour. They are served in the same manner as almonds, and by many are considered superior to the latter. The nuts are also used considerably in the making of confections. In Camarines, the roasted kernels are used to adulterate chocolate. The uncooked nuts have a purgative effect. The oil obtained from the nuts of *Canarium ovatum* is sweet, and suitable for culinary purposes. The fruits are 6 to 7 centimetres in length and consist of hard, thick-shelled, triangular nuts surrounded by a small amount of pulp. This pulp, which is edible when cooked, also contains an oil which is occasionally extracted locally and used for lighting and in cooking."



Distributions of some SE Asian and Australian species of Canarium. No. 51 is C. Australianum [Leenhouts, 1959]

The chemical constituents of the nuts have been reported by Duke (1989):

"Per l00g, the seed is reported to contain 699 to 714 calories; 12.2 to 15.6 g protein; 73.2 to 75.9 g fat; 6.0 to 10.8 g total carbohydrate; 2.3 to 3.5 g fibre; 3.0 to 3.6 g ash; 130 to 180 mg Ca; 71 to 591 mg P; 2.9 to 4.8 mg Fe; 3.2 to 3.3 mg Na; 521 to 537 mg K; 26 to 35 μg beta carotene equivalent; 0.75 to 1.04 mg thiamine; 0.07 to 0.13 mg; riboflavin; 0.44 to 0.58 mg niacin; and 0 to 25 mg ascorbic acid. Campbell (1984) reports the kernel contains 74% fat, 12% protein, and 5% starch. Rosengarten (1984) reports 71.1 % fat, 11.4% protein, and 8.4% carbohydrates."

Harvesting of the nuts begin when the trees are 6-8 years old but full production is only achieved after 12-15 years. Fruits are gathered by shaking or by knocking them from the tree. Fresh nuts do not store well and become rancid if not roasted (Duke, 1989).

Pili trees also produce commercially valuable resin (see below) and Abarquez (1982) has suggested that an integrated approach to commercial exploitation of the tree should be explored. He states:

"Integrating resin tapping with nut production, that is, the possibility of getting 2 products without disabling the tree, can be studied. As practiced, it is observed that flogging, girdling, or wounding the bark of trees on the lower trunk part usually increase the production of fruits in some trees like mango ..... Controlling the downward translocation of carbohydrates and other hormones from the canopy to the root system, by wounding the bark on the trunk, would induce the production of flower hormones, and consequently, fruits. Timing the tapping activities so that it complements with the natural budding and fruiting season would give us the desired result."

Although the nuts are eaten locally they are also traded regionally. They suffer, however, from very short fresh nut life and have to be roasted for storage purposes. The nuts can however be used to extract a valuable kernel oil. When extracted locally it is used for lighting

and in cooking (Brown, 1921). Nuts are said to contain 72% - 75% oil (Burkill, 1966; Duke 1989). Studies on the chemical composition of the kernel oil has been carried out by Kameoka et al. (1976) who obtained a 0.11 % yield of essential oil following steam distillation of fresh fruit. The oil was separated into various fractions and analyses revealed the presence of various terpenoids, 14 kinds of carboxylic acids, 6 kinds of phenolic compound and alkenes of C10- C32. Later work by Mohr and Wichmann (1987) on the composition of the fatty acids and triglycerides of the oil showed a high content of palmitic acid and an uncharacteristically low value of low fatty acids. The triglycerides had a low content of triolein.

In assessing the other uses of *C. ovatum* Duke (1989) mentions the use of the nut shells and trunk timber as valuable sources of combustible energy for local consumption.

2. *Canarium indicum* L. Java Almond. Kenari nut (Syn: *C. amboinense* Hochr.; *C. commune* L.; *C. moluccanum* Blume;)

C. indicum is a large buttressed tree growing to 40m high and 1m in diameter. Leaves are compound, shiny with 3-8 leaflets. The terminal inflorescences bear many male and female flowers. Fruits are developed in clusters of 30 and each ovoid fruit bears 1 seed.

By far the most important economic value of the tree lies in its nuts. These are regarded as a delicacy in many parts of Malaysia and the kernels have a very delicate taste. They are used as a substitute for almonds in the manufacture of cakes and pastries (Burkill 1966). Mature nuts are normally dried over fires to increase their storage life and are an important item of the diets of many Solomon Islanders (Chaplin and Pao, 1985; Chaplin, 1988). Fresh nuts can also be ground to a powder and used to supplement taro flour and fresh, pressed coconut cream (Yen, 1974). One authority, quoted in Burkill (1966), mentions the use of oil extracted from the kernels as an additive to water to form an emulsion for feeding infants.

The value of nuts, particularly those of *Canarium indicum*, in the diets of the British Solomon Islanders has been stressed by Tedder (1973) who suggests that the nuts are "a main source of protein". Nuts are known as Ngali nuts and Chaplin (1988) has demonstrated yields of up to 600 kg of kernels per hectare per annum from 25-30 years old trees; 130 trees/hectare being the optimum density, 85% of which were female.

Chemical analysis of the seeds show them to contain 72% fat; 13.5-19% protein; 7% starch; 3.8% ash and 3.8% moisture.

Extracted kernel oil has been analysed by Steger and Loon (1950) who showed it contains 10.2% stearic; 30.5% palmitic; 39.9% oleic; 18.7% linoleic and 0.7% linolenic acids.

Extension of Canarium species out into the Pacific Ocean [Leenhouts, 1959]

When trees become old an oleo-resin oozes from wounds made on the trunk. At first the resin is clear but later it becomes milky and Burkill (1966) considers this phenomenon of exudation to be a sign of decay. The resin is fragrant and is used in inks, varnishes and Chinese joss sticks. The resin once formed part of the Manila elemi trade but this is now confined to another species *C. luzonicum* (see below).

3. *Canarium album* (Lour.) Raeuschel. Syn *C. sinense* Rumph; *Pimela alba* Lour.; *Hearnia balansae* De Candolle; *C. tonkinense* Engl. *C. copaliferum* Chev.

This tree produces the much valued "Chinese olive" and according to Menninger (1977) it is the only *Canarium* fruit to reach world markets.

The tree can grow to 30m high on dry to moist soils between altitudes of 400m - 1200m in Annam, Tonkin, Southern China and Taiwan. Cultivated trees are also found in the Ryukyu islands and in Okinawa (Walker 1976).

The Gisau, Canarium williamsii, from the Philippines [Brown, 1921]

A description of the fruit is given by Leenhouts (1959) thus:

"Fruits ovoid to spindle-shaped, round in cross-section, 2.5 - 3.5 by 1.5 - 2 cm, glabrous, pyrene acuminate, rounded (to 6-angular) in cross-section, with a distinct groove between the blunt angle-ribs and the lids, the latter with a faint median rib, surface furthermore slightly undulated; lids 1.5 - 2 (-3) mm thick. Seeds 1-2, the sterile cells slightly reduced, round in cross-section."

The green fruit are either eaten fresh, pickled in salt, preserved in honey or made into a liquor (Tanaka, 1976).

The oldest description of the fruit and its social importance is provided in the Nam-fang ts'ao-mu Chuang of the 4th century (Li, 1979) who gives the following translation:

"The Kan-lan tree is very lofty and with branches all several tens of feet high. The fruits do not ripen until later autumn. Although their taste is acrid and astringent, they become fragrant when chewed, better than holding Chi-ku-hsiang in the mouth. During the Wu Kingdom period, the fruits were presented as a gift to the court every year and they were bestowed upon the immediate courtiers. In the present dynasty, the same tradition has been followed since the time of the T'ai-k'ang period (A.D. 280-289)".

This description of the tree and its fruit by Chi Han is probably the first in Chinese literature and a later work from the Tang Dynasty (the Ling-piao lu-i of Liu Hsun) supplies the following information:

"The Kan-lan tree and its branches are both tall and ascending. The fruit ripens in late autumn. The people of the south value it, and chew it when fresh. The taste although acrid,

is more scented than the Chi-shà-hsiang. These are wild trees. Though fruitful, the trees are lofty and cannot be reached by ladders. It is only necessary to carve the base of the trunk about one inch square and fill it with salt. Over night, all the fruits are dropped and the tree is not affected in any way."

While local knowledge of the nut has indicated that it is rich in fats and oils a critical analysis of the essential oil was carried out only recently by Kameoka, Cheng and Miyazawa (1976) who obtained a 0.11 % yield of essential oils following steam distillation of fresh fruit. Analysis of the bicarbonate, neutral and hydroxide fractions revealed the presence of various terpenoids, 14 kinds of carboxylic acid, 6 kinds of phenolic compounds and alkenes of C10-C32. Similar work was carried out on the essential oil from tree bark and wood of the same tree by Kameoka, Miyazawa and Kato (1976) while the fatty acid composition of the seed oil was investigated by Kameoka and Miyazawa (1976).

Canarium album [Duke, 1985]

More recently unique hepatoprotective triterpenes were extracted from this tree by Tamai et al. (1989) and by Ito et al., (1990). These workers showed that while the fruits and roots of *C. album* have long been known to combat poisoning, diarrhoea and dermatitis in humans the exact mechanism of protection was not understood. Their work involved the use of purified ethanolic extracts and illustrated both triterpene protection against galactosamine induced inhibition in rat hepatocytes and also led to the isolation of brevifolin, hyperin and ellagic acid as hepatoprotective compounds.

Canarium pimela [Duke, 1985]

The tree is now widely cultivated in areas of China such as Fukien, Kuangtung, Hainan, Szechuan and even as far as Indochina and Indonesia. No list is available of selected varieties but Chiu, Lu and Zhuang (1981) have listed established cultivars in Fuzhou, Minchou, Minqing, Fuan and Putian countries of Fujian in an attempt to select the best varieties for further exploitation.

4. *Canarium luzonicum* (Bl) A. Gray. Syn: *Pimela luzonica* Blume; *C. polyanthum* Perkins; *C. carapifolium* Perkins; *C. olignanthum* Merrill

This species is closely related to *C. ovatum* (Leenhouts 1959) but differs in having persistent stipules and stiff, rather coarse leaves; it also has smaller fruit than those of *C. ovatum*.

C. luzonicum is a large tree up to 35m high and 1m in diameter. The inflorescences are axillary and the fruits are short, ovoid, triangular in cross section and bear one (sometimes 2) seeds. The tree is found in primary forest at low and medium altitudes in Luzon, Rizal Province, San Mateo where the type specimen was found in 1915.

The tree is the main source of the resin, Manila-elemi, but it also produces pili nuts which are eaten locally. Menninger (1977) stresses the fact that *C. luzonicum* along with *C. ovatum* are among the most important species of nut-bearing trees in the Far Pacific and they provide essential fat and protein in the diets of countless people.

Notwithstanding the production of locally consumed edible nuts, the economic importance of *C. luzonicum* lies in its resin. Many species of *Canarium* produce resins when the trunks are wounded but the resin from *C. luzonicum* - The Manila elemi - is unique, and therefore much sought after, because of its fragrance and its usefulness in pharmaceutical products as ointments and perfumes.

When the resin is at first collected it is soft, pastry and ointment-like but after evaporation of the volatile components it resembles any other hard brittle resin (Burkill, 1966). An analysis of the resin and details of its commercial use is provided by Brown (1921) and details of tapping methods, collection and marketing practices are provided by Alonzo and Ordinario (1972) and Tongacan (1973).

The volatile oils which evaporate from newly tapped resin are of particular interest in that suggestions have been made that they may have a sufficiently high octane rating for then to be used as supplements when mixed with automotive fuels such as diesel oil.

Preliminary studies on this possibility were carried out by Oliveroz-Belardo et al., (1985) who showed that water distillation of freshly tapped resin gave an average yield of 30% of essential oil. The heating value of the oil approached that of foreign crude oils and when blended with diesel oil in a 1:3 ratio could successfully run a 240 diesel motor vehicle. Suggestions now exist that 'tree-run' engines are a distinct possibility in remote forest areas of the Philippines; the added advantage being that the tapping process does not destroy the source of oil which continues to be produced as long as the tree is healthy.

Further studies on the essential oil of this tree by Brieskorn and Krauss (1986) showed that by differential fractionation various terpenes, phellandrenes and alcohols could be obtained indicating a wider economic importance for this tree in the future if it is exploited wisely.


Canarium luzonicum, the source of Manila Elemi [Brown, 1921]

5. *Canarium schweinfurthii* Engler. Syn: *C. thallonicum*, Guill.; *C. velutinum* Guill.; *Boswellia occidentalis* Chev. (ex. Guill); *Bersama zenkeri* Gürke (ex Chev.)

A tree of tropical West and Central Africa growing in primary rain forest or, in drier regions, in the riverside forests; sometimes found in periodically inundated regions. It grows at altitudes between 700 and 1300m.

The main economic value of the tree is in its exudation of the resin, 'élèmi africaine'. The fruits, including the pulp and seeds, are boiled and eaten; an edible oil can be pressed from the kernels.

The tree does not show any affinities with any other species of the genus indicating its isolation for a very long period of time (Leenhouts, 1959). It grows to 50m high and has unique, strongly elongated stipules; the inflorescence is axillary and the fruit are ellipsoid or oval, pear-shaped and contain one (sometimes 2) seeds.

Canarium villosum, the source of Pagsahingin Resin [Brown, 1921]

The fruit is like an olive or date, 4cm long, blue-black with a distinctive triangular calyx at the base; the greenish oily pulp is of an oily consistency and edible (Dalziel 1948). Menninger (1977) describes the fruit thus:

"The fruits are eaten in many parts of Africa, and are sometimes sold in African markets, the greenish oily pericarp being edible uncooked, though it is somewhat of an acquired taste. They are best softened in warm water before eating. The very hard nuts are sometimes made into necklaces, or carved. The seeds contains an oil which is a possible substitute for shea butter. The seeds are sometimes cooked with food and are only eaten cooked."

The kernel oil is occasionally used in Africa as a substitute for butter (Fanshawe, 1950).

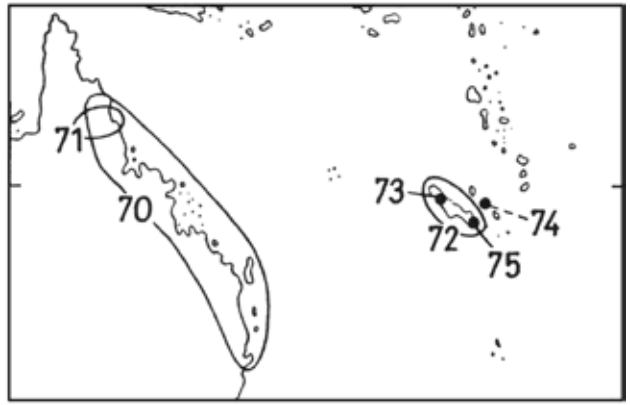
The tree also exudes, on wounding, an oleoresin which Uphof (1968) states is used for the preparation of ointment and plasters; the manufacture of printing inks and varnishes; and as an incense in churches in Uganda. The powdered bark is also said to have therapeutic powers against scorbutic ulcers.

As with many plants which have localised pharmaceutical applications, modern analytical techniques are invariably applied to such raw material. Among the earlier work on the analysis of 'élèmi africaine' was that of Talalaj (1966) who examined the essential oil component of elemi from Ghana and isolated a phellandrene. More recently Cardoso do Vale et al. (1978) analysed the chemical composition of the essential oil and isolated various terpenes, some of which had some biological activity. Later work by the same authors (Cardoso do Vale et al. 1979) on the chromatographic analysis of the oleoresin fraction showed it to contain amyrin, elemadienonic acid and elemadienolic acid. Later work by Sawadogo et al. (1985) isolated triterpenes and triterpenoids from the oleoresins.

6. Other species of limited economic importance

During the decade since the end of World War II considerable effort has been made towards the exploitation of our natural resources, not the least of which has been the overexploitation of what many people think are the limitless resources of tropical rain forests. Virtually any and every tree species has been investigated as a source of some useful commodity whether it be pharmaceutical byproducts, timber, food, pulp or fuel. The genus *Canarium* suffered the fate of all other tropical trees and below I outline those species that show potential as a source of exploitable raw material.

(a) **Pulp**. *C. euphyllum* Kurz., has been a well-known timber producing species in the Andaman Islands for some time (Uphof, 1968). More recently Kayama (1978) suggested that the wood of this species might be acceptable as a source of pulp for paper making; previously Poller (1969) had suggested that *C. nigrum* (a species not listed in Leenhouts, 1959) was suitable for this purpose but his investigations were carried out on Vietnamese trees and understandably were not continued. More recent work by Madan, Upadhyaya and Singh (1983) showed that the ash and acetyl content of *C. euphyllum* wood were low and comparable with the results for other hardwoods. The lignin, alpha-cellulose and hemicellulose contents were about average for hardwoods and therefore suitable as paper making materials. Later work by Upadhyaya and Singh (1986) showed that pulps prepared from equal mixtures of *C. euphyllum* and other hardwoods produced a suitable material when treated with anthraquinone at a rate of 0.05 % - 0.15 % (of dry wt of chips). Following this treatment there were significant increases in delignifcation rate and pulp yield with a concomitant reduction of rejects without significant losses in strength.



Some Canarium species of Australia and New Caledonia. 70, C. baileyanum; 71, C. muelleri; 72, C. oleiferum; 73, C. trifoliatum; 74, C. balansae; 75, C. whitei [Leenhouts, 1959]

In Africa attempts have been made to utilize *C. schweinfurthii* Engl. as a source of pulp (Mueller and Koch, 1986).

(b) **Timber**. Except for a few exceptions the wood of *Canarium* is not suitable for timber. Burkill (1966) mentions *C. bengalense*; *C. grandiflorum*; *C. kadondon*; *C. nitidum*; *C. rufum*; *C. secundum* and *C. zephrinum* as localised sources of wood but dismisses almost all of them as either being difficult to work; liable to insect attack; non-durable; liable to splitting; or too light in weight. Uphof (1968) mentions *C. littorale*; *C. mansfeldianum*; *C. samoaënse*; *C. zeylanicum* and *C. zollingen* as sources of timber but gives no indication of quality or specific use.

More recent investigations on the physical and mechanical properties of *Canarium* wood

have been made by Wang (1975); and Sekhar and Singh (1978) while the use of *Canarium* timber in wood-plastic composites was investigated by Yamashina, Kawakani and Tanada (1975).

(c) Extracted chemicals. Watt (1908) describes both *C. bengalense* and *C. resiniferum* as sources of "dammar" resin which was the basis of the varnish trade. In South India the . "dammar" producing tree is said to be *C. strictum*. More recently Poehland et al. (1987) have shown that "dammar" resin has antiviral properties in vitro particularly against Herpes simplex virus type I and II.

C. boivinii has been shown to be a source of terpenoids (Bullet et al. 1971) as has *C. zeylanicum* (Bandaranayake, 1980). Triglycerides have been isolated from *C. pimela* (Liao and Chen, 1987) and more recently the kernel oil of *C. manii* has been shown to contain 43.3% oleic, 24.4% palmitic and 15.7% stearic acid (Rangari et al. 1989).

Many other species, some of which are of doubtful nomenclatural authenticity, produce oils and resins and a list of these can be found in Uphof (1968).

Conclusions

In this short paper I have looked at the tree genus *Canarium* from the point of view of its nut- and fruit-producing potential and I have examined five species in detail; four of them nut/ fruit producers and the fifth a source of oleoresin.

The fruits, and particularly the nuts, are consumed locally in the country of origin and only one is traded regionally i.e. within S.E. Asia. The nuts however have high nutritional values and high yielding cultivars could be selected for exploitation. Germ plasm is available in the Philippines, in Southern China and presumably in East Malaysia and Thailand. The climatic requirements of the trees are easy to assess and virtually any region with a high rainfall and good soil would suffice. The cultivation of these nuts outside their country of origin has not, to my knowledge, been attempted and their exploitation in Australia merely requires the acquisition of seeds, some time for planting and some patience.

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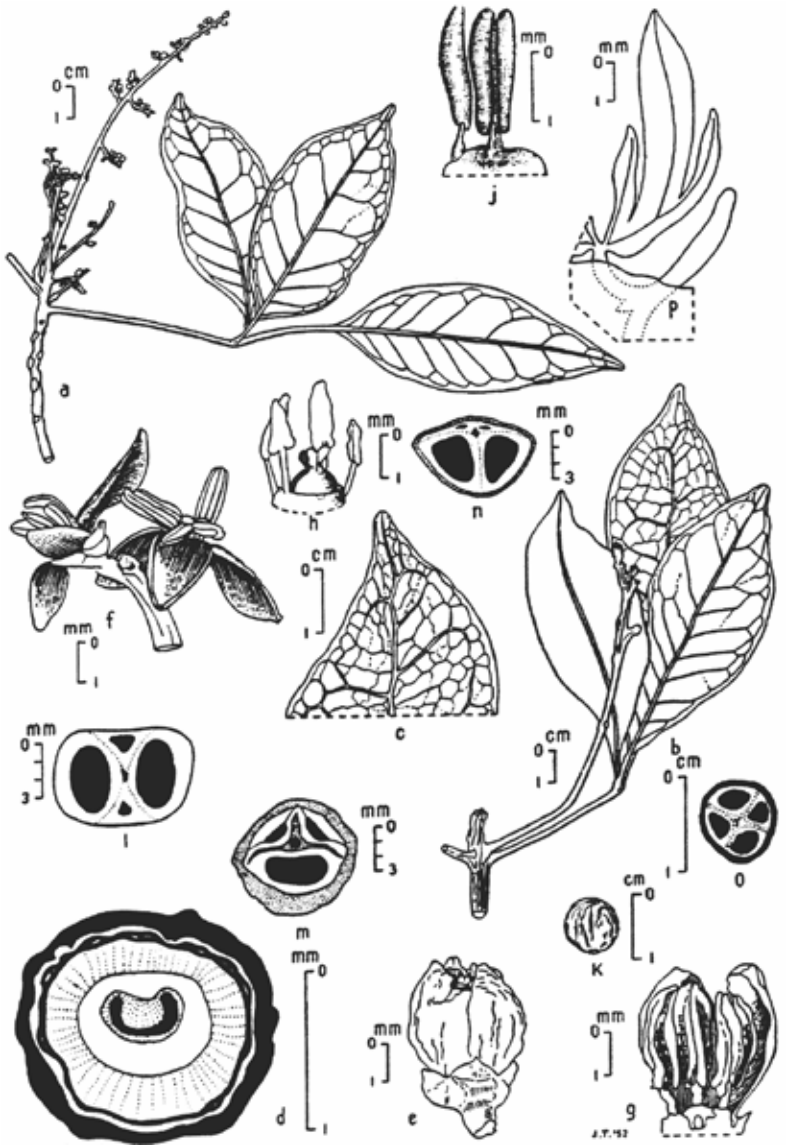

The most temperate Australian species, Canarium baileyanum. a, male specimen; b, fruiting specimen; c, nervature in apical part of leaflet; d, petiole cross-section; e-g, male flower bud, flowers and longitudinal section; h, hermaphroditic flower, sepals and petal removed; j, male flower with stamens; k, fruit; l-o, fruit cross-sections; p, unfolded embryo, partly covered by the testa.

THE FUTURE FOR MACADAMIA NUTS
IN WESTERN AUSTRALIA

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Introduction

Western Australia has a small but growing involvement in the production of macadamia nuts. With the macadamia being one of the most highly-regarded nuts in the world, a question foremost in people's minds is whether the State has suitable conditions to support a major macadamia industry or not.

My belief is that long-term prospects for the establishment of a local macadamia industry of world significance are very good. Large areas of the State have climatic and phytocultural characteristics which can be turned to excellent advantage in macadamia culture.

However, for such a scenario to be achieved, it will be essential to recognize and make use of these characteristics, rather than attempt to copy cultural practices which have evolved in areas with quite different characteristics. It will also be essential to undertake significant local development and research work if an industry of world standard, competitive on the world market, is to be developed here.

Climate and Environment Zones

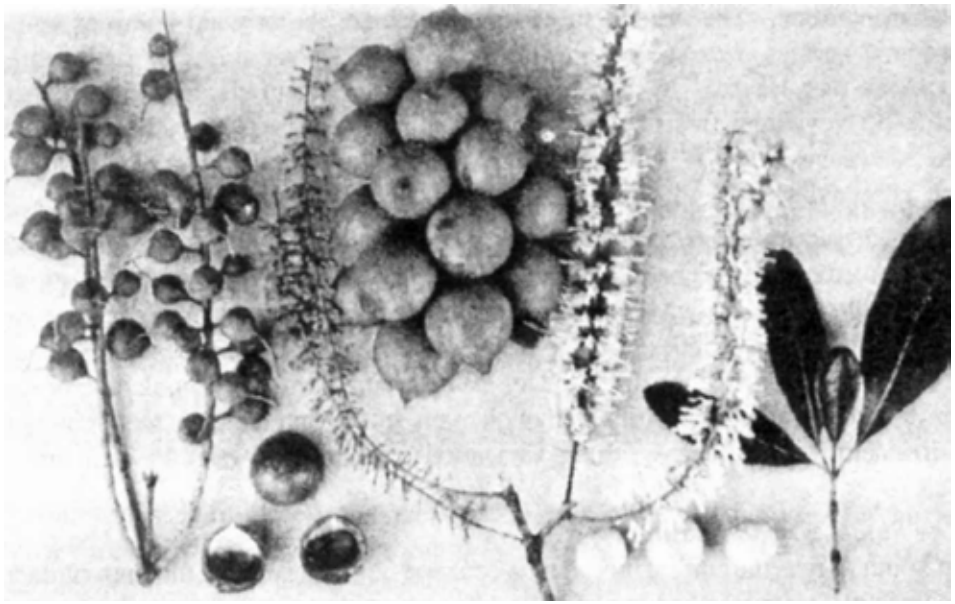
To gain an appreciation of relevant factors affecting nut production in a particular area, it is vital to have local knowledge of the growing site and of the broader climatic and environ mental zone which contains it. This assertion has been particularly supported by experience with the macadamia nut industry.

The Hawaiian Ecozone

Although the two edible species of macadamia are Australian natives, the macadamia industry was, in fact, developed in Hawaii, largely from work carried out by the Hawaiian Agricultural Experiment Station (HAES) beginning in the 1930s. The HAES varieties were all selections from about 1000 seedling trees grown from nuts of the smooth-shell species *Macadamia integrifolia*, native to Queensland, and usually referred to as 'Integrifolia'. Some of these nuts originated from Australia, but many were local produce from trees grown from nuts brought into Hawaii around the turn of the century.

In this article the set of growing conditions applying in a particular large area will be referred to, for brevity, as an ecozone. The Hawaiian macadamia ecozone essentially consists of medium-altitude slopes of volcanic mountains, with relatively young volcanic-derived soils, and lying within the true tropics. In this situation, the vast majority of rainfall comes from deposition from moisture-laden air as it comes up against a given altitude barrier. This

§ Member, WANATCA



Macadamia integrifolia nutlets, nuts, flowers and leaves [Photo: DPI Queensland]

rainfall is both strongly altitude-dependent, and also relatively even and regular through the year.

The HAES selections, such as 246 and 508, consisted of individual seedling trees which showed promise under the local conditions. The variety names adopted were simply the tree numbers in the Experiment Station identification scheme. Certain of these varieties formed the basis of the commercial Hawaiian macadamia nut industry which was built up over the 1940s and 1950s.

The Queensland/NSW Ecozone

Meanwhile, back in Australia, trial orchards of macadamias had been planted by pioneers such as Norm Greber, but a true commercial industry was not underway until the early 1970s, when the Australian company CSR of Queensland, and Hoult and Braham of Macadamia Plantations of Australia Ltd, in NSW; both made substantial investments into and commitments to the new crop. So the Australian macadamia industry is really only about 20 years old.

With these investments came regular research, and in particular the search for optimum growing conditions and productive varieties. By 1983, at the time of the First Australian Macadamia Research Workshop, all the favoured Hawaiian varieties had been imported into Australia and grown to the stage where comparative yields could be measured. The results were sobering.

It was found that the varieties which performed well in Hawaii gave markedly poorer yields when grown in Australia. These varieties would often be out-performed by local Australian selections such as H2, but even these were apparently not capable of producing the same yields per hectare as were being obtained in Hawaii.

The reason was that the NSW/Queensland macadamia ecozone was very different to the Hawaiian ecozone. The Australian ecozone involved, the original home of both edible macadamia species, was subject to much more marked variations in both rainfall and temperature than Hawaii. In subtropical rather than tropical latitudes, with some areas at appreciable elevations, frosts occurred during winter. This was especially so in the more southerly ranges, in NSW, where the rough-shell species *Macadamia tetraphylla* ('Tetraphylla') predominated.

To obtain success under the local ecozone conditions, various deviations from the accepted Hawaiian methods had to be worked out. The soils were not very different, mostly also volcanic, although of somewhat older origin. The principal developments have been the continuing search for varieties suited to the NSW/Queensland ecozone, such as the patented varieties A4 and A16, and the discovery of the profound influence of mulching practices on yields in this ecozone. In addition, although many of the first orchards were purely rainfed (non-irrigated), newer orchards installed irrigation to make up the water deficit in times of low rainfall.

The South African Ecozone

In South Africa, the current macadamia ecozone lies mostly in the medium-altitude areas of the Eastern Transvaal (the Lowveldt), grading down closer to the coast on moving further south in Natal. This area is fairly similar to the Queensland/NSW ecozone.

Nevertheless, in South Africa too, local differences have led to the favouring of local selections, such as Nelmac 1 and Nelmac 2, or the use of different varieties to those used elsewhere, such as the hybrid selection Beaumont for rootstock or the 791 variety for nut production.

The West Australian Ecozone

The principal West Australian macadamia ecozone covers most of the Southwest region of the State, a roughly triangular region extending from Northampton at latitude 28° in the north down to Albany at latitude 35° in the south. It corresponds approximately to zones 7, 8,9, and 10 on the West Australian Nut & Tree Crop Association leaflet.

It may be commented that this leaflet summarizes the position for macadamia as "will grow and produce anywhere in the State which does not have hard frosts. Irrigation is needed...". This summary has been current in the Association's literature for some 15 years and has never been challenged.

The W A ecozone is certainly markedly different to the east coast ecozone in many respects. Rainfall patterns are almost reversed, the east coast rainfall peak occurring in March, a dry time in W A. Temperatures are actually not so very different.

Soils are very different. Our upland soils are often the product of breakdown of ancient granitic rocks, while the coastal zone consists mostly of deep sands of low fertility.

W A is far more windy than places at similar latitudes on the east coast. Summers are much drier, and peak summer temperatures are higher. Light incidence, with normally cloudless skies and high sunshine hours, is much higher. A person familiar only with east coast conditions could assume that all horticulture would be at risk in W A, but such an assumption would be totally unjustified - W A has been a significant horticultural producer since early

in the century.

What outsiders see as disadvantages have, in fact, been turned into advantages by adopting local practices suited to the local ecozone. All plant crops function by turning sunlight into harvestable plant biomass, and if this sunlight can be effectively trapped by plants, the more the better. Irrigation is the norm in W A horticulture, in contrast with the east. Water applied by irrigation can be delivered in a controlled manner, rain falling cannot. 'Fertigation', the application of nutrients through irrigation lines, is also the norm in W A, and gives much better control of plant feeding than does ground application of fertilizer.

Local experience has led to the extensive use of windbreak plants both around and within orchard plantings, and the use of nitrogen-fixing plants in this role has led to soil improvement, reduced fertilizer needs, and the availability of ample biomass for extensive mulching. Close planting of crop trees has led not only to higher yields per hectare, but also to reduced moisture loss from winds and improved microclimates for plant functioning.

A mature example of these techniques can be seen in the Carnarvon banana industry. Bananas are a crop which may be grown in the same areas as macadamias in the east coast ecozone, and in the east they would be viewed as a typical moisture and humidity demanding crop, completely unsuited to hot dry areas. And yet they are very successfully grown in the hot, dry Carnarvon conditions, with a natural annual rainfall less than 250mm - less than Alstonville (NSW) receives in one month.

The California Ecozone

Of all the ecozones considered, that of California is perhaps the closest to W A. With a 'Mediterranean' climate, typically hot dry summers and with winter rainfall, a person familiar only with subtropical east coasts with summer rainfall might assume it unsuited to horticulture. And yet California is the leading agricultural state of the United States, and the majority of its production is from tree crops, especially nuts and fruits.

As far as the macadamia is concerned, this crop is of particular interest in California, and for many years California was the centre of macadamia research. The premier organization in the field, the California Macadamia Society, the first in the world, was founded in 1953.

There are differences between the Californian and W A ecozones. Most of the Californian work on macadamia was carried out by pioneers such as Paul Thomson in the coastal ranges of southern California, where much greater cold is met with than anywhere in W A. It is of interest that Thomson, who addressed local audiences at the First Australasian Conference on Tree & Nut Crops held in Perth in 1982, was also involved in the development of both the avocado and the mango as mediterranean-climate crops, in addition to extensive work on macadamia for the region.

It is also pertinent to note that Thomson has recorded the importance of cold-resistance in selections of avocado and mango for California. The avocado variety 'Fuerte', one of the mainstays of the present industry, was the only variety to survive the great California freeze of 1916 - it was given its name because 'fuerte' means strong or resistant in Spanish. At the 1982 Conference, Thomson described a mango selection he had trialled which was exceptional in being able to survive the conditions in his home area.

In contrast, Californian growers have shown little concern with the cold resistance of the

local macadamia crops. As might be expected, varieties for the local ecozone were selected to meet the local conditions, varieties such as Elimbah, Cate, and, more recently, Fenton. It is perhaps true that varieties with some Tetraphylla parentage have been of especial interest, because of their better cold and drought tolerance.

The principal message which Thomson brought to Australia in 1982 was this: successful, mature horticultural enterprises are usually based on locally selected varieties, selected to suit local conditions - but the parents of these selections may well have been brought in from elsewhere. "Your salvation lies in your own hands", he told us.

The Macadamia in W A

If the commercial macadamia industry in Australia is only about 20 years old, that in W A is even younger. But individual macadamia trees of considerable age exist in the State. At the foot of Mount Eliza in Kings Park, Perth, there is a large macadamia which Kings Park staff believe was planted in the 1920s. A seedling tree, it fruits each year. Higher up in Kings Park are two grafted macadamia trees which fruit heavily each year.

In the University of W A, in the original tree section of the Great Court, are two macadamia trees which are believed to have been planted in the 1930s. One is a Tetraphylla, the other an Integrifolia. Both fruit each year.

In the late 1970s, members of the West Australian Nutgrowers Society, the forerunner to the West Australian Nut & Tree Crop Association, visited the Lynn-Robinson plantation in the Chittering Valley. On the Chittering Valley Road there was the opportunity to see a large, mature, and fruiting macadamia tree which was thought to be at least 30 years old.

At Margaret River, approximately 225 km south of Perth, a mature macadamia tree believed to date to the 1940s grows.

In more recent years, plantings have been made further south and at colder spots inland. For more than 20 years I have had macadamias growing at Dwellingup, in the hills some 90 km south of Perth, a location which shares the all-time State minimum temperature record of -7°C. A macadamia at the MacDougal property in the hills behind Denmark, some 340 km south of Perth on the south coast, has been growing and fruiting well. This has encouraged the planting of a 100-tree macadamia orchard on the nearby Cyster property.

At the Barreca property in Donnybrook, some 180 km south of Perth and in the heart of W A's apple country, a macadamia grows which has produced around 25 kg of nuts for each of the last two years. At the Davies property at Bridgetown, near Donnybrook, a planting of 100 macadamia trees has been made.

In my backyard in suburban Perth, I have a seedling macadamia growing in typical poor Perth sand which has produced around 10 kg of nuts in each of the last two years. This is a tree which does not receive any special attention, and is watered together with adjacent lawn and garden flowers.

To summarize the status of macadamias in W A, it might be mentioned that at the W A Nut & Tree Crop Association's display at the 1992 Perth Royal Agricultural Show, the macadamia and the pecan were placed together as the two most commercially prospective nut crops for the State.

It is undeniable that the commercial industry is still at a young stage, with selection and propagation of locally-suited varieties still to be advanced. But much basic groundwork is already underway, in particular with such things as close planting, intra-orchard nurse trees, new-plant protection, mulching and irrigation practices, windbreaks, and other factors which are of local importance but may be of no relevance in a different ecozone.

Cluster of macadamia nuts [Tankard, 1990]

Cultural considerations

Some forecasts of the future for W A macadamias, made from remote locations, have been found to contain errors. The basic origin of these errors appears to be that authors are familiar with conditions applying to macadamias in their own particular area, and have assumed that any other conditions will be unsuitable. This is quite incorrect, but even so it is worth examining some of the suggestions which have been made.

One suggestion is that there are severe climatic constraints on the productive capacity of a sub-tropical rainforest species like macadamia in a mediterranean climate. This view is clearly invalid since a number of local plantings have grown and produced well, and since the macadamia has seen extensive commercial development in California, which also has a mediterranean climate.

It has also been suggested that macadamia is intolerant of frost, and that local sites are too cold to expect macadamias to succeed. This view must, in my opinion and experience, be totally rejected. While it is certainly true that macadamias are cold-sensitive, local trees have not shown any particular long-term effects from the type of frost experienced here.

In my experience, cold damage to macadamias in W A is limited to burning of new or young growth, of the type which can occur even in temperate crops such as apples if there is an unseasonable or exceptionally heavy frost. The cold experienced in W A during the winter of 1990 was the most severe that I can remember, and while I lost a number of tropicals, such as jakfruit, my macadamias showed no ill effects.

Of course, with newly-planted trees, even tip growth killing might take a small plant back to the graft. But even with trees which have been so affected, it can be expected that they will re-sprout and can be re-grafted.

It should be noted that species which Thomson reckons as at risk under cold conditions in California--avocado and mango--are not troubled by cold in the Perth region. For example, Perth has a grove of healthy mango trees over 90 years old, living proof that the minimums

of a 90-year stretch are not a problem for this species locally.

Another suggestion which has been made is that W A is too hot to grow macadamias, because plant photosynthesis falls off as the temperature increases. Laboratory studies [Allan, 1983] have shown that such a fall-off does occur as temperatures rise through 35-40°C. What is important in the present regard, however, is the fact that these measurements were made under laboratory conditions. Within an actual macadamia tree, temperatures within the canopy may be as much as 5° below those of an exposed ground site, due to sheltering and transpirational cooling.

Another suggestion which has been made is that if temperatures exceed 40°C, macadamias will shed their crop or at least 80% of the crop, and this phenomenon will occur almost annually. This 'phenomenon' is just not observed in practice. No significant amount of nut drop is observed with macadamia trees in the region, it just is not a problem. And this is in spite of the fact that 40°C is not an exceptional summer temperature in Perth - we have had temperatures up to 47°C, and the macadamia trees are still with us!

There are matters to be closely watched with macadamia growing in W A, but these have to do with protection from drying winds, rather than matters of maximum or minimum temperatures. In this regard, provision of windbreaks, massive mulching, close planting, and use of nurse trees may be expected to be vital, and it must be accepted that there is a lot of local work to be done in these areas. The same factors have a marked influence on water needs, and make invalid any standard figures on the irrigation requirements of macadamias which are quoted without qualification of these factors.

Another major local requirement is the selection or breeding of varieties suited to local conditions. For the south of W A, such varieties might well have a good proportion of Tetraphylla parentage, and might well be partly derived from wild plants, extracting genes from wild parents with drought and wind resistance, as well as ones with good nuts. It is usually stated that Tetraphylla nuts are unsuited to commercial use, as their high and varying sugar content makes them impractical in roasting. Against this, most of the newer macadamia varieties, like A4 and A16, which do not have problems in roasting, are believed to be hybrids with significant Tetraphylla parentage.

Yields and Commercial Considerations

According to Trochoulias [1989], yields of up 9 tonnes per hectare of nut in shell have been obtained with older Australian varieties. It has been suggested that consistent macadamia yields of 10 t/ha are a feasible target. However, a realistic present-day average figure would be lower than this.

Government information sheets from Queensland [Thew, 1989] and New South Wales [Chalker, 1988], both give relevant data. Both suggest yields of around 6 tonnes per hectare. From these references, it is clear that closer planting does not basically affect ultimate yields per hectare, it just allows the steady yield figure to be attained at an earlier age. It is also relevant that at modem close-planting rates of 660 trees per hectare, a yield of 6 tonnes per hectare represents only 9 kg per tree. This figure has been easily exceeded in local trees.

Prices achieved for nut in shell have ranged up to $4.00 per kilogram. The Queensland Government cash-flow figures are based on $3.00/kg, which seems an acceptable basis for budget calculations. Obviously such prices fluctuate with various external factors, but recent events suggest prices attained in the future will be above $3.00. Macadamia prices are effectively set on the world market, and as the Australian dollar declines, the Australian price achieved rises. The financial figures in Thew's farm note are based on A$1.00=US$0.80, whereas the current level is around US $0.70.

The lower prices obtained for Australian macadamias in the past year or two is probably due to the disturbing effect of much greater local production than sales staff were geared for. According to a recent Industry Commission report [1992], the value of macadamia production grew very dramatically over the previous five years, more than quadrupling from around $5m to $22m. In effect, macadamia growers were caught short by their own success.

Longer-term prospects for the macadamia industry look good. A recent report from Debenham Tewson International, International Property Advisors of Brisbane, stated that "It is anticipated that over the next two years we will see a strong resurgence in the macadamia nut industry worldwide". In the competitive market of today, the key to success is not just to produce a product cheaply, but rather to produce a product of the highest quality as efficiently as possible. To achieve this needs considerable investment in development and research.

In Australia, an example for all new tree crop industries has been given by the Australian Macadamia Society, who were one of the first such industries to use the system of voluntary and statutory industry levies in the furthering of their work. The levies they raised, put together with matching funds from federal and state governments, have been parleyed into an outstanding series of research projects which have already made a very positive contribution to the viability of the whole industry.

The current macadamia levy is 3 cents per kilogram, but in light of the excellent returns perceived from past research investments, the AMS propose a doubling of this levy, with further substantial increases foreshadowed - they are convinced the work repays the cost manyfold. With the development of the W A macadamia industry, local growers will be in a position to press for a greater proportion of this research work to be directed towards local concerns.

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BUSHFOODS-
AN ANNOTATED LIST: FRUITS & SEEDS EATEN BY ABORIGINAL PEOPLE IN NORTHERN AUSTRALIA

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Introduction

In recent years there has been an increased awareness of the importance of ethnobotanical studies in Northern Australia. It is now recognised that information on traditional Aboriginal plant use is a major part of our cultural heritage. However with the increasing dependence upon European type foods and forced sedentary life styles, much of this traditional or old time knowledge is being lost. In some areas there is an urgent need to document this information before it is lost altogether.

Newly researched data on bush foods can provide valuable information on the choice of species for trial as new commercial crops. Many species commonly eaten by Aboriginal people are untried in cultivation and some have great potential for the horticultural industry, eg. *Horsfieldia australiana* and *Terminalia ferdinandiana*, highly valued for their fruits.

This paper outlines some of the more commonly utilized fruit and seeds in Northern Australia, much of which comes from recent survey work. Major references have been vIewed and information on 132 species or forms are presented. The list presented is not comprehensive, representing some of the more commonly utilized foods eaten by Aboriginal people in Northern Australia. Many more species have been recorded as eaten and undoubtedly many more will be documented in the future by further field work.

Note: Caution should be shown when collecting some of the species described in this paper as unless prepared properly they can be highly toxic and may cause serious illness. One should be sure of the identification of the plant concerned and should consult the references cited for full preparation procedures.

The species used are listed alphabetically by botanical name.

Acacia auriculiformis "Black Wattle" Mimosaceae

The seeds are ground to flour to make 'Johnny cakes' or damper (15).

A. difficilis Mimosaceae

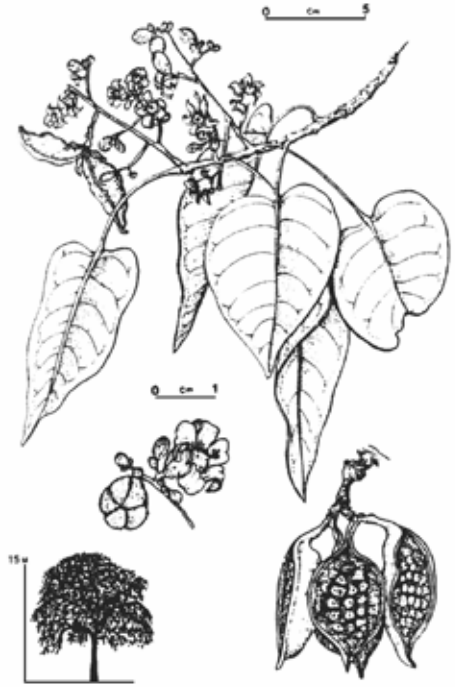
The seeds are eaten (2).

A. holosericea "Soap Bush" Mimosaceae

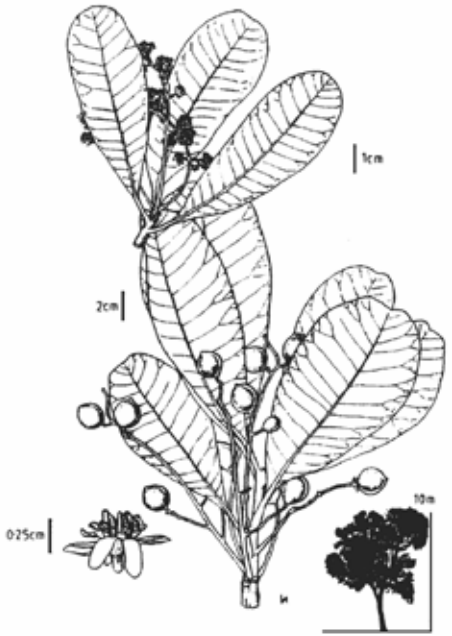
The seeds are collected, ground on stones and made into a flour. The flour is made into a damper or flat bread that is cooked on hot coals protected or wrapped in leaves (2,8,10,15).

A. torulosa Mimosaceae

The seeds are ground to flour for damper. The young green fruit and seeds may be eaten raw (15).



Brachychiton diversifolia



Buchania obovata

A. tumida Mimosaceae

The seed pod is eaten raw or the seeds can be lightly roasted on hot ashes (3).

A. umbellata Mimosaceae

The seeds are made into a flour for damper (15).

Adansonia gregorii "Boab/Bottle Tree" Bombacaceae

The pith inside the fruit is eaten raw or if it is hard it can be added to water with a little sugar to make a thirst quenching drink (3,10,11).

Aidia cochinchinensis Rubiaceae

Edible fruits (7).

Ampelocissus acetosa "Bush Grape" Vitaceae

The fruits are eaten raw when ripe (Black). They have a hot taste and are considered to be "cheeky" (3,4,6,7,10,11,2,14,16,17).

A. frutescens "Bush Grape" Vitaceae

The fruits are eaten raw when ripe (black). They taste cheeky or hot (10).

Amyema bifurcatum "Mistletoe" Loranthaceae

The fruits are eaten raw when yellow and ripe (15,16).

A. sanguineum "Mistletoe" Loranthaceae

The fruits are eaten raw when ripe (3).

Antidesma ghaesembilla "Black Currant" Euphorbiaceae
The fruits are eaten raw when purple and ripe (1,2,3,5,6,7,11,16,17) ..

A. parvifolium "Bush Currant" Euphorbiaceae
The fruits are eaten raw when black and ripe (7,13).

Avicennia marina "White Mangrove" Verbenaceae
The fruits are roasted on hot ashes then eaten. These fruits are not eaten much nowadays. Some bury the seed in mud for 3 days then boil before eating to remove any toxins (8,9,10,12,17).

Brachychiton diversifolius "Kurrajong" Sterculiaceae
The fruits are roasted on hot ashes to remove the irritant hairs that surround the seeds. The seeds are then picked out and eaten (2,3,8,10,11,12,15,16).

B. megaphyllus "Red Flowered Kurrajong" Sterculiaceae
Used in the same way as *B. diversifolius* (2,3,5,10,11,12,14,16).

B. multicaulis "Wild Curry Kurrajong" Sterculiaceae
The seeds are ground into a flour to make a damper (15).

B. spectablis "Kurrajong" Sterculiaceae
Used in the same way as *B. diversifolius* (10).

B. viscidulus "Kurrajong" Sterculiaceae
Used in the same way as *B. diversifolius* (11).

Bridellia tomentosa Euphorbiaceae
The fruits are eaten raw when ripe (black) (2,7).

Buchanania arborescens "Green Plum" Anarcardiaceae
The fruit are considered edible (2).

Buchanania obovata "Green Plum" Anarcardiaceae
The fruits are eaten raw when yellow and ripe; often they are collected from the ground (1,2,3,5,6,7,9,10,11,12,13,14,16,17).

Canarium australianum "Canarium" Burseraceae
The fruits are collected from the ground, they are cracked open and the seeds eaten raw (3,4,5,9,10,12,17).

Canthium lucidum Rubiaceae
Edible fruits when ripe (1,2,7).

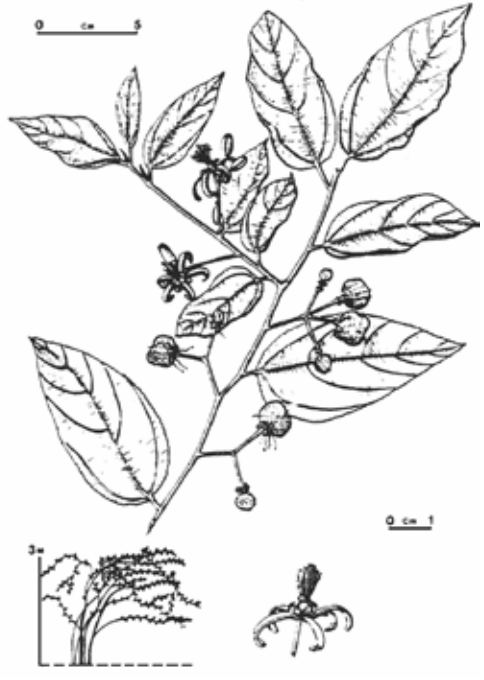
Capparis lasiantha "Split Jack" Capparaceae
The whole fruit is eaten raw, including seeds. Tastes very sweet and is highly sought after (10,11,15,16).

C. umbonata "Wild Orange" Capparaceae
The fruit is considered good food, eaten raw when soft and ripe (3,10,11,12,15,16).

Carallia brachiata Rhizophoraceae
The small fruit is eaten raw when red and ripe (1,7,10,12,13,14).

Carissa lanceolata "Conker Berry" Apocynaceae
The fruits are eaten raw when ripe (soft and black). A highly prized food (8,10,11,15,16).

Capparis umbonata



Grewia orientalis

Cassytha filiformis "Dodder" Lauraceae
The fruits are eaten raw when ripe (clear/translucent). They are highly regarded as a food source (1,5,6,7,8,9,10,12,16,17).

Cayratia trifolia "Native Grape" Vitaceae
Fruits eaten raw when black (7,10,16,17).

Celtis philippensis "Celtis" Ulmaceae
Edible fruits when red and ripe (5,6,14).

Cordia subcordata *Boraginaceae*
The seeds are edible (1).

Corypha elata "Corypha Palm" Arecaceae
Some say the seed is edible (5,14).

Cucumis melo "Wild Cucumber" Curcurbitaceae
The fruits are eaten raw after rubbing off the white bloom on the outside of the skin (3,10,11,15,16,17).

Cycas angulata "Cycad" Cycadaceae
The ripe fruits are soaked in running water for 2- 3 days to remove any toxins, they are then ground into a flour to make a damper (6,10).

C. armstrongii "Cycad" Cycadaceae

The ripe fruits are edible only after thorough preparation involving crushing and soaking in running water. The mixture is then thoroughly cooked in ashes to make a damper (1,2,4,5,6,7,10,12,17).

Cynanchum pedunculatum Asclepiadaceae

The young fruits are eaten after roasting on hot coals (2,3,10,12).

Dillenia alata Dilleniaceae

The seed is eaten raw (6).

Diospyros humilis "Ebony" Ebonaceae

The fruit is eaten raw when red and ripe (16).

Drypetes lasiogyna Euphorbiaceae

The fruits are eaten raw when ripe (red); tastes very sweet (2,4,5,6,10).

Elaeocarpus arnhemicus Elaeocarpaceae

The fruit is edible (6).

Erythroxylum ellipticum Erythroxylaceae

The fruits are eaten raw when red and ripe (10,11,16).

Eucalyptus confertiflora Myrtaceae

The seeds are edible (4).

E.ferruginea "Bloodwood" Myrtaceae

The seeds are edible (7).

E. miniata "Woollybutt" Myrtaceae

The seeds are edible (7).

Exocarpos latifolius "Native Cherry" Santalaceae

The fruits are eaten raw when red and ripe (4,10,12).

Ficus benjamina "Weeping Fig" Moraceae

The fruits are edible (14).

F. coronulata "River Fig" Moraceae

The fruits eaten raw when ripe and soft. (1,10,11,13,16).

F. hispida "Fig" Moraceae

The fruits are eaten raw when yellow and ripe (6,16).

F. leucotricha "Rock Fig" Moraceae

The fruits are edible (2).

F. opposita "Sandpaper Fig" Moraceae

The fruits are eaten raw when ripe (black); they are considered good tucker (3,5,6,7,8,9,10,11,12,16,17).

F. platypoda "Rock Fig" Moraceae

The fruits are eaten raw when ripe (yellow/red). Dried fruits can be collected from the ground, ground to flour then made into a paste and eaten or rolled into a ball re-dried and stored for later use (1,2,3,4,5,6,7,10,11,14,16).

F. racemosa "River Fig" Moraceae

The fruits are eaten raw when ripe (red); often they are collected from the ground (1,2,3,7,10,11,13,14,16).

F. scobina "Sandpaper Fig" Moraceae

The fruits are eaten raw when black and soft (1,2,5,7,10,13).

F. virens "Banyan" Moraceae

The fruits are eaten raw when white and soft (2,5,6,10,12,13).

Flacourtia territorialis Flacourtiaceae

The fruits are eaten raw when ripe (red). The many fine seeds are spat out (2,10).

Flagellaria indica "Supple Jack" Flagellariaceae

The fruits are eaten and the seeds discarded (2).

Flueggea virosa "White Currant" Euphorbiaceae

The fruits are eaten raw when ripe (white). This is a highly regarded food (1,2,3,5,6,7,8, 9,10,11,12,13,14,15,16,17).

Ganophyllum falcatum "Termite Tree" Sapindaceae

The fruit is edible (6).

Gardenia megasperma "Gardenia" Rubiaceae

The fruit is edible (2).

G. pyriformis Rubiaceae

The flesh inside the fruit is eaten when soft and ripe (8).

Grevillea decurrens Proteaceae

The seeds are eaten raw (7).

G. heliosperma Proteaceae

The seeds are eaten raw (1,2,4,7).

Grewia asiatica Tiliaceae

The fruit is eaten raw when ripe (black); very sweet (10).

G. breviflora Tiliaceae

The fruits are eaten raw when black. (10,11).

G. orientalis Tiliaceae

The fruit is eaten raw when black and soft (3,10,12,16).

G. retusifolia "Emu Berry" Tiliaceae

The fruits are eaten raw when ripe (brown). Children love this fruit (1,3,4,5,6,7,9,11,12, 14,15,16,17).

Hakea arborescens "Hakea" Proteaceae

The seeds are edible (6).

Helicia australasica Proteaceae

The seeds are eaten raw (1,7).

Hibiscus meraukensis Malvaceae

The seeds are eaten raw (6).

Horsfieldia australiana Myristicaceae
The seeds are eaten raw (7). This is a very highly regarded fruit.

Ixora klanderana "Native Ixora" Rubiaceae
The fruit are edible when black (5,6).

I. tomentosa Rubiaceae
The fruit is eaten raw (2,7).

Leea rubra "Leea" Leeaceae
Fruits eaten raw when black and soft (1,3,5,7,10,13,17).

Livistona humilis "Fan Palm" Arecaceae
The fruits are edible (1,2,14).

Lysiantha spathulata "Mistletoe" Loranthaceae
The fruits are eaten raw when yellow and ripe (15,16).

Malasia scandens Moraceae
The fruit is eaten raw when black (1,5).

Malotus nesophilus Euphorbiaceae
The fruit are eaten when white (2,5,6).

Marsdenia australis "Bush Banana" Asclepiadaceae
Young fruits are eaten after they have been lightly roasted on hot ashes (10,11).

M. viridiflora "Wild Banana" Asclepiadaceae
The young fruits are eaten when green but soft (8,16).

Melastoma polyanthum "Native Lasiandra" Melastomataceae
The fruits are eaten raw (6).

Mimusops elengi "Mimusops" Sapotaceae
The fruit is eaten raw when red (4,5,6).

Momordica balsamina Cucurbitaceae
The fruits are eaten raw when red; the many black seeds are spat out (10,11).

Morinda citrifolia "Stinking Cheesefruit" Rubiaceae
The fruits are eaten raw when ripe and soft (4,5,6,7,10,12,13).

Nauclea orientalis "Leichhardt Pine" Rubiaceae
The fruits are eaten raw when ripe and soft (1,2,7,10,11,13,16).

Nelumbo nucifera "Red/Lotus Lily" Nelumboniaceae
The whole fruiting capsule is eaten raw or after roasting on hot ashes (10,16).

Nymphea gigantea "Lily" Nymphaeaceae
The seeds are ground to a flour to make a damper (3,10).

N. macrosperma "Lily" Nymphaeaceae
The fruit is eaten raw or after roasting on hot ashes. The seed are ground to a flour to make a damper (2,10,11,16).

N. violacea "Lily" Nymphaeaceae
Used the same way as *N. macrosperma* (2,16).

Opilia amentacea "Oplia" Opiliaceae
The fruits are eaten raw when yellow to red (1,2,7,10,11,14,15).

Osbeckia australiana Melastomataceae
The fruits are eaten raw (7).

Pandanus basedowii "Rock Pandanus" Pandanaceae
The seeds are edible (1,2,7,13).

P. spiralis "Screw Palm" Pandanaceae
The red/yellow flesh at the base of the fruits is eaten raw. The seeds are eaten raw or roasted. A highly prized food source (1,2,4,5,6,7,8,9,10,11,12,13,14,16,17).

Paramignya trimera Rutaceae
The fruit is eaten raw when red (10,17).

Passiflora foetida "Wild Passionfruit" Passifloraceae
The fruits are eaten raw when ripe (yellow). Unripe fruits are considered poisonous (1,2,3,5,6,7,10,11,12,13,15,16,17).

Persoonia falcata "Milky Plum" Proteaceae
The fruits are eaten raw when yellow (1,3,4,5,6,7,8,9,10,12,16,17).

Physalis minima "Gooseberry" Solanaceae
The fruit is eaten raw when ripe purple (2,5,10,11,16).

Planchonella pohlmania "Big Green Plum" Sapotaceae
The fruit is edible (5).

Planchonia caryea "Cocky Apple" Lecythidaceae
The fruits are eaten raw when ripe soft but still green (1,3,5,6,7,9,10,14,17).

Pogonolobus reticulatus "Colour Root" Rubiaceae
The fruit is eaten raw when purple (1,7,10).

Portulaca oleracea "Pig Weed" Portulacaceae
The seeds are winnowed and ground to a flower to make a damper (10,15).

Pouteria sericea "Black Plum" Sapotaceae
The fruits are eaten raw when ripe (purple); a highly prized food (2,3,4,5,6,7,8,9,10,11,12,13,14,17).

Santalum album "Sandalwood" Santalaceae
The fruit is edible (5).

S. lanceolatum "Sandalwood" Santalaceae
The fruits are eaten raw when purple (8,10).

Semecarpus australiensis "Native Cashew" Anacardiaceae
The seeds are eaten after the fruits have been lightly roasted and the poisonous section discarded. Contact with most parts of this plant will cause blisters and welts (5,10,14).

Smilax australis "Smilax" Smilacaeceae
The fruits are eaten raw when black (4,5,6,10,17).

Solanum cunninghamii "Wild Tomato" Solanaceae
The skin and rind of the fruit are eaten but not the flesh or seeds (8).

S. ellipticum "Wild Tomato" Solanaceae
The fruits are eaten raw when ripe (10,15).

S. tumulicola "Wild Tomato" Solanaceae
The fruit is eaten, but not the skin (15).

Sterculia quadrifida "Bush Peanut" Sterculiaceae
The seeds are eaten raw when ripe (black), the black seed coat is peeled off or spat out. A highly sought after food (1,2,5,6,7,10,12,17).

Syzygium angophoroides Myrtaceae
The fruit is eaten raw when purple (2).

S. armstrongii "White Bush Apple" Myrtaceae
The fruit is eaten raw when white (1,2,6,7,10,12,13).

S. eucalyptoides ssp. *bleeseri* "White Bush Apple" Myrtaceae
The fruit is eaten raw when white (1,2,10,12,13,14).

S. eucalyptoides ssp. *eucalyptoides* "Bush Apple" Myrtaceae
The fruit is eaten raw when white (1,2,7)

S. forte "Wild Apple" Myrtaceae
The fruit is eaten raw when white (1,7).

S. minutuliflorum Myrtaceae
Edible fruit when white (7).

S. nervosum Myrtaceae
Edible fruit when black (2,7).

S. suborbiculare "Red Bush Apple" Myrtaceae
The fruit is eaten raw when red (1,2,4,5,6,7,9,10,12,13,14,16,17).

Taccaleontopetaloides "Cheeky Yam" Taccaceae
The fruits are eaten raw when ripe; the seeds can be eaten or spat out (10,12,17).

Tamarindus indica "Tamarind" Caesalpiniaceae
The fruit pulp is eaten raw when soft and brown (4,5,6,10,14,16,17).

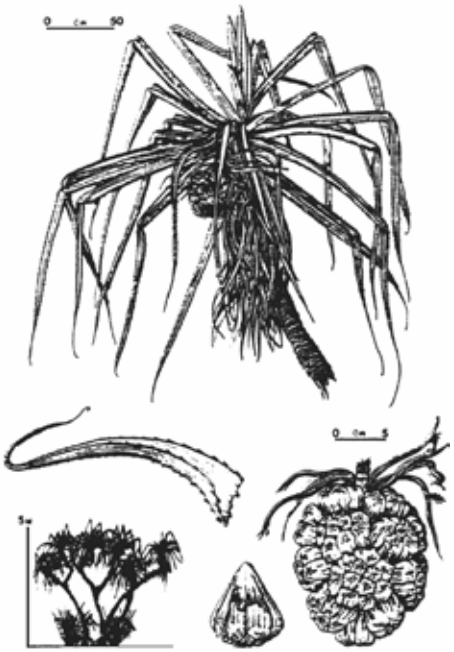
Terminalia arostrata "Nut Wood" Combretaceae
The seeds are eaten raw; the fruits are collected from the ground and are cracked between stones (10,11,16).

T. carpentariae "Wild Peach" Combretaceae
The fruit is eaten raw when ripe (yellow); considered sweet and a highly sought after food (2,5,10,16,17).

T. erythrocarpa Combretaceae
The fruits are eaten raw when purple (16).

T. ferdinandiana "Billy Goat Plum" Combretaceae
The fruit is eaten raw when ripe (yellow/pale green). Often they are collected from the ground (1,2,4,5,7,8,9,10,11,12,13,16,17).

Grewia retusifolia



Pandanus spiralis

T. grandiflora "Nut Tree" Combretaceae
Used in the same way as *T. arostrata* (2,3,5,6,7,10,14,17).

T. petiolaris Combretaceae
The fruit is eaten raw when purple (8).

T. sericocarpa Combretaceae
The fruits are edible (1,7,13).

T. volucris "Wild Peanut" Combretaceae
The seed is taken out of the fruit and eaten (15).

Vitex acuminata "Black Plum" Verbenaceae
Edible fruit when black (2,7).

Vitex glabrata "Black Plum" Verbenaceae
The fruits are eaten raw when ripe (black), often they are collected from the ground. Sometimes the fruit is crushed in water to make a sweet liquid drink (1,2,3,4,5,6,7,10,11,12 ,13,14,16).

Ziziphus quadrilocularis Rhamnaceae
The fruits are eaten raw when red (10,11).

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PINUS PINEA - AN UPDATE FOR AUSTRALIA

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There seems to be no end to the study and experiences that I have with *Pinus pinea*, the Stone Pine or Umbrella Pine, the source of most of the pine kernels of commerce. I have prepared here an update on the position of this tree crop for Australia. After the update is a summary of some stone pine information extracted from my earlier articles on the subject.

Update

The Stone Pine is an easy tree to grow and has many features which suit nearly everyone. What is important to Australia is that it can stand soil with a high salinity as well as salt laden air. Trees grow in many places in the Mediterranean on the water's edge, and can survive long periods of dry weather, but also wet weather.

The only place in Australia where I consider that it would not do well is North Queensland or places with a similar climate, where it is very hot for a long time with a very high humidity. It can stand from -20°C to about 30°C without any problems. Seeds germinate well at between 18 and 20°C and prefer to remain at that temperature till they are about four centimetres high. I lost a whole crop by planting too late in the season, and the little seedlings were killed by several days of 30°C.

The best way to germinate the seed is in river sand mixed with a handful of mycorrhizal mycelium, which can be gathered from under any healthy pine tree. The container has to be about 15 cm deep with a solid bottom, as otherwise the root will penetrate wood or polystyrene. If necessary a piece of glass at the bottom of the planting box would be suitable. Normally seeds germinate all at once if kept not too dry but not too wet. Plant the small seed about one centimetre deep. Transplant them into long bags as soon as they have discarded the shell.

The Stone Pine [Rosengarten, 1984]

You will find that the taproot is already quite long, so be careful when digging them out to make sure that the taproot is not damaged. The seed can be sown as soon as the frosts are over. (Under northern New Zealand condi-

tions this would be July to August.) For the first five months the young plants like it a bit shaded so they do not dry out too much. When they are 30-40cm high they can go out into the open.

In New Zealand this tree is often used as a shelterbelt, planted about 5 metres apart. However I recommend for Australian conditions where shelter belts are not in use that the trees be planted on a 10 x 10m spacing. They like wind, which is an exception to the general rule for most trees.

It has been worked out that by planting the trees this way and protecting them from sheep and cattle for the first five years the ultimate production from that land will be higher. This is because the sheep and cattle will graze in shaded areas which should produce better grasses, and the meat and wool will be of a better quality and should command higher prices.

It is very important to keep the trees to a single stem or trunk as they can develop big branches lower down. If they do develop two trunks, one should be removed so that the tree can develop a parasol shape. This has two advantages. First it is easier to walk or drive a tractor under the trees to gather the cones, and secondly it gives more space for sheep to shelter. It is also correct to say that with a good shape, the tree's nut production will be higher and will be easier to harvest.

The only soil that this species does not like is 'lime' country and very wet ground such as peaty areas. They will tolerate it, but may not develop a strong tap root, and later the tree might fall over. I have had some reports from Australia where they have "tried everything". The only tree that has survived in some of these places is *Pinus pinea*. Also Australia has some large areas with high salinity and this species is worthy of a trial in such places.

Soil varieties do not pose much of a problem. If the soil is heavy clay, or has a lot of rock, growth might be somewhat slower. These trees love sandy soil and are also very good for erosion control. They give a small crop in the tenth year and will increase that crop every year thereafter. Once every three or four years they have a bumper crop, which nature has built in to keep the species going when animals eat most of what has fallen to the ground.

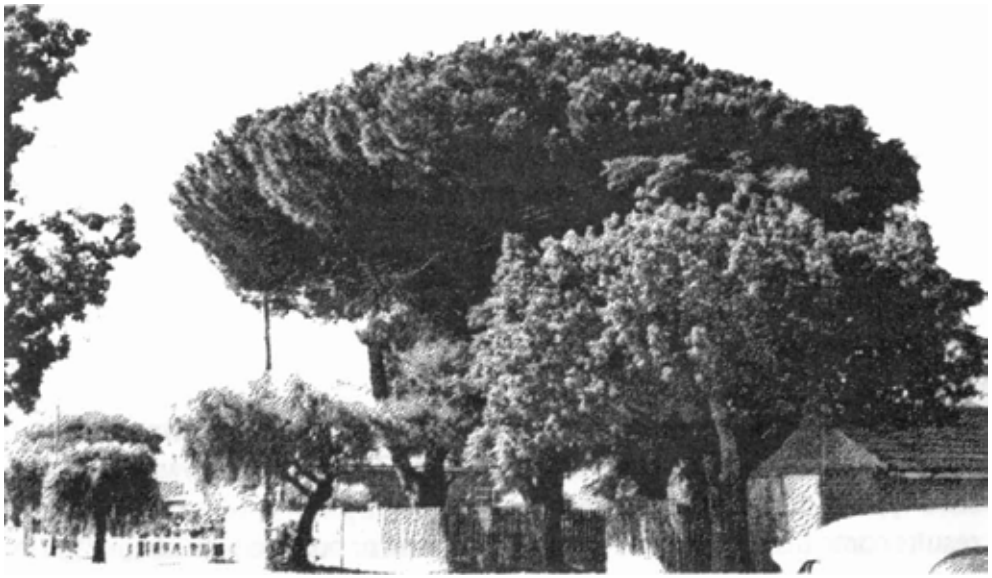
They can be sold as Christmas trees in about three years. You would not prune them if you intended to sell them for this purpose. I have never detected any pests or diseases, and even if trees are damaged they quickly grow new needles. They can stand some grass fires when about seven years old if the lower branches have been pruned.

Previous information

The pine nut, known as *Pinus pinea*, is also called the 'Stone Pine' and sometimes the 'Umbrella Pine'. These names apparently came from the idea that this tree grows well in stony ground and also at times it has a shape rather like an umbrella. The tree has many uses and is a very important plant in Italy, Spain and Portugal. The best Stone Pine forest I have seen is one of 105 hectares in Bucaco, Portugal.

As shelter belts. The trees can stand strong winds and salt sea air. Once established they tolerate both dry and wet conditions. The trees develop low branches that remain green all their life, and lower branches tend to deter rabbits and hares while the tree is young - the animals do not like pine needles in their eyes. The strong tap root in this species will drive through hard ground and helps when there is competition for water.

For nuts. The pine nuts imported into New Zealand at the moment are well known for use in cooking, salads, and confectionery, and are nice eaten raw. Trees start to bear a crop



Mature Stone Pine in a Perth suburb, showing typical umbrella shape [Photo: David Noël]

of nuts when about 10 years old, and this means that a shelter belt can give an extra income. Each cone holds about 50 nuts and 100kg of cones holds about 20kg of nuts. The annual yield of nuts per hectare is about 500kg, but 1500kg in a bumper year.

Harvesting is done by means of a hook on a long pole. This is used to pull the cones off the tree. In Italy they have started to experiment with mechanically shaking trees to get the cones off them. The cones are spread out on plastic or concrete in the sun. They open up and the nuts fallout.

The nuts are crushed between cylinders, and separated by sieving, then the kernels are sieved again to remove the brown skin around the kernel, which comes off easily.

Nuts are then sorted into whole and broken kernels. These are used in cooking, for snacks, and for confectionary. Oil can be pressed from them. Kernels will keep for some time because they have a high oil content, 48%. They also contain 34% protein.

As erosion control. The trees are very useful for erosion control on coastal areas as they do not mind salt winds. They will grow in sand as well as clay or peat. They will stand very hot summers and also cold down to 23° below freezing. During 1985, Italy had one or the coldest winters for many years. Large orchards of olives died, but there was no sign of any decline on pine nut trees.

For resin. This is not likely to be of great value in New Zealand, because large number of trees are needed to make resin production worth while. An interesting fact is that when a tree is tapped for resin, the nut production goes up for a few years and then decreases sharply. This decrease continues even if the tapping stops. Saw mills will not accept *P. pinea* trees that have been tapped because of the likelihood of nails and other pieces of metal being left in the tree.

For timber. As the branches start low to the ground these can become large if left unpruned. This may not be true if the trees are planted close together. Planting distance for a woodlot is approximately 7 x 7m, or 150-200 trees per hectare. Trees reach about 15m in

height. There is a difference of opinion as to the value of the timber. In Italy it is used for pallets and packing material, but in Portugal, where there is a shortage of timber, it is used for many other purposes.

Recreation. As these trees do well in sand they can be planted near beaches and in parks. They give very good shade when the lower branches are pruned and the tree grows into an umbrella shape.

Both in Italy and in Portugal, owners of blocks of *P. pinea* trees near a beach have several incomes from them. There are the nuts, the resin, and they often charge a fee for visitors to park their cars under these trees. Some of these places are used as caravan and holiday camps in the summer.

Some problems occur with growing the seedlings. The optimum temperatures for seed germination is 17 - 19°C. Any temperatures above 25°C can inhibit growth, and below 10°C often cause a type of dormancy.

Best results come from planting in coarse river sand or pumice with about 25% moisture. If it is too wet, the seed will rot. It is necessary to add mycorrhizal fungus gathered from under a stand of other pine trees. This is very important because, without it, you are unlikely to get any growth from your *Pinus pinea*. Very little is needed, and the mycorrhizal fungi not only help to feed the young tree but also give protection against too wet or too dry conditions.

Once the seedlings are up, do not overwater thus causing rotting. Once the nut shell has fallen off, transplant the seedling into deeper containers. The tap root will already be quite long and, if this is broken, the young tree can have something of a setback. When the seedling has reached a height of about 110cm, overwatering is no longer a danger.

Grafting. Work is still being done in Italy on propagation. There, people are attempting to get trees with more cones and better nuts. The types of grafting normally done are cleft graft and veneer side graft. The cleft graft seems to be the more favoured and the favourite time is mid-summer. The rootstock must be more than 18 months old, otherwise delayed mortality occurs in two years after grafting.

Apart from *Pinus pinea*, other rootstocks that can be used include *P. radiata* (80-85% success), *P. halepensis* and *P. sabiniana* (60-70%), and, with somewhat lower success (20-50%), *P. pinaster*.

I wish to record my gratitude to both the Italian and the Portuguese governments, who gave me a lot of information and books, and to Claire Boardman of Australia.

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AMARILLO PEANUT - A PERENNIAL ORCHARD GROUNDCOVER

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Amarillo peanut (*Arachis pintoi*) is a low growing perennial legume native of Brazil. It belongs to the Arachis genus and is a relative of the commercial peanut. It was introduced into Australia for testing as a pasture legume in 1954 and evaluated over a number of years at the Grafton Agricultural Research and Advisory Station.

In 1982 a trial was commenced from the Tropical Fruit Research Station at Alstonville to investigate the suitability of a number of legume species as low growing groundcovers. Amarillo peanut (Pinto's peanut as it was then named) performed very well and along with other potentially suitable biennial or perennials, was assessed in larger plots in orchards over the next five years. It has emerged from the testing program as one of the most promising perennial low growing legumes.

Amarillo is ideally suited to the high rainfall (over 1000 mm) frost-free areas of the subtropical north coast, especially the elevated red krasnozem soils of the Richmond-Tweed region. It meets all the criteria of an ideal permanent orchard groundcover species:

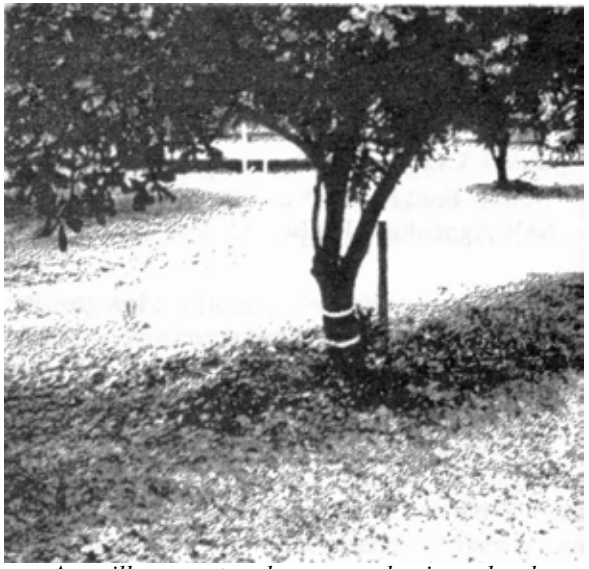
- permanent low-growing perennial (maximum height 30 cm) providing continuous year-round cover nonclimbing
- tolerates shade
- tolerates competition from grass and effectively excludes broadleaved weeds
- some drought hardiness, does not die out in a dry spring (although growth is reduced)
- some frost tolerance, leaves and stolons are killed by frost, but plants survive and shoot again in spring
- tolerates high levels of aluminium and manganese typical of the acid soils of the region
- can fix some atmospheric nitrogen in soil
- is not a host for common pests and diseases of orchard species
- will establish quickly with reasonable soil preparation and management regenerates after mowing or grazing and tolerates low mowing.

Points for concern in relatively unmanaged swards are:

- it may compete with young trees of some orchard species
- it may attract or harbour undesirable vermin such as rats and mice.

Function in the Orchard

The common orchard management program is to maintain a mown grass sward in the orchard interrow and a bare herbicide strip along the tree row. Because some tropical grasses adapt poorly in low light situations, they tend to die out as the orchard canopy enlarges. This leaves soil exposed to erosion, especially on steeper slopes.



Amarillo peanut under a macadamia orchard [Photo: author]

Groundcovers adapted to low light can protect the soil surface from erosion and the destructive effects of large droplets in canopy throughfall. The dense stolon mat and leafy growth of Amarillo peanut helps to reduce overland water flow and erosion, and the destructive effects of large water droplets falling through the orchard canopy. Soil structure is noticeably improved under the stolon mat in a well-established peanut covercrop.

In addition, the peanut, either alone or in combination with suitable grasses, promotes a more manageable orchard cover which requires less maintenance by mowing in the interrow than some grass species. It is also suitable for grazing animals if livestock are to be grazed in the orchard as it is a palatable, nutritious feed.

Adaptation

Amarillo forms a dense mat of stolons or runners above the ground when well established and, if left unmown in the orchard, the leafy canopy will grow to 38 cm. Small edible peanut seeds in a single pod are formed underground within a year of establishment, mostly within a depth of 7 cm. It is a summer dominant grower and tends to go dormant in winter.

When sown at the recommended rate, Amarillo will exclude most weed growth after six months in good growing conditions and resist invasion by grasses. However, where a mixed stand is desired, it combines well with tropical grasses such as kikuyu and will persist without being forced out by the grass. A grass-legume mixture is often desirable in orchard interrows to provide fibre and bulk for transfer to the undertree area as mulch if covercrop is not desired under trees.

Keep soil disturbance to a minimum. This will reduce potential erosion, especially on steeper sloping land. On reasonably level land, kill off vegetation with glyphosate before planting if a dense stand of peanut is desired. A pre-emergence herbicide such as Goal can also be added to the glyphosate or applied separately to give residual weed control.

Where a mixed grass-legume stand is required and the desired grass is already established, use a desiccant herbicide such as paraquat to burn off the grass without killing it. This technique can also be used on steeper sloping land. Using a desiccant herbicide will give the legume time to germinate and establish with minimum competition.

Late Spring-early Summer

Plant Amarillo peanut after the soil has warmed. In a very dry spring delay planting until sufficient rain falls for germination and establishment. Successful establishment has been achieved with late summer (February) plantings followed by ideal weather conditions in autumn. Broadcast molybdenised superphosphate at a rate of 500 kg/ha (less if super has been applied in the past 2 years) or incorporate it with seed if you are using a sod seeder. Alternatively, use ordinary superphosphate and coat the seed with molybdenum trioxide to enhance rhizobium activity and correct possible shortages in seed.

Inoculate seed with the specific rhizobium inoculum available for Amarillo peanut, and then lime-pellet before planting. Seed is currently sold in the shell and it is not necessary to remove the seed before inoculation.

Because seed must be buried in the soil for reliable germination, small rills up to 5 cm deep need to be opened up with a sodseeder or tined cultivator which will provide a row spacing to suit the desired sowing rate. An optimum row width to ensure rapid soil cover by the plant is about 50 cm. A sowing rate of 20 to 25 kg is recommended. An appropriate seed spacing for this rate is seven rows 50 to 70 cm apart in the orchard interrow. Plant seeds 2 to 3 cm deep at intervals of 30 cm along the row.

Amarillo peanut in a banana plantation [Photo: author]

Amarillo peanut will establish easily from cuttings. Cuttings 15 to 20 cm long buried 2 to 3 cm in soil with a few centimetres protruding quickly establish and spread if planted in showery weather in late summer. Water inoculum in to ensure effective nodulation.

In natural pasture, grasses tend to gradually spread to areas dominated by legumes to use the nitrogen made available. Amarillo competes with grasses, and the combination provides fibre and bulk for use in under-tree mulching. Species such as bahia grass (*Paspalum notatum*), perennial rye, kikuyu and rhodes grass are suitable. Bahia grass has shown promise in combination with peanut in trial work.

Establishment

With enough moisture, seeds germinate in 2 to 3 weeks. In good growing conditions weeds and unwanted grasses will compete unless residual pre-emergence herbicide has been used before planting. When a mixed legume-grass stand is required, suppress broadleaf weeds. Broad spectrum herbicides cannot be used. Control weeds by slashing them off about 10 cm above the height of the peanut, which should be spreading close to ground level in the first few weeks after emergence. Spot spray or use a rope wick applicator on difficult-to-control weeds.

If grass tends to dominate early, apply a specific herbicide such as Fusilade or Sertin to kill grass. With minimal competition, good growing conditions and the recommended sowing rate, Amarillo will cover the ground area within 3 months. Wider row spacings may take longer. The soil will be completely covered in 4 or 5 months.

Management of Established Stands

Management will vary according to whether it is a mixed grass-legume stand, amount of weed growth present, and the depth of groundcover you want in your orchard.

Spring and summer management normally requires mowing at 3-4 weekly intervals in the inter-row area to keep the stand about 10 cm high. Growth in the shade under the tree canopy is less vigorous and can be controlled with an offset slasher. The resulting low growth provides a good substrate for recovery of nuts by the new rotating finger mechanical harvesters.

In macadamia orchards in late January it is necessary to mow to ground level under trees or use a desiccant herbicide to suppress growth before first harvest in late February. This assists harvest as nuts can be picked from a clear, level surface. Reducing covercrop canopy at this time also reduces rat harbours in the orchard. Rats are attracted to the underground nuts when the peanut is left unmown for long periods. However, an active baiting program and eliminating perimeter harbour areas reduce rat problems and the likelihood of the peanut acting as an extended harbour area. Amarillo is a competitive legume species which tends to compete with rapidly cycling orchard species such as bananas.

The competitive effect of peanut has not been quantified in other orchard crops. Negative effects have not yet been observed in macadamias where the peanut has been established for 3 years in the interrow and one year under trees. However, it is likely that strategic knockdown or low mowing will be necessary under young unirrigated trees in a dry spring. The positive benefits of a legume covercrop (erosion control and nitrogen fixation) can still be obtained by suppressing growth for short periods in the year.

Amarillo is best left as an unmown canopy in the interrow from late summer to early spring in the first year. This allows sufficient depth of groundcover to build up to prevent weed growth in the dormant season.

Closely-related peanut, Arachis glabrata, used as a ground cover in a banana plantation in South Africa [Photo: David Noel]

Summary

In summary, Amarillo peanut is a useful perennial legume for the macadamia orchard floor, either alone or in combination with grasses. It establishes quickly and withstands mowing better than other useful groundcover legumes such as maku lotus, and tolerates grass competition better. It forms a dense mat that withstands the passage of machinery and protects the soil from compaction, is amenable to harvest machinery, and is adapted to low light under orchard trees. It is one of the most effective species for protecting soil from erosion. In addition, because it is a legume, it will add nitrogen to the soil when effectively nodulated.

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Note: Amarillo Peanut seed is available from Primae Associated Ltd outlets in Queensland (GPO Box 486, Brisbane Qld 4001) and northern NSW.

THE RED PITAYA, A NEW EXOTIC FRUIT

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The Red Pitaya, also called Strawberry Pear (*Hylocereus undatus* Britt. & Rose) is a spiny tropical cactus originating in Central America. It is cultivated in Nicaragua over a 150-hectare area on the west and south slopes of the Mount Santiago volcano, about 20km from Managua.

The fruit of the cactus is very attractive, with a distinctive appearance and a vivid red colour. In recent times, several consignments of this fruit have been exported to European countries.

The Fruit

The pitaya bears a large fruit which is pink, red, or mauve in colour, weighing around 250- 350gm. The oval or rounded fruits have skins on which strongly or weakly expressed scaly markings appear; these scales correspond to the bracts of the flower. The flesh is dark red, approaching mauve in colour, and contains numerous tiny shining black seeds. Between the flesh and the skin there is a thin mucilaginous layer.

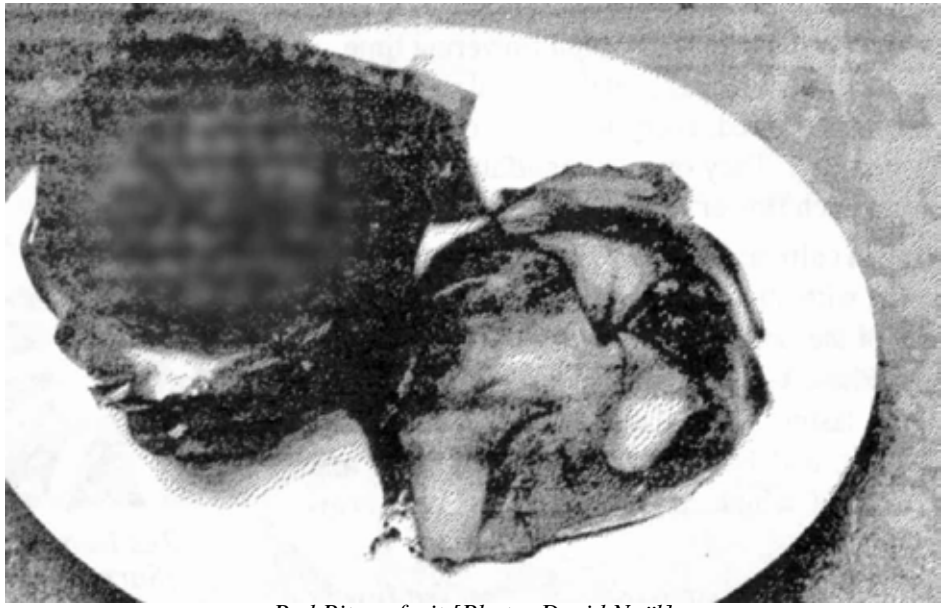
The fruit is pulped for juice, used in ice cream, or added to fruit salads. It does not have a strong taste, so lime juice is often added to bring out the flavour.

According to Incer [19S9], the fruit is useful in combatting anaemia. In Colombia, Becerra [1986] has noted that the pitaya (in this instance the yellow-fruited variety, Cereus triangularis Haw.) contains the heart tonic captine; whether this is also true of the Red Pitaya of Nicaragua is yet to be determined.

The skin and the mucilaginous layer together make up 30- 50% of the fruit weight, with this proportion varying with variety and fruit size. A Nicaraguan study [Campos-Hugueney, 1986] has shown that the pulp contains 84.4% water, 0.4% fats, 1.4% protein, 11.8% carbohydrates, 1.4% cellulose, and 0.6% ash. It also detected the presence of vitamin C (8mg/100g) and traces of vitamin A. The pulp colour is due to anthocyanins.

Ecology

The pitaya is a species of dry tropical climates. Its heat requirements are high - the average temperature should be 21-29°C, while the maximum can go to 38-40°C without the plant suffering any apparent harm. Water requirements are modest (600-1300mm), with alternating wet and dry seasons. Excessive rain leads to flower drop and rotting of immature fruit. For good production, the plants need a lot of sunshine.



Red Pitaya fruit [Photo: David Noël]

The pitaya is a species which has been shown to have resistance to the sulphurous gases emitted by the Mount Santiago volcano. This explains the location of its present area of production, as growers in that area have hardly any other feasible alternative apart from pineapples.

Plant Development

The plant grows in the form of jointed stem segments. Each segment can reach a length of 2m and be 3-7 cm across. Each segment has three, or occasionally four, longitudinal ridges, along which lie small swellings equipped with spines.

The segments easily form aerial roots, which they use to attach themselves to supports. These can be living or dead, such as trees, wooden or cement posts, stone walls, or volcanic rocks. These roots can extend down to the soil to extract nutrients from it.

The pitaya is found wild over most of Nicaragua. Seeds are spread by birds, and may be found germinating high up in tall trees, such as *Pithecolobium saman*, *Enterolobium cyclocarpum*, and *Crescentia cujete*.

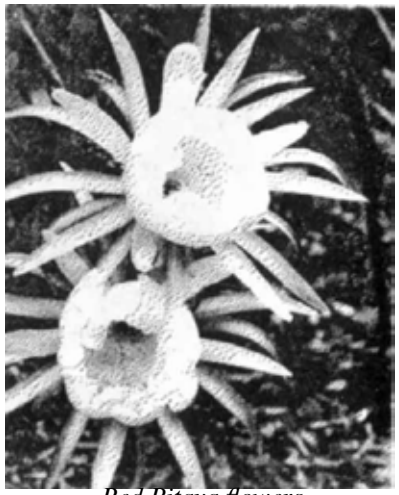
In cultivation, pitaya is propagated by stem cuttings, put directly in place at the end of the dry season. Usually three segments are placed around a living tree support; in current plantings, these supports are on a 3 x 5 m grid.

The best living posts are leguminous trees which root easily from large cuttings, such as *Erythrina* species and *Gliricidia sepium*. Other species used include *Bursera simaruba, Spondias purpurea, Crescentia cujete,* and *Cordia* species. The living posts must be pruned regularly so that they do not shade the pitayas too much.

Flowering

Flowering is initiated at the end of the dry season, in April, and continues through the wet season, to October. It seems to have a dependence on day-length (photoperiodism); irrigating plants during the dry season does not initiate flowering unless it is already close to the normal flowering time.

Flowers appear individually on the lateral stem ridges. They are large, perfumed, ivory white in colour, with a great many stamens. They open at nightfall and close at daybreak, with each flower lasting only one night.

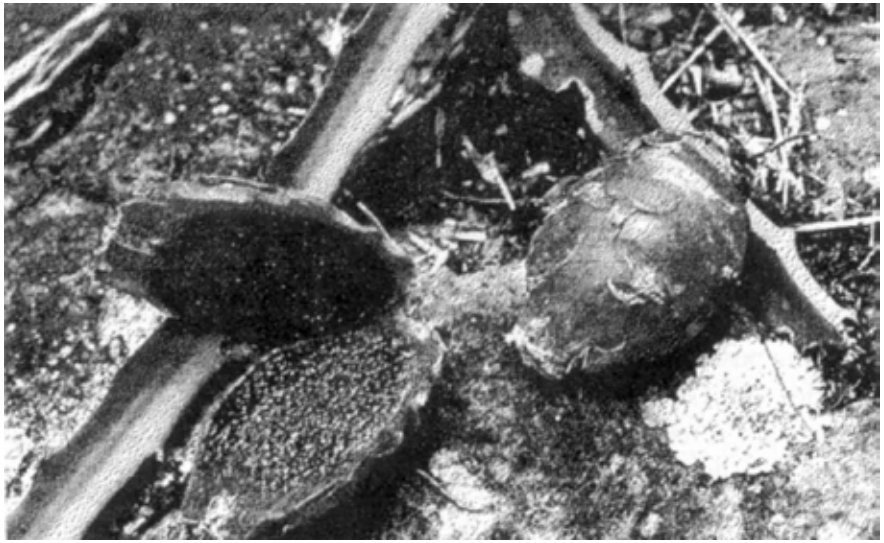


Red Pitaya flowers [Sarmiento, 1989]

Flowering in cultivated plants goes according to well defined cycles, with all the flowers of the same plant, and all the plants of the same clone, developing according to three phases. Phase 1 is the appearance and development of flower buds, lasting 15-16 days; Phase 2 is flowering, lasting 3-5 days; and Phase 3 is the development and ripening of the fruit, which takes 30-35 days from flowering.

Flowering may have barely ceased when the flower buds of the following cycle appear. So it is possible to find flower buds, young fruits, and almost ripe fruits on the same plant at any given time.

Theoretically it would be possible to have 7-9 separate fruiting cycles during one wet season. In practice, 5 or 6 cycles occur, probably due to climatic or nutritional limitations. Fruit drop in immature fruit is an important occurrence, but its cause is not known.



Red Pitaya fruits and stems [Sarmiento, 1989]

Varieties

There are no varieties in the proper sense, only clones which differ markedly in such things as type of stem segment, colour and shape of fruits, skin thickness, and scale expression. One clone is spineless. Other plants differ in flowering season, some being late, others early. It will be of interest to find out if these variations have a genetic basis or are more due to environmental factors. In either case, these variations offer the possible of extending the production season.

Growers have assigned descriptive names to some clones, such as 'rosa' (pink), 'mariposa' (butterfly), and 'orejona' (big-ears).

Cultural Requirements

During the three years of first establishing a Pitaya plantation, it is possible, and even desirable, to intercrop, as long as the low intercrop does not compete with the pitaya cultivation. Kidney beans are the commonest intercrop. In recent years, some growers have interplanted with pineapples. These plants have the advantage of better resistance to sulphurous gases from the volcano, and allow earlier recovery of the initial investment. Whatever, it is desirable that the pineapples be eliminated after two harvests.

Stems growing on support posts [Sarmiento, 1989]

No formal fertilizer trials have been carried out. Growers will apply urea or a complete fertilizer if this is economically worthwhile to them. Some have applied fertilizer as a foliar spray - this can bring about flowering several weeks earlier and reduce immature fruit drop.

Each year, rotted support posts must be replaced and weak ones reinforced. Maintaining the supports is one of the biggest costs to the grower.

Pruning living posts is an ongoing cost in pitaya culture; a balance needs to be maintained between growth of the living posts and that of the pitaya, which must not be excessively shaded. The pitayas themselves must also be trimmed to keep their volume down and permit movement along the interrows.

Pitayas have only superficial roots, and so are very vulnerable to damage if the soil is worked. In mature plantations the recommendation is to avoid working the soil, and control weeds with a herbicide instead.

Pests and Diseases

As a cultivated plant locally selected from the wild, the pitaya is subject to attack by numerous locally-evolved pests and diseases. According to Urbina [1989], the most important

problems are due to:

• The larva of a beetle, *Cotinus mutabilis*, which chews the stem segments and favours infestation by pathogenic fungi;

• A winged insect, *Leptoglossus zonatus*, which sucks the sap of the stems and fruits, leading to marks and deformations. This is also suspected of transmitting fungal and bacterial diseases.

• Ants, particularly leaf-cutting ants of the genus *Atta*, which can cause great damage to fruits. The ants attack the scales and so the fruit skin, weakening the fruit and rendering it liable to disease attack and skin splitting when ripe.

• Often some stem segments show symptoms of a watery rot, which may be limited to a single segment without affecting those above and below. The segment later dries out, leaving only the main veins. The problem is due to a bacterium, *Xanthomonas campestris*.

Pitayas growing on bamboo frameworks, Colombia [Villegas, 1990]

• A fungus problem, called 'fish-eye', where a fungus of the genus *Dothiorella* causes brown circular spots, 1- 3mm across, to appear on the stems. When the infection is severe, the spots can join up, and the surface available for photosynthesis is greatly reduced.

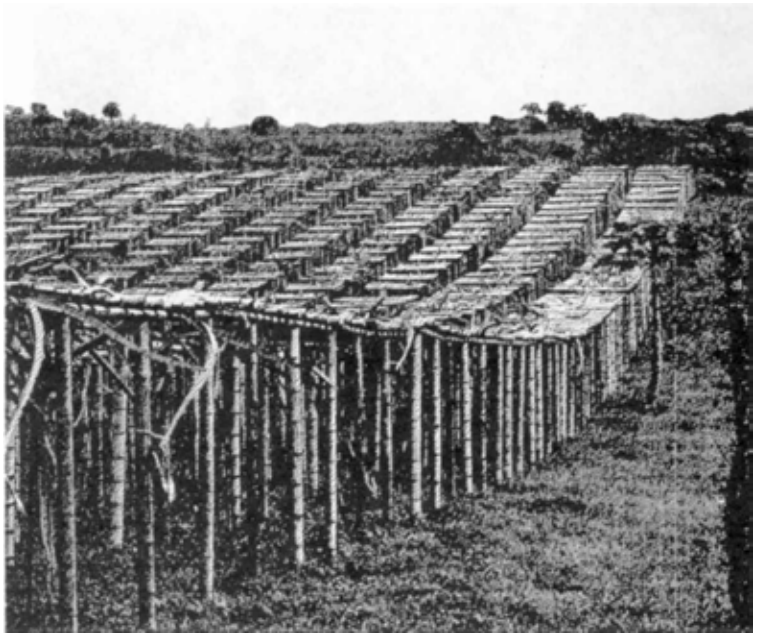
Finally, mention should be made of damage caused to ripening fruits by birds, lizards, and rodents.

Yields and postharvest factors

The first harvest can be expected 18 months after planting. Using local measures, a yield of 300 dozen fruits can be expected per hectare in the second year, equivalent to 0.8-1.0 t/ha. Yields increase progressively up to 3000 dozen fruits (10-12 t/ha) by the fifth year, which corresponds to the mature stage of establishment.

Each clump of adult plants produces about a dozen fruits per cycle between June and November, that is 5-6 dozen fruits per year. Production records show a number of peaks, corresponding to the different flowering cycles.

Fruits can be harvested once the colour of the skin starts to change from green to red. They are then held in a shaded spot which is sheltered from birds and rodents. The fruit should be cut off with secateurs, since it has no real fruit stalk and if it is just twisted off, this tears the fruit skin at the point of attachment and makes it unsalable.



A different individual bamboo pitaya frame [Villegas, 1990]

Preliminary studies on fruit keeping have shown that:

• Fruits harvested green, two days before the expected colour change, ripen normally at ambient temperatures (25-30°C) and have a keeping life of 9-11 days.

• Fruits harvested at the colour change keep for 7-8 days.

• Fruits harvested fully ripe, that is when the skin has become fully red, remain good for eating for 5-6 days at ambient temperatures.

• Ripe fruits left on the plant keep for 8 days after the colour change, provided they are not eaten by birds.

Fruits kept in cool storage (10-12°C) for a week continue to ripen, but more slowly, and colouration is less intense. After removal from cool conditions, ripening is accelerated.

After four days, fruits harvested just ripe begin to rot. Those harvested at colour change or green remain presentable for 5-7 days.

So cool storage slows ripening of green or turning fruit, and can prolong its life. While a little skin colouration may be sacrificed, the pulp colour does not seem to be affected.

A different individual bamboo pitaya fram [Villegas, 1990]

The influence on lifetime of higher and lower temperatures, and of different clones, remains to be evaluated.

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[Based on an article *La pitahaya rouge, un nouveau fruit exotique*, published in the magazine Fruits, Vol. 45, No.2, 1990. Translation from French: David Noël]

Submission of Articles

The WANATCA Yearbook is devoted to useful longer articles, likely to have continuing reference value, about any aspects of nuts, fruits, and other tree or perennial crops.

Articles would be gladly received from any source - there is no requirement to be a member of WANATCA. If the text is available on a computer or word-processor disc (Macintosh is preferred), this is greatly appreciated.

The WANATCA Yearbook is produced at the Tree Crops Centre for the West Australian Nut & Tree Crop Association Inc.

Please send articles or enquiries to:

The Editor. WANATCA Yearbook, PO Box 27, Subiaco. WA 6008. Australia

WEST AUSTRALIAN NUT & TREE CROP ASSOCIATION (Inc)

Founded in 1974, the Association has built up a wide membership among professional growers, amateurs, researchers, horticultural bodies, libraries, nurseries, and investors. Members are based throughout the State, all over Australia, and in many overseas countries.

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