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WANATCA Yearbook 1995

Ziziphus joazeiro, the Jua or Juá da Caatinga (see page 14)

West Australian Nut and Tree Crop Association (Inc)

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West Australian Nut and Tree Crop Association (Inc)

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West Australian Nut and Tree Crops Association (Inc.)

PO Box 565, Subiaco, WA, 6008

Publications

The Association publishes a quarterly magazine *Quandong* and the *WANATCA Yearbook*. Members receive these publications of the Association as part of their current year's subscription. The Association also sponsors the *Australasian Tree Crops Sourcebook* (ATCROS). Members also receive a free copy of this if an edition is published while they are current members.

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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HIGH-DENSITY PLANTING OF MACADAMIA NUTS

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High-density planting techniques now being trialled in Queensland may revolutionise the macadamia-nut industry by drastically increasing yields and accelerating full production.

The techniques are being developed by Henry Bell, the first plant breeder in Australia to be granted Plant Variety Rights (PVR), and his son, David. In David's words: "We are growing macadamias like wheat."

At their Hidden Valley Plantation at Beerwah, in the Sunshine Coast hinterland, the Bell family works 10,000 macadamia trees. They also process their own nuts and breed new macadamia varieties noted for high yields and suitability to Australian conditions. A large proportion of their trees are progeny that are still being assessed as part of the breeding program.

Henry outlines the principles of high density growing as aiming for production per hectare instead of production per tree. Under traditional production methods, at five years of age macadamias may produce about two kilograms of nuts per tree. With the standard 200 trees to the hectare, this produces 400kg/ha.

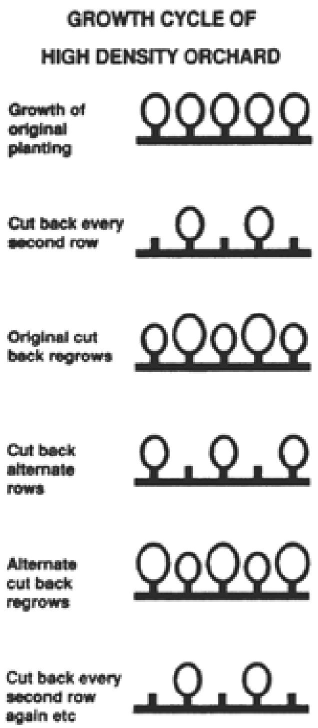
The Bells' new high-density management techniques, coupled with precocious varieties, have the potential to produce one-and-a-half tonnes of nuts in shell/ha within three years of planting. In the fourth year it is possible to achieve three-and-a-half tonnes/ha, based on results to date in trials being conducted at Hidden Valley Plantations.

Henry expects that after the 15th year it is likely that the traditional 200 trees/ha will out produce those with high-density spacings, but says there are more advantages in getting into maximum production eight years early.

The Bells are also experimenting with an alternative density of 2000 trees/ha (3 metre x 1.5m spacing), which would bring forward full production to about the sixth year. However, they say the lower density of 5m x 2m would be more practical, based on harvesting and management with present day farm machinery.

High-density plantings can create a closed canopy with problems of fungal disease and harvesting difficulties. Therefore new management techniques have to be evolved, such as cutting back trees to knee height in alternate rows once full production has been achieved. This process continues over the life of the orchard, with all trees being lopped and allowed

David and Henry Bell with a healthy bunch of nuts produced by one of their four-year-old A16 varieties.



to shoot again, and returning to full production in a cycle lasting four to six years. The staggered cutting back of alternate rows in each block maintains constant yields. As well as not allowing trees to grow more than 4-5m high, the Bells are looking at varieties that have more open canopies.

Management techniques must also be developed to cater for the difference in row spacing of the standard 8-10m rows with trees at 4-5m intervals (as developed in Hawaii and followed by Australian growers), compared with the high density plantings of 5m x 2m rows (considered the best option) or the 3.5m x 1.5m and 6m x 3m rows (from interplanting existing areas) being trialled.

Having already designed original harvesting machinery for macadamia nuts and being therefore well accustomed to making innovations when necessary, the Bells expect to be able to readily adapt existing management methods and equipment to cope with spraying and harvesting high-density crops.

The objective, as Henry outlines it, is to have a very high yielding block that is easier to maintain, with less capital outlay for machinery per tonne of kernel and a faster pay back period. In addition, by reducing the height and size of the canopy, there will be fewer disease problems and easier control of insect pests. Higher light levels into the canopy will induce more crop and because the adjacent tree rows will be at different heights, there will be more ground cover and less erosion.

Table 1. Economic effects of planting macadamias at high densities

Spacing	10x5m	7x4m	5x2m	3.5x1.5m
Trees/ha	200	350	1 000	2000
Experience	Good	Good	Poor	Poor
Set up costs	Med-Low	Medium	High	High
Yields				
Short term kg/ha	Poor	Fair	Good	Good
Long term kg/ha	Good	Good	Fair*	Fair*
Maintenance costs/ha				
Short term	High	Med-High	Medium	Med-Low
Long term	Medium	Medium	Medium	Medium
Tree				
Tree size	Very Large	Med Large	Small	Small
Dieback	Yes	Yes	No?	No?
Canopy				
Control	Long Term	Medium Term	Essential	Essential
Machinery access	Good**	Good	Fair	Poor
Spray etc	Poor	Fair	Good	Good
Other issues				
Special machinery	No**	No	Maybe	Probably
Comments	Large Trees , are difficult to maintain long term	Will meet and may require canopy control	Many unknowns but potentially a better system	Current practices need to be substantially altered

* High long term yields can be achieved if the access row width can be reduced-which will probably require special machinery.

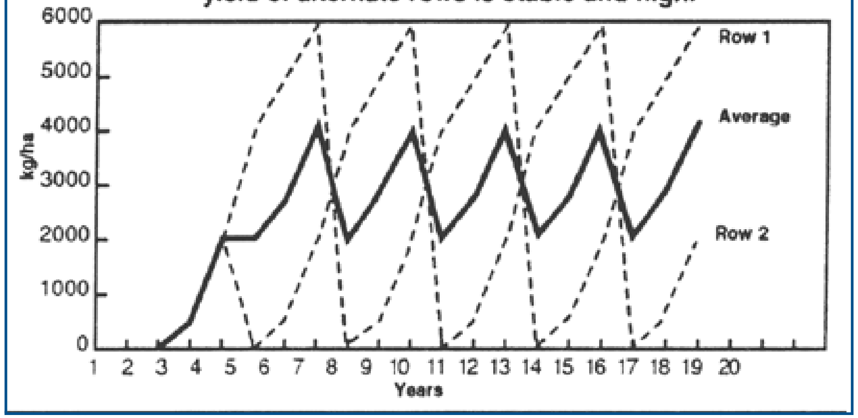
**Current machinery is not really adequate for large trees.

The new technique may also reduce dieback. Although dieback can be caused by a number of factors, it always produces the same result of the canopy coming back to a size that can be maintained by the root system under prevailing conditions. Using the management system outlined, Henry says the canopy remains young and is never allowed to become too large, which should overcome the dieback problem in macadamia orchards.

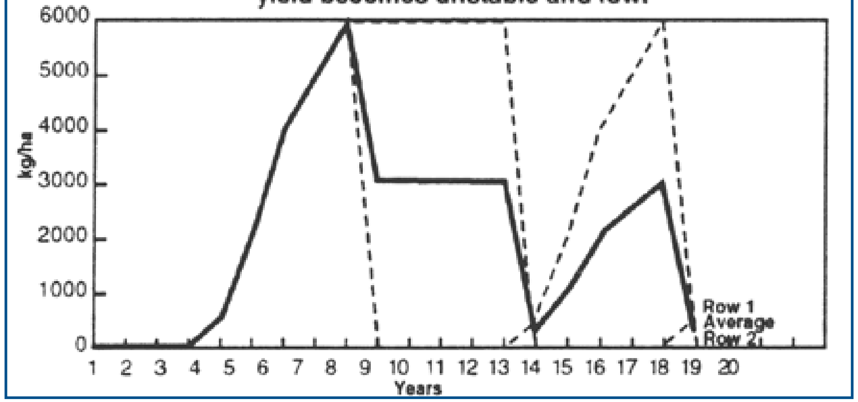
High-density planting does not have to be limited to new areas. The technique can be used to renovate established growing sections where large old trees are declining and producing less crop. These old trees can be skeletonised and interplanted with precocious high yielding varieties. Reducing the height of the old trees creates higher light levels and less competition for the young trees. A decision can be made at any time whether to keep the skeletonised trees as cross-pollinators, top-work to better varieties over a period of time, or remove them altogether. The old trees should come back into commercial production long before the new planting starts to bear crop.

High-density planting means greatly improved yields, but at a much higher initial cost because of the numbers of trees required. In order for this cost to be minimised, large-scale production of cutting-grown (rather than grafted) stock is required - the Bells' estimates show that stock from cuttings needs to be about half the price of grafted stock for high-density planting to be considered a viable alternative.

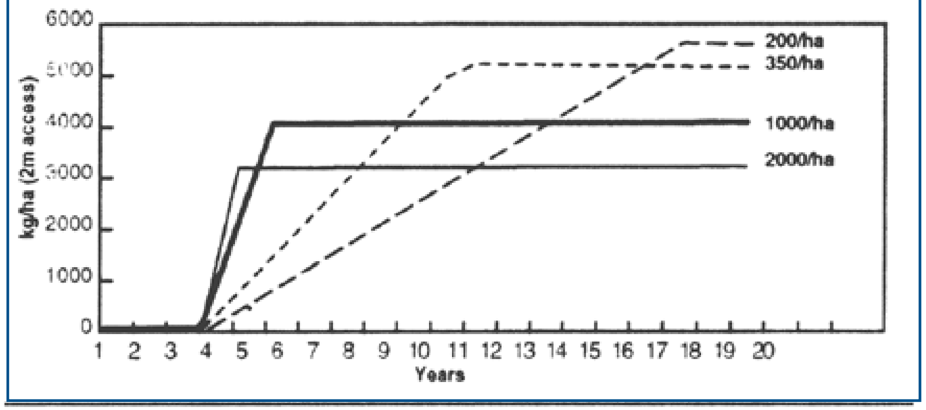
The Bells have been experimenting with cutting-grown stock for the past seven years and have found no difference in nut quality between cutting grown and grafted stock. Cuttings are taken from branch tips, retaining two nodes and one set of leaves, and placed in either a mixture of perlite and peatmoss or foam pads on heated beds. Strike rate is about 50%. To date, the Bells seem to be achieving greater success with the mix, as the foam pads retain too much moisture for healthy rooting. However, the foam pads take far less space on the heating beds, so trials continue with both media.



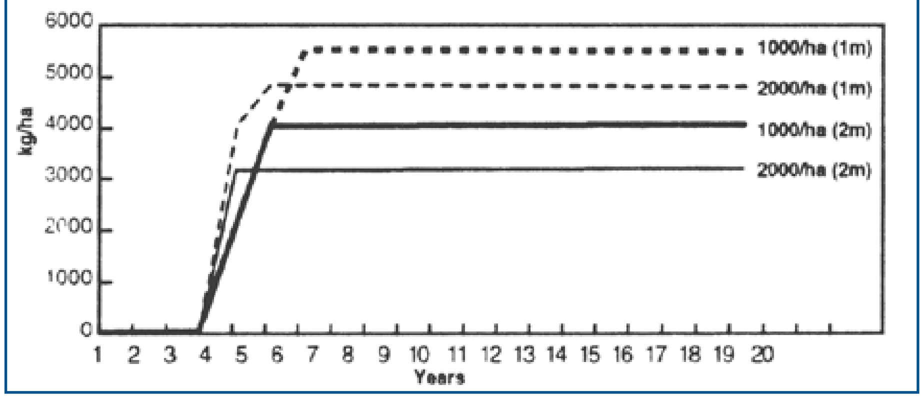
If the regeneration period is short, the average yield of alternate rows is stable and high.



However if the regeneration period is too long, the average yield becomes unstable and low.



Higher planting densities have lower maximum yields, but can reach the level faster



High planting densities can have high maximum yields, if the tractor access width can be reduced

The Bells say one way to reduce planting costs is for growers to obtain one-year-old cuttings from specialist production nurseries and then pot and grow them until they are ready for planting in another year. "What we are aiming for here is to work out how to produce large numbers of trees quickly and cheaply," Henry says.

Although not the popular method in Hawaii (where most of the world's production of macadamia nuts takes place), production from cutting-grown varieties is common in Africa and Israel, where copy trees are grown on from Beaumont cutting rootstock. Henry says his cutting varieties are proving as vigorous as Beaumont. He lists the advantages of cutting-grown trees as:

- *being clones and true to type;*
- *eliminating any incompatibility between rootstock and scion;*
- *no need for removal of rootstock suckers; and*
- *a tendency to bear commercial crops earlier than the same varieties grown as grafted*

trees.

The disadvantages are:

• *difficulty of striking some varieties;*

• *uneven growth rates of some varieties at nursery level (now being overcome by improved methodology); and*

• *concern about the ability of cutting-grown plants to produce good root stocks (yet macadamias are surface rooting and the Bells say this is not a problem if cuttings are grown correctly)* .

Table 2. Macadamia tree volumes (m^3) for 1993 and 1994.

	HV-A4 Control Trees		**HV-A4 Truncated Aug 93**		**HV-A16 Control Trees**		**HV·A16 Truncated Aug 93**	
Tree Type	Cutting	Grafted	Cutting	Grafted	Cutting	Grafted	Cutting	Grafted
Yrs Planted (in 1994)	3-4	14	3-4	14	3-4	14	3-4	14
Yrs Topworked (in 1994)	n/a	7	n/a	7	n/a	7	n/a	7
Aug'93 Vol m^3	2.60	36.08	2.33	31.18	6.80	22.16	7.38	18.42
Sept '93 Vol m^3	2.60	36.08	0.23	6.24	6.80	22.16	1.37	5.29
% expected Sept'93	100%	100%	10%	20%	100%	100%	19%	29%
Apr '94 Vol m^3	10.43	45.23	3.32	14.61	16.02	26.77	6.69	10.93
% expected Apr'94	100%	100%	36%	37%	100%	100%	38%	49%

The high-density trials at Hidden Valley Plantations have already produced two crops. In the next few years, Henry and David will be assessing the success of their pioneering high density techniques. As part of the program, they hope to assess the period between lopping (truncating) and the next production phase, the ideal cycle time, the rate of mortality due to lopping, and the varieties most suited to their high density management system.

As Henry points out, the Australian macadamia industry faces considerable competition from countries with lower labour costs. It is also located in coastal areas with high land values. This combination puts the Australian grower under increased pressure to increase the kernel yield/ha. Hence the importance of the trials at Hidden Valley Plantations which, he says, should have considerable impact on macadamia-nut production in the future.

"Many horticultural industries have taken a dramatic turn from growing large fruit trees to semi-dwarf and dwarf-type trees and high-density plantings. We feel that the way of the future lies with developing high-density management systems and the varieties to suit those systems," Bell says.

(Based on an article in 'Australian Horticulture', October 14, 1994)

GENETIC RESOURCES AND BREEDING POTENTIAL OF SEABUCKTHORN (*HIPPOPHAE RHAMNOIDES*) IN RUSSIA

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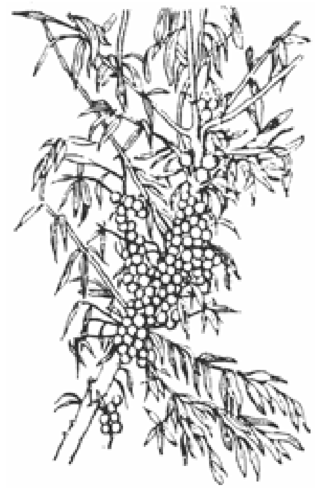
The seabuckthorn (*Hippophae rhamnoides* L.) is widespread on the territory of Russia. It produces dense scrub in the maritime part of the Kaliningrad Region, in the Subcaucasus, in the southern part of Western Siberia (Altai) and in Eastern Siberia (Sayan and Transbaikal). In Siberia the most frost resistant populations are found.

In the above mentioned regions the seabuckthorn is represented by various isolated forms and geographical races. With the onset of selection and breeding, the seabuckthorn was introduced as a crop, and was spread to the northern part of European Russia, the Urals, and the 'new' regions of Siberia.

The distribution of the seabuckthorn began in 1850 from the Tavricheskyi Garden in St Petersburg, which at that time had trees already 20 years old. These plants were received in the beginning of the century from the Gornyi Altai in Central Asia. The Botanical Garden of St Petersburg used the seabuckthorn as ornamental plant.

At the beginning of the 20th century, a great interest in the seabuckthorn as a fruit crop arose, and its propagation in the nurseries of the European part of Russia was begun (St Petersburg, Moscow and Voronezh). The crop achieved wide popularity in the 1960s. At present the seabuckthorn is found (as a crop) from Arkhangelsk in the north, through Tomsk and Chita, right down to the southern border of the country.

In nature the seabuckthorn has a lot of different forms; this allowed use of the most promising of them in breeding programmes. Russian scientific organizations have carried out great work on the development of commercial cultivars (up to the present, 24 cultivars have been released). The most fruitful work has been done at the M A Lisavenko Siberian Research Institute of Horticulture (SRIH) where 14 commercial cultivars have been released and 4 promising new forms are before the State Variety Trial Committee.



Sea Buckthorn, Hippophae rhamnoides

§ Member. WANATCA

The Botanical Garden of Moscow State University, the All-Russian Institute of Medicinal Plants, the Novosibirsk Zonal Fruit and Small Fruit Experiment Station, the Nizhni Novgorod Agricultural Institute, and the Buryat Fruit and Small Fruit Experiment Station are all working at their own breeding programmes, and have recently been joined by the Chelyabinsk Horticultural Breeding Station and the Krasnoyarsk Fruit Growing Experiment Station.

The objectives of these programmes are the development of cold resistant cultivars, well adapted to the conditions of the regions where they will be cultivated, in particular trees with compact dwarf crowns (not more than 2 m in height), without thorns, with high productivity, that is average yield about 8-10 t/ha, and fruits with different periods of maturity.

The vitamin-rich fruits of Seabuckthorn

The breeding targets are: average fruit weight not less than 0.6 g; length of fruit stalk, 10 mm; strength of their attachment to shoots, not more than 100 g; no fruit tearing at harvesting; durable skin; and firm flesh.

The content of oil in fruits should be not less than 7%; of vitamin C, 100 mg/100 g; total carotenoids 30 mg/100 g, and carotene, 6 mg/100 g. In addition, the fruits of new cultivars should contain other biologically active substances such as vitamin P (bioflavonoids), 100 mg/100 g; B1 (thiamine), 0.05 mg/100 g; B9, 0.15 mg/100 g; cumarins, 3.5 mg/lOO g. The sugar level should be not less than 9%, tannins not more than 0.04%, and acids not more than 1.3%. The oil in fruit flesh should contain biologically-active fat-soluble substances in quantity not less than 50 mg/100 g; carotenoids, 250 mg/100 g; vitamin E (tocopherol), 120 mg/100 g; vitamin K1 (phylloquinone), 5 mg/100 g; and sterines, 200 mg/100 g.

It is not by chance that the first priority in breeding programmes is given to the problem of winter resistance. This is despite the fact that the above-ground parts of the plants endure frosts up to -50°C and their roots up to -20°C in their natural habitats in Siberia, thanks to the long dormancy period of the plants. However, in the European part of Russia the seabuckthorn does not always preserve this valuable property because its dormancy period is short under these conditions. In the north-west of Russia, the dormancy period may cease at the end of November. Under the conditions of frequent thawings, the plants very often lose their frost resistance, and become vulnerable even at not very low minus temperatures.

Winter resistance decreases in mild snowy winters, when deep snow cover keeps the temperature in the root system zone from 0 to 2oC. In this case the root is damped off and plants die. The active parts of the roots are subject to damping off when a heavy fall of snow occurs onto unfrozen soil.

List of released commercial cultivars of the seabuckthorn

(with regions of use)

1. **Aley** (male form) - M.A.Lisavenko Siberian Research Institute of Horticulture (SRIH) (Novost Altaya x Katunskaya form), 1988: Altai and Krasnoyarsk Territories;

2. **Atsula** - Buryat Fruit and Small Fruit Experiment Station, 1988: Buryat Republic;

3. **Ayaganga** - Buryat Fruit and Small Fruit Experiment Station, 1988: Buryat Republic;

4. **Botanicheskaya** - Botanic Garden of Moscow State University (Leningradskaya form x open pollination [OP]), 1991: Latvia;

5. **Botanicheskaya Aromatnaya** - Botanic Garden of Moscow State Univ. (Leningradskaya form x OP), 1991: Latvia;

6. **Botanicheskaya Lubitelskaya** - Botanic Garden of Moscow State Univ. (Leningradskaya form x OP), 1991: Latvia;

7. **Velikan** - SRIH (Shcherbinka-l x Katunskaya form), 1987: Kemerov, Kurgan, Perm, Ekaterinburg, Chelyabinsk Regions;

8. **Vitaminnaya** - SRIH (Altaiskaya form x OP), 1974: Vladimir and Chelyabinsk Regions;

9.**Vladimirka** - Collective garden in Vladimir Region (Transbaikal form x OP), 1991: Ivano Frankovsk Region (Ukraine);

10. **Dar Katuni** - SRIH (Shcherbinka-l x Katunskaya form), 1965: Altai and Krasnoyarsk Territories, Kemerov and Novosibirsk Regions;

11. **Zolotistaya Sibiri** - SRIH (Shcherbinka-l x Katunskaya form), 1985: Altai Territory, Perm and Ekaterinburg Regions, Udmurt Republic;

12. **Zyryanka** - Institute of Cytology and Genetics, Siberian Branch, Russian Academy of Sciences and Novosibirsk Zonal Fruit and Small Fruit Experiment Station (from gamma-ray irradiation of seeds of the Kaliningradskaya population), 1992: Arkhangelsk and Vologda Regions;

13. **Maslichnaya** - SRIH (Altaiskaya form x OP), 1965: Chelyabinsk Region;.

14. **Novost Altaya** - SRIH (Altaiskaya form x OP), 1965: Chelyabinsk Region;

15. **Obilnaya** - SRIH (Shcherbinka-l x Katunskaya form), 1979: Altai and Krasnoyarsk Territories, Irkutsk, Novosibirsk and Omsk Regions;

16. **Oranzhevaya-** SRIH (Dar Katuni x Sayanskaya form), 1979: Altai Territory, Vladimir, Nizhni Novgorod and Omsk Regions;

17. **Panteleevskaya** - SRIH (Velikan x Katunskaya form), 1993: Altai Territory;

18. **Prevoskhodnaya** - SRIH (Shcherbinka-l x Katunskaya form), 1987: Altai and Krasnoyarsk Territories, Kurgan, Novosibirsk, Perm, Ekaterinburg, Tyumen and Chelyabinsk Regions;

19. **Priokskaya** - Nizhni Novgorod Agricultural Institute (Novost Altaya x the form Tunchinskaya 40), 1989: Nizhni Novgorod Region;

20. **Samorodok** -SRIH (Shcherbinka-1 x Katunskaya form), 1985: Altai Region, Kurgan and Chelyabinsk Regions, Udmurt Republic;

21. **Sayana** - Buryat Fruit and Small Fruit Experiment Station (selected form from the local wild population), 1992: Buryat Republic;

22. **Trofimovskaya** - Botanic garden of Moscow State University (Leningradskaya form x OP), 1991: Grodno Region (Byelorussia);

23. **Chuiskaya** - SRIH (Chuiskaya form x Chuiskaya form), 1979: Altai and Krasnoyarsk Territories, Vladimir, Irkutsk, Kurgan, Moscow, Novosibirsk, Omsk, Perm, Ekaterinburg, Kemerov, Tyumen, Chelyabinsk and Yaroslavl Regions, Udmurt Republic;

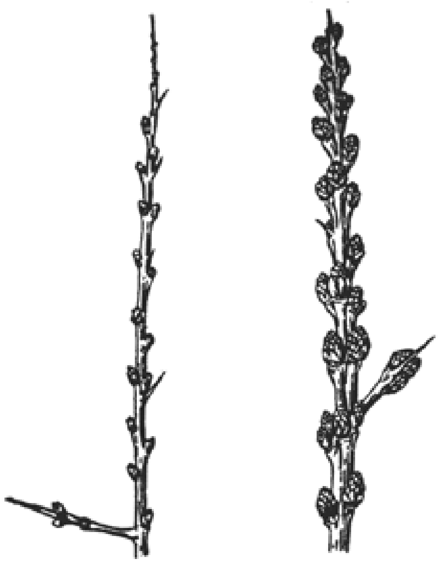
24. **Yantarnaya** - SRIH (Chuiskaya form x Chuiskaya form), 1989: Vladimir Region,

Udmurt Republic.

The breeders of the SRIH have established the importance of male plants in orchards. A plant pollinator exercises considerable influence on quality and quantity of the fruit, on the setting of fruits, their size and chemical composition.

Since the flower buds of male plants are less frost resistant than those of female ones, their death may be a reason for low yields. Therefore it is most essential to develop male forms that would combine general winter resistance with high hardiness of flower buds.

The wide spread of Fusarium Wilt (*Fusarium* sp.) has become a significant factor that limits the yield of the seabuckthorn, since the disease kills up to 10-20% of young and mature trees every year. To our regret, there are no measures of control against this disease. The only way is to create resistant cultivars. The development of such cultivars as Zyryanka, Sayana and Panteleevskaya with sufficient level of resistance is the first step in this trend. These varieties were released in 1992 and 1993.



Male and female shoots of seabuckthorn before winter. Female buds are larger.

The correct choice of parental forms is of great significance for breeding new commercial varieties on the basis of extensive use of the richest genetic resources of the seabuckthorn.

The study of biochemical compositions in the various geographical forms of the seabuckthorn has helped to reveal that fruits differ significantly for these traits. For example, the Katunskaya population is very promising for developing sweet-fruited, oil-bearing hybrids with high content of carotene; Chulyshmanskaya populations, for sweet fruits rich in vitamins and carotene; Sayanskaya and Kaliningradskaya populations, for breeding hybrids with high level of vitamin C; and Tien-Shanskaya populations, for breeding fruits with improved content of oil and vitamin C.

Crosses between the variety ‘Shcherbinka-l’ (from Eastern Siberia) and the Katunskaya and Chulyshmanskaya populations appear to be most promising. Hybrids with large-sized, oil-bearing fruits rich with vitamins and with small numbers of thorns on the shoots have been obtained in such progenies. Some of these hybrids have been named and released, such as Velikan, Dar Katuni, Zolotistaya Sibiri, Obilnaya, Prevoskhodnaya, and Samorodok.

Crosses between the selected forms of the Chulyshman population (Kudyrga-1, Bashkaus-2 and Bashkaus-6), and thornless seedlings of the cultivars Novost Altaya and Shcherbinka-1 are promising for the creation of sweet-fruited hybrids.

The crosses between: Vitaminnaya x Sayanskaya form, Dar Katuni x Sayanskaya form,

Pskemskaya form x Chitinskaya form, Chuiskaya form x Chuiskaya form, Kaliningradskaya form x Katunskaya form are the most promising for improved content of vitamin C. The crosses Shcherbinka-1 x Chulyshmanskaya form, Chuiskaya form x Chuiskaya form, Selection B-30 x Chitinskaya form, Shcherbinka-1 x Katunskaya form are suitable for obtaining forms with high content of oil (up to 9%). Crosses between Vitaminnaya and Sayanskaya form, Chuiskaya form x Chuiskaya form, Bashkaus x Katunskaya form, Kudyrga-1 x Katunskaya form, Novost Altaya x Katunskaya forms are useful to obtain high-carotene forms.

For the development of dwarf forms of cultivars the most promising as female parents are the following varieties: Novost Altaya, Shcherbinka-1, Vitaminnaya. Cultivars with different periods of ripening can be obtained by crossing geographical forms with different vegetative period lengths. To obtain early cultivars, it is recommended to use in hybridization the selected forms of Chuiskaya population; for obtaining late cultivars, the use in crosses of the selected forms of Kaliningradskaya, Jutland populations, and a number of elite forms is recommended. In breeding for elongation of the fruit stalk (up to 10 mm), good results are achieved by crossing Dar Katuni and the Sayanskaya form, the progeny from the crosses of the selected form 6-60-227 and a seedling of Shcherbinka-1. By crossing Kudyrga-1 x Katunskaya form and a number of selected forms x Katunskaya seabuckthorn, it is possible to improve such traits as strength of fruit attachment (up to 100 g).

Fruits of Seabuckthorn, Hippophae rhamnoides

From the above it may be concluded that known genetic stocks of the seabuckthorn exist with the capacity to solve practical problems in cultivation of this crop through appropriate breeding.

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ZIZIPHUS: JUJUBE FAMILY SPECIES, DISTRIBUTION, EXPLOITATION

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Introduction

When people talk about Jujubes or Chinese Dates, they are usually thinking of just one or two species in the genus, out of a total of 80 - 100 which actually exist around the world. In this article, a preliminary listing is given of all species names which have been located in the literature, together with synonyms found and an indication of where each species grows. A tentative world distribution map is given for the genus.

As with so many tree crop families, research and development work has tended to be concentrated within quite a narrow genetic base. Some suggestions are given as to how broad overview information on a whole plant family such as the big jujube genus can be used to exploit genetic characteristics in a systematic way, and possibly greatly improve the economic and ecological value of plants and plant products available to the world.

The Species

In Table 1, a listing is given of all the different species found which have been referred to (classed in) the genus *Ziziphus* in a range of literature sources, old and new. Also included are species from other genera, such as *Rhamnus* or *Condalia*, which some workers have considered should properly be referred to *Ziziphus*.

The genus name itself was originally spelled *Zizyphus*, as explained in Griffiths [32], and this form is still a valid synonym, often found in both modern and older literature. In Table 1, the abbreviation 'Z.' is used, so the form which seems to be coming into use for the 'common' jujube as commercially grown, appearing in the table as '*Z. zizyphus*' , is expanded to *Ziziphus zizyphus*, thus using both spellings!

The second column lists areas where the species is considered to be native, and has been generalized to include all areas listed in the original sources. The third column gives the plant form, where noted, denoting either a tree, a shrub, or a scrambling climber. The fourth column refers to the references listed in Table 2.

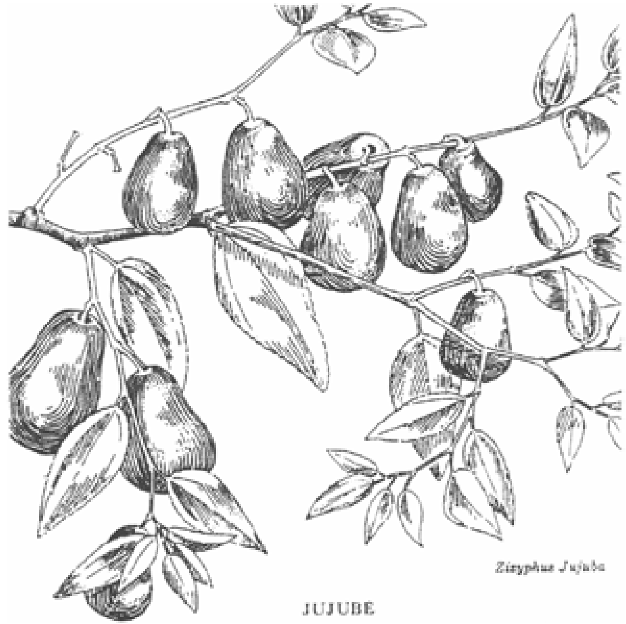
Listings with the sign '=' between two names means that the first name has been regarded as superseded and should be replaced by the second name, so, for example, the listing

Z. napeca=Z. oenoplia 21

§ Member, WANATCA

means that Hundley, the author of reference 21, believed that a jujube species which had been recorded as *Z. napeca* did grow in Burma, but that its name should more properly have been referred to as *Z. oenoplia*. On the other hand, two other references to *Z. napeca* are given in the table, referring to authors who accepted this as the correct name. .

Table 1 is derived from a computer database, which I intend to maintain, expand, and update as more information comes in. However, such a database can never be completely accurate and definitive, for reasons which will be mentioned.



The common Jujube, Ziziphus jujuba

Species Names

Dividing a number of populations of related plants up into different species within a genus is still largely a matter of individual opinion and judgement, strongly dependent on individual criteria applied. In extreme cases, two populations can be regarded as being in two different species because of some quite trivial difference, such as long or short leaf-stalk.

The theoretical basis of a species is that for two populations to be regarded as falling within the same species, all individuals within both populations should be capable of breeding freely with all other individuals within them (of appropriate sex, etc.). Unfortunately, this definition is not always of much practical use.

For example, almost all of the hundreds of species of oak, *Quercus*, seem capable of interbreeding, so there should be only one oak species on this basis. Sometimes a widely ranging species varies gradually along its range, so an individual at one end cannot freely cross with one from the other end, even though there is no sharp distinction in between. And sometimes individuals within a species have different numbers of gene sets, so that a 'Granny Smith' apple, classed as a diploid, would have to be regarded as a different species as a 'Bramley' apple, a triploid with which it cannot freely breed.

For this and many other reasons, there can never be complete agreement as to exactly where the division between one species and another should be placed, or exactly how much difference there should be between two related populations for them to be split between two species. There is some help to be had from detailed genetic analysis, and from observed behaviour in such things as graft compatibility, but all such criteria have limitations.

The species names listed in Table 1 must be looked at with these points in mind.

Distributions

According to Mabberley's The Plant-Book [31] (arguably the most useful book in world history for someone interested in exploiting plants), there are 86 species of *Ziziphus*, found in most tropical and warm parts of the world.

Figure 1 shows a map of the world with the areas marked where any *Ziziphus* species have been noted as growing wild. These markings are only tentative, as the sources used to compile them are often fairly vague, saying 'North Africa', or 'Brazil', for example. The genus is, obviously, very widespread.

Those interested in just why the genus should show up in one part of the world and not another, why, for example there are no *Ziziphus* recorded in the Pacific Islands, or along the west coasts of North or South America, or in the Sahara area, can refer to my book Nuteeriat [30]. This does provide an explanation of why a genus like *Ziziphus* can be clearly native on all continents, and yet not be found on parts of some of those continents.

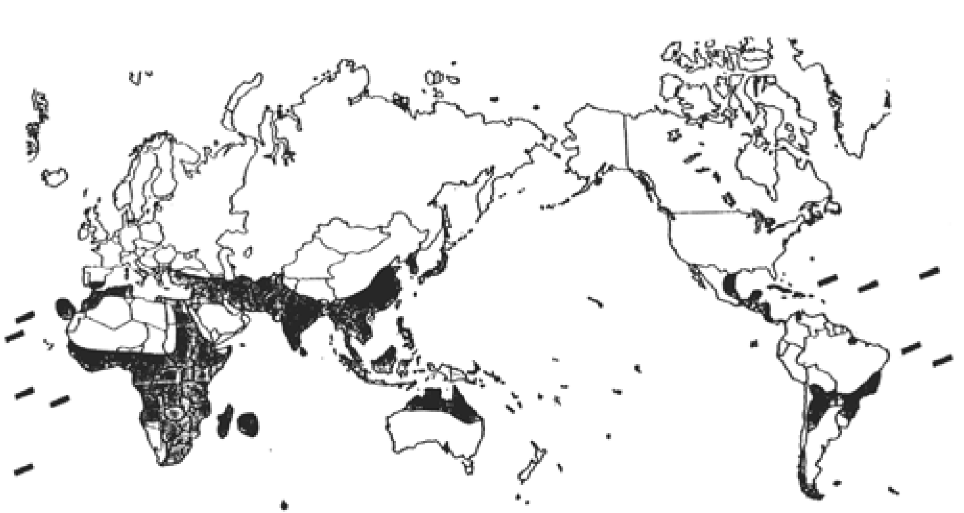


Fig. 1. World distribution of Ziziphus species

Exploitation

There are three great areas of use of plants of the Jujube family: Fruits; Medicinals, and Fodder[31,32].

To best exploit the genetic potential of the family, it is useful to regard the Family Gene Pool, not as a Swimming Pool full of uniform water, but rather as a Labour Employment Pool, from which individuals, and combinations of individuals, can be systematically selected to meet a defined need.

Table 1. Plant Species referred to the Genus *Ziziphus*

(see text for explanation)

Species	*Area of Distribution*	*Form*	*References*
Ceanothus chloroxylon=Z. chloroxylon			2
Condalia pedunculata=Z. pedunculata			8
Laurus chloroxylon=Z. chloroxylon			1
jujuba=Z. mauritiana			1
Rhamnus nummularia=Z. nummularia			12
Rhamnus sarcomphalus=Z. sarcomphalus			1
Rhamnus trinervius=Z. jujuba			21
Rhamnus zizyphus=Z. zizyphus			25
Sarcomphalus laurinus=Z. sarcomphalus			
Z reticulata			14
Z. abyssinica	Central Africa	t	5 18
Z. abyssinica=Z. mucronata			4
Z. acuminata	Mexico, Costa Rica	s	8
Z. agrestis	Indochina		14 18
Z. albens=Z. oenoplia			21 27
Z. amphibia=Z. mauritiana			32
Z. angolito	Columbia	t	9 17 18
Z. angustifolius	Sarawak	t	22
Z. apetala	India	s	16 23
Z. attoensis	Indochina		18
Z. attopensis			16
Z. brunonia	Burma	s	21
Z. brunoniana	India	s	23
Z. burraea=Z. rugosa			21
Z. calophylla	Malaya, Indochina	cl	5 18
Z. cambodiana	Indochina		18
Z. caracatta	E. Indies		27
Z. celtidifolia=Z. oenoplia			21
Z. chloroxylon	Jamaica	t	1 9
Z. cyclocardia	Venezuela	s, t	9
Z. djamensis	New Guinea	t	3
Z. endlichii	Mexico	t	5
Z. endlichii=Z. sonorensis			8 14
Z. ferruginea=Z. oenoplia			21
Z. flexuosa	Nepal	s, t	9
Z. fungii			16
Z. funiculosa	Malaysia, Burma, India	s	18 21 23
Z. glabra	Andamans, Burma, India	s, cl	10 21 23
Z. glabra=Z. rugosa			21
Z. glabrata=Z. trinervia			13
Z. grewioides	Sarawak		22
Z. guatemalensis	Guatemala		9

Z. helvola	Southern Africa		18
Z. hoaensis	Vietnam		18
Z. horrida	India	s	23
Z. horsfieldii	Nicobars, Malaya	s	23
Z. incurva	India, Nepal, Burma	t, s	15 16 19 23
Z. joazeiro	Brazil	t	5 14 18 20
Z. jujuba	India, Malaysia, China, Japan	s, t	5 7 13 23
Z. jujuba=Z. zizyphus			25
Z. kunstlerii	Sarawak	cl	11
Z.latifolia=Z. rugosa			21
Z.laui			16
Z. longifolia	India	s	27
Z. lotus	North Africa, S. Europe	t	5 14 15 19
Z. lycioides=Condalia lycioides			5 8 14
Z. mairei			16
Z. mauritiana	Mauritius, Africa, Asia, Australia	s, t	1 5 6 14
Z. mexicana	Mexico	t	5 8
Z. microphylla=Z. nummularia			5 27
Z. mistol	Andes - Argentina, Bolivia...	s, t	5 14 15 18
Z. montana			16
Z. mucronata	Southern, Central Africa	t	4 5 14 15
Z. napeca	Ceylon		14 27
Z. napeca=Z. oenoplia			21
Z. nummularia	India, Iran, Arabia	s	5 7 13 23
Z. obliqua=Z. rugosa			21
Z. obtusifolia=Condalia obtusifolia	Mexico, Texas		8 14
Z.oenoplia	Australia, Malaysia, India	t, s cl	6 7 10 13 23
Z. orthacantha=Z. mauritiana			32
Z. oxyphylla	Himalayas		14 23
Z. paliurus=Paliuris spina-christi			15
Z. pallens=Z. oenoplia			21
Z. paniculata=Z. rugosa			21
Z. parryi=Condalia parryi			8
Z. pedunculata	Mexico	s	8
Z. pubescens	Southern, Eastern Africa	s, t	4 18
Z. pubinervis			16
Z. quadrilocularis	Australia	t	6
Z. rhodoxylon	Haiti, Domenica	t	9
Z. rivularis	Southern Africa	s, t	4 29
Z. rotundala=Z. mauritiana			32
Z. rotundifolia=Z. nummularia			5 12 14

Z. rufula=Z. oenoplia			21
Z. rugosa	India, Nepal, Burma	s, t	7 13 14 20
Z. sarcomphalus	Jamaica	s, t	1
Z. sativa	India, Baluchistan	s	12 13 14
Z. sativa=Z. jujuba			15
Z. sativa=Z. zizyphus			25
Z. scandens=Z. oenoplia			21
Z. seleri=Z. sonorensis			8
Z. sinensis	China, Japan	t	20 27
Z. sonorensis	Mexico	s, t	5 8
Z. sororia=Z. jujuba			21 27
Z. sp. A	Sarawak		11
Z. spina-christi	North Africa, Arabia	t, s	5 14 19
Z. spinosus			16
Z. talanai	Philippines		24
Z. tomentosa=Z. rugosa			21
Z. trinervia	India, Philippines	t, s	13 23 26
Z. trinervius=Z. jujuba			21
Z. vulgaris=Z. sativa			12 19 23
Z. vulgaris=Z. zizyphus			25
Z. wynadensis=Z. jujuba			28
Z. xiangchengensis	China		16
Z. xylocarpus	India	s, t	5
Z. xylopyrus	India	s, t	7 14 23
Z. zeyheriana	Southern Africa		18
Z. zizyphus	Asia, Africa		25
Z. zonulata	Philippines		26

It is quite likely that all *Ziziphus* species will allow some degree of hybridization, of graft compatibility, of inter-pollination potential between themselves. This means that a variety with good fruit but poor drought resistance from Burma may be grafted on a rootstock from the southern African deserts to introduce this capability. It means that a deciduous species with good fruit but poor yields from a cold part of China may be grafted on or crossed with an evergreen, working year-round species from Sri Lanka to harvest more light and convert it into available fruit. It means that a variety imported from a humid area, showing poor pollination because it is missing its normal insect pollination vector, may be crossed with a pollen abundant desert relative to restore its performance.

Somewhere within the Gene Pool, the factors already exist, ready for exploitation, to create better fruit, better yields, better and more medicinals, better and more nutritious fodder, wider and more tolerant cultural abilities. It's only a matter of locating and using them.

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DATES: THE AUSTRALIAN INDUSTRY AND THE FUTURE

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Introduction

The date palm has perhaps been grown longer as a domesticated fruit than any other in the world.

The date palm, *Phoenix dactylifera*, belongs to the family Arecaceae. It is in the same genus as ornamental palms such as *Phoenix canariensis*, the Canary Island palm and *Phoenix sylvestris*, the Sugar palm. One of the main distinguishing features of the date palm is that it produces offshoots.

Botanical description

Date palms may live for over 80 years, although the commercial life of the palm may be much less, depending upon many factors including climate, soils, quantity and quality of water etc. They may also attain great heights, up to 20 metres.

It was not until the late 1800's and early 1900's that date research and development began with the introduction of seeds and later offshoots into the United States from the old world, including Algeria and Egypt. The commercial development of the date however did not occur until a satisfactory method of handling imported offshoots had been developed.

Major date producing countries

Dates are produced by a number of countries centred on Africa and Asia. The date is still a staple food item in many of these countries. The quality of the product however varies considerably. Many of the major producers such as Egypt, Iran, Iraq, China and Pakistan produce high volumes of low quality fruit. Countries such as the USA, Israel and Tunisia produce a high percentage of high quality fruit which is in demand on export markets.

Brief history of date growing in Australia

Date palms have been grown in Australia since late last century. Palms were originally established in a number of areas which were considered suitable for date production.

Northern Territory

The first planting of a significant number of palms was at the Hermannsburg Mission, 130 km west of Alice Springs. These palms were established from seeds which were sent to the mission by Baron von Mueller. Many of these palms are still growing although they are in a neglected condition. The quality of the fruit produced is inferior to the named commercial selections and a high percentage of the palms are males. The palms have never been managed to produce commercial quantities of fruit.

The CSIRO planted palms at the Research Station in Katherine in 1952-53. These palms were grown from seeds which had been imported. Few survived transplanting and many remained in the nursery and were not planted out.

South Australia

In the 1890's plantings were made at Hergott Springs (now Marree) and Lake Harry, approximately 30 km north of Hergott Springs. These palms were both seedlings and offshoots. Some offshoots originated from India. In 1894 Deglet Noor offshoots were presented as a gift from the French Government. These plantings were cropped successfully for more than twenty years. During the peak of development 279 palms were planted at Hergott Springs and 3,300 at Lake Harry. The plantings became unthrifty due to a large percentage of palms being culled because of poor quality fruit, or the high percentage of males. Decreasing bore flows, increasing salinity and dry seasons also contributed to the planting's demise.

Some of these palms were transplanted to the Cobdogla - Lake Bonney Irrigation Channel (Barmera) and to the Berri Experimental Farm. Most were removed in 1958.

New South Wales

The remaining palms from the Lake Harry planting were reestablished at Pera Bore Experimental Farm and at Wollongbar. Neither plantings have survived for various reasons.

Seedling palms were planted at Lake Curlew in NSW in 1936 and some palms actually cropped despite a lack of management.

Queensland

Seedling palms were planted at Biloela in 1937. The seeds originated from the USA and were of known parentage. They were then transplanted to Rayford Park near Miles. The palms did not produce commercial quantities of fruit at this location due to summer rainfall and no further plantings were made.

Western Australia

Plantings of seedling date palms have been made at the Gascoyne Research Station since 1940. Ten named varieties of offshoots were obtained from California in 1952.

Commercial date plantings in Australia

Date palms are ideally suited to the climate in Central Australia. Many date palms were planted in the town of Alice Springs and at various Station homesteads and waterholes throughout the arid part of the continent.

El Mima (now Mecca Date Gardens)

The first commercial date planting was established at Alice Springs in 1952 by Mr and Mrs V J De Fontenay. The palms were selected from seedlings which were growing in the town area. Twenty female palms were pollinated and fruit quality assessed. Fifteen of these palms were eventually selected and eight were transplanted to El Mima (now Mecca Date Gardens). The age of these palms conservatively ranged from 15 to 60 years. Offshoots from all palms are growing at the Date Gardens to this day.

Fig. 1. Date palms at Gascoyne Research Station, Carnarvon, WA

Between 1953-55 offshoots of named varieties were given as a gift to De Fontenay by a grower in California. These were established successfully at El Mima.

A Deglet Noor palm transplanted to the Cobdogla - Lake Bonney area from Lake Harry was also located. Permission was obtained to remove the six offshoots from the parent palm and these were successfully established at El Mima. These were later removed and destroyed when found to be infested with Parlatoria Scale.

Another two date plantations have also been established in the Alice Springs area.

Arid Gold Farms

Located at Deep Well, approximately 80 km south of Alice Springs. Approximately 2,000 palms are established here and consist of seedlings, offshoots from seedlings, offshoots of named varieties from California and tissue cultured palms. The oldest palms, which are seedlings, are 8 years old and the youngest offshoots and tissue cultured palms are 4 years of age.

Limestone Bore

Located approximately 60 km south of Alice Springs in the same area as the Arid Gold Farm. This area has only recently been developed as a date plantation. An initial planting of approximately 150 palms of named varieties, either offshoots or tissue cultured, has been made. Further plantings are planned in the near future using tissue cultured palms which are being weaned and grown in pots at the present time.

Western Queensland

Commercial plantings of dates have been established in the Cunnamulla - Eulo area of Queensland. Approximately 5,000-6,000 palms are planted in the area. They are all seedling selections or offshoots from seedling selections. Plantations range in size from 300 to 1,100 palms.

Many palms are 6 to 8 years of age and cropping for the first or second year this season. Apart from being marketed as fresh dates, the fruit is also value added by being used to produce Date Chews, Date Wine and Date Spread.

Carnarvon

A small planting of palms has been established at Gascoyne Junction, west of Carnarvon. The palms were obtained as offshoots from California and are all named commercial varieties. They were planted out in 1990.

Agronomic requirements Soils

Dates will grow on a range of soil types. The desirable attributes of a suitable soil are a loam or sandy loam texture with good moisture holding capacity yet free draining, with a pH around 7. The salt content should be low. Although palms will grow in salty and sodic soil, plant growth and yields are reduced significantly.

Climate

A long hot growing season and the absence of rain during the fruit maturation period is essential for commercial date production.

Irrigation

Like all other commercial horticultural plantings in the Centre, date palms will not survive and produce commercial quantities of fruit without frequent irrigations. Bores are used to supply irrigation requirements. Water quality varies considerably from 1,000 mg/l T.D.S. up to 2,500 mg/l T.D.S. Plant growth and yields do not suffer with efficient application of poorer quality water.

Drip irrigation is the most common system used to irrigate palms in Central Australia. Water can be supplied efficiently using this system and at a reasonable cost. Annual water requirements for a hectare of palms grown in the Alice Springs region range from 2.5 megalitres in year 2, to 27 megalitres for mature palms at year 12.

Nutrition

Palms grown in Central Australia do not appear to have any extraordinary requirements compared to those of other perennial crops. A preplant application of complete fertiliser is advisable. As all palm plantings are under micro irrigation, fertigation is the most efficient means of applying nutrients. The exact nutritional requirements of date palms growing in Central Australia has not been properly defined. The Department of Primary Industry and Fisheries is conducting a comprehensive soil and plant analysis program to determine crop requirements.

Pollination

The date palm is dioecious, having separate male and female plants. Natural pollination will result in poor yields therefore the female flowers must be hand pollinated. The male flowers are cut from the palm as they emerge from the spathe which protects them up to maturity. The flowers are then dried and the pollen removed by shaking and sieving the loose flower parts from the pollen.

The spathe is cut from the female flower as it begins to open. The flower is thinned by removing the flowers at the tip of the bunch. The pollen is then blown onto the female flower parts using an applicator. The flower strands are tied together after pollinating, with sufficient twine to allow for expansion as the fruit begins to grow.

Pests and diseases

Parlatoria Scale is the major insect pest of dates in Central Australia and many other parts of Australia and overseas countries. The scale originates from the Middle Eastern countries where dates are grown and is thought to have been introduced into Australia on offshoot material in the early 1900's.

The insect infests the leaves, leaf stalks and fruit. It can increase in numbers rapidly and although in most instances it does not kill the plant it does cause it to become unthrifty, yield is affected and fruit quality is downgraded.

It is recognised by the industry and the Department of Primary Industry and Fisheries that if the date industry is to reach its full potential and have a viable future, Parlatoria Scale must be eradicated from the commercial date growing areas of the Territory.

An eradication program is in place which involves foliar applications of a range of insecticides and trunk injection of insecticides on date palms at the Arid Zone Research Institute and in commercial plantings.

The incidence of diseases which affect date palms in Central Australia's hot, dry climate is negligible.

Flowering

Low temperatures at pollination may reduce set. A temperature around 32°C is considered ideal for pollination.

Fruit maturation

A long, hot growing season is necessary to maximise fruit growth, quality and maturity. Varieties such as Deglet Noor are late maturing and require a long growing season to mature quality fruit.

A method of determining the suitability of an area for date growing based on temperature is to add degrees C above 18° for each daily maximum temperature, for the 6 months from mid September to mid March (flowering to fruit maturity). It is considered that 2,000 units is the minimum for date growing and then only the early maturing varieties may be suitable. Alice Springs has 2,843 heat units which is marginally adequate for maturing Deglet Noor. Figure 2 illustrates areas of Australia suitable for date production based on heat units.

Summer rainfall

The incidence of rain during the fruit maturation period can have a deleterious effect on fruit quality. Checking, blacknose and splitting are problems associated with rain damage.

Secondary infections by moulds and fungi and insect damage may also result.

Some varieties are more tolerant to rain than others. In addition to this early maturing varieties are more suited to areas with a high incidence of summer rainfall. Research work is being conducted at the present time at the Arid Zone Research Institute using various bunch covers and materials to protect fruit and reduce the incidence of rain damage.

Propagation

There are three main methods of propagating date palms:

Seedlings

The majority of early date plantings were established from seed, some using seed of known parentage. There are a number of disadvantages in using seedlings including:

• Seedlings do not produce fruit true to type to that of the parent palm. In most instances fruit quality and yields are inferior to that of named varieties.

• As date palms usually do not flower until they are at least 5 years of age it is not possible to determine what sex the palm may be until flowering. As there is a 50% chance that the palm may be a male the planting of seedlings may result in a high number of male palms which are of no commercial value.

• As date production in Australia increases and consumer preference for high quality dates increases it may become more difficult to market seedling dates which are inferior in quality to named varieties.

Offshoots

Offshoots grow from auxiliary buds towards the base of the trunk of the palm, although some aerial offshoots may be produced. Offshoots have the same characteristics as the parent palm from growth and fruit quality aspects.

Palms produce offshoots for approximately the first 12 years. When the offshoots reach 20-25 cm in diameter and have formed an adequate root system, they can be removed from the parent palm. They are usually established in containers before being planted out.

Due to the shortage of named commercial varieties being grown in Australia, the availability of planting material of these varieties is also limited. At the present time those growers with named varieties of palms are using the offshoots produced to expand their own plantings. The availability of planting material of named commercial varieties, sourced within Australia, is virtually nonexistent at the present time.

Offshoot material from overseas, particularly California, has been imported in previous years in an effort to overcome the shortage of planting material. The stringent quarantine measures which must be applied to this material including fumigation with Methyl Bromide has caused the death of many plants and raised serious doubts as to the economic viability of this practice.

Because of the involved procedures associated with the importation of named varieties of date offshoots they are valued at around $250 per offshoot.

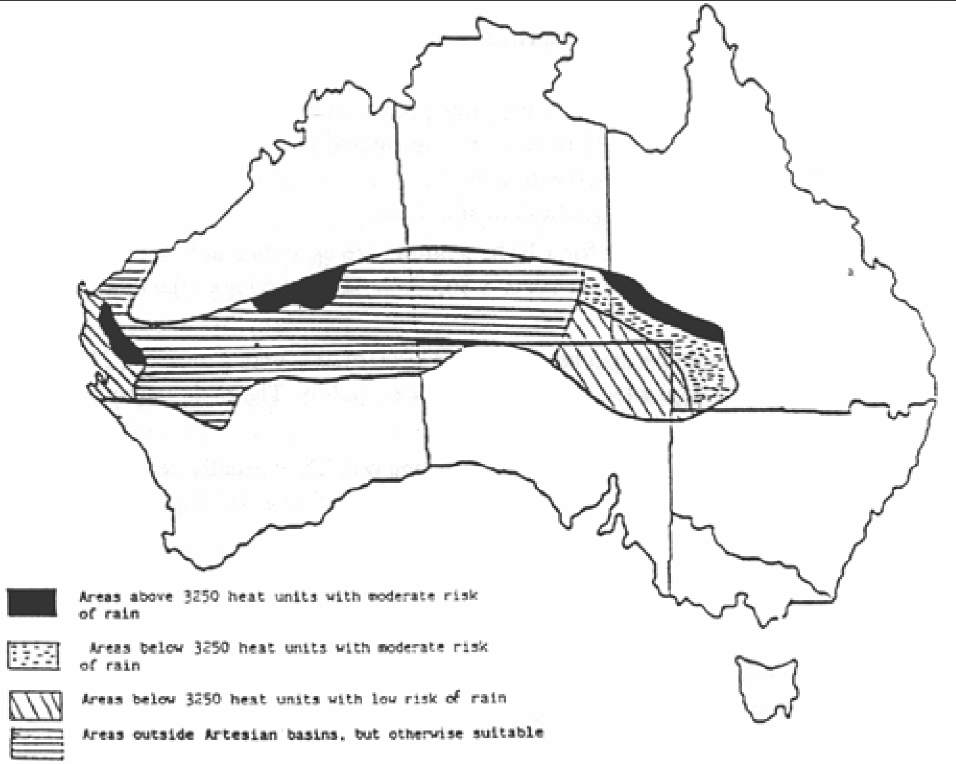

Fig. 2. Ecologically favourable areas in Australia for date cultivation

Tissue culture

The import of tissue cultured plants in vitro appears to be a viable alternative to the import of offshoots. A number of laboratories in the northern hemisphere have a wide selection of commercial varieties of palms available. The quarantine regulations pertaining to the entry of this material into Australia are not as severe as with offshoot material.

The tissue cultured palms are imported in a sterile medium and must then be weaned into pots and grown on before reaching a suitable size and being planted out. Losses can be expected during the weaning process, however they are not high if a nursery with the necessary expertise handles the job.

The question as to whether tissue cultured palms are identical in plant growth and bearing characteristics as the parent palm has been raised. The Department of Primary Industry and Fisheries has established a trial planting of a range of tissue cultured palm varieties from England and France with offshoot material from California to compare growth and yield characteristics. Results to date indicate that tissue cultured palms compare favourably in all respects.

Total costs associated with the purchasing, importation and weaning of tissue cultured palms are around $200 up until they are ready to plant out.

Labour requirements

Date production is highly labour intensive. Virtually all of the operations in the plantation involve manual labour.

Dethorning of leaves to gain access to the palm, pruning old leaves, collecting male pollen, separating the pollen from the dried flowers, preparing and pollinating the female flowers, thinning, applying bunch covers, harvesting, packaging fruit and applying sprays for Parlatoria Scale control all require a substantial labour input.

At peak production fixed costs for a 10 ha planting are estimated at $94,225 per annum. The cost of permanent labour plus on-costs is $63,250. This is 67% of the total cost.

Yields

Palms are usually planted at spacings of 9 metres x 9 metres with a total of 123 palms per hectare. One male palm is planted for every 30 female palms. The male palms are usually grown together in one area of the planting.

Palms begin to bear fruit 5 to 7 years after planting out. They usually peak in production at year 12. Average yields range from 5 kg at year 6 (615 kg/ha) to 100 kg for a mature palm (12,300 kg/ha), from year 11 onwards.

Varieties

The number of named commercial varieties of dates is extensive. The varieties being grown in the Alice Springs region at the present time are based on the Californian industry assessments.

Fruit size, time of maturity, eating qualities at various stages of maturity and rain tolerance are criteria for selecting varieties which may perform well in Central Australia.

Varieties being grown commercially at the present time include:

Medjool A soft date with excellent eating qualities. Matures early and has some rain tolerance.

Barhee A soft date which is dark brown in colour when mature. Matures early to mid season and has excellent eating qualities at all stages of maturity.

Deglet Noor An excellent variety which matures late. The fruit has excellent eating qualities and is soft and dark in colour. Fruit is subject to humidity and rain damage.

Halawy An excellent variety which matures early and is rain tolerant.

Khadrawy A soft date with good eating qualities.

Thoory A dry date which matures late and is rain tolerant.

Zahidi A semi-dry date which grows well in most areas.

Male palms are also selected for various quality characteristics. Time of flowering and the number of flowers carried are criteria for selecting male palms. Named male varieties include Fard No 4.

The Department of Primary Industry and Fisheries has established a planting of a range of varieties which are being grown commercially overseas. Further varieties will be added in the near future. These varieties will be assessed for their performance under Central Australian growing conditions and market potential.

Fruit quality characteristics

Dates are graded according to the stage of maturity and moisture content.
Stages of maturity include:
Khalal hard ripe - change colour from green to yellow, red etc.
Rutab partially to fully soft, ripe.
Tamar cured fruit.
In addition dates are graded according to moisture content:
Fresh dates have greater than 50% moisture. Soft dates greater than 30% moisture.
Dried dates have less than 30% moisture.

The economics of date production

A recent economic analysis of date production in Central Australia indicated that a price of at least $3.20/kg was required in order to break even at the end of a commercial date project. Obviously for commercial production of dates to be financially attractive returns higher than this are necessary.

Table 1. Date Imports to Australia -1992

	Dried Dates			*Fresh Dates*		
Country	*Quantity* kg	*Value* $A	*Unit Value* $A	*Quantity* kg	*Value* $A	*Unit Value* $A
China				33 000	53 392	1.61
Iran				125 735	295 503	2.35
Israel				15 990	110 188	6.89
Lebanon	600	956	1.59			
Mexico	17 635	98 322	5.57	5 001	28 709	5.74
Pakistan	876 801	1 021 122	1.16	711 369	602 924	0.84
Singapore	225	429	1.68			
Thailand	90	276	3.06			
USA	181 554	901 886	4.96	266 123	1762839	6.62
TOTAL	**1 076 935**	**2 022 911**	**1.88**	**1 157 218**	**2 853 555**	**2.46**

As manufacturing grade dates, which includes much of the production from seedling palms will return less than $3.20/kg the production of high quality dates must be the priority for commercial date plantings in Australia.

Over 1,100 tonnes of fresh dates valued at more than $2,853,554 were imported into Australia in 1992. The price per kilogram for these dates ranged from between $0.84/kg and $6.89/kg. During the same period 2,673 tonnes of dried dates were imported with the price per kilogram ranging from $1.16/kg and $5.57/kg. Tables 1-6 detail date imports into Australia from 1990 to 1992 with country of origin.

Table 2. Date Imports to Australia -1991

Country	Dried Dates Quantity kg	Dried Dates Value $A	Dried Dates Unit Value $A	Fresh Dates Quantity kg	Fresh Dates Value $A	Fresh Dates Unit Value $A
China	614 027	868 962	1.41	58 423	74 527	1.27
Egypt	4 980	7 533	1.51			
Greece	10 341	30 563	2.95	15 990	110 188	6.89
Hong Kong	63 768	93 609	1.46			
Iran	827 008	1 092 725	1.32	114 300	179 035	1.56
Israel	71 500	63 333	3.62	16 000	102 615	6.41
Malaysia	3	4	1.33			
Mexico	8 505	53 310	6.27			
Pakistan	884 565	915 000	1.03	768 040	709 211	0.90
USA	170 913	821 293	4.80	197 467	1 381 151	5.76
TOTAL	**2 601 610**	**3 946 352**	**1.51**	**1 172 232**	**2 203 538**	**1.87**

**Source - Australian Bureau of Statistics

Table 3. Date Imports to Australia, 1990

Country	Dried Dates Quantity kg	Dried Dates Value $A	Dried Dates Unit Value $A	Fresh Dates Quantity kg	Fresh Dates Value $A	Fresh Dates Unit Value $A
China	683 146	884 777	1.29	230 675	254 053	1.10
Egypt	4	33	8.25			
Iraq	98 425	99 541	1.01	29 625	51 271	1.73
Hong Kong	6 565	18 766	2.85	600	2 224	3.70
Iran	666 454	886 373	1.32	307 381	393 541	1.28
Israel	70	310	4.42	21 000	66 411	3.16
Malaysia	10	1	0.10			
Japan	1 380	4 269	3.09			
Pakistan	406 288	423 277	1.04	620 244	633 376	1.02
USA	218 268	913 079	4.18	197 467	1 138 151	5.76
Lebanon	80	214	2.87			
Singapore	240	1 006	4.19	307 381	393 541	1.28
Spain	3 920	244 289	6.19	612	2 997	4.89
U K	18 962	34 542	1.82			
TOTAL	**2 103 812**	**3 290 477**	**1.56**	**1 368 112**	**2 272 826**	**1.66**

Market opportunities for Australian dates Domestic markets

The demand for high quality dates in Australia is not high at the present time. There are a number of reasons for this including the fact that consumers are not aware of the excellent eating qualities of this type of fruit. In many instances Australians have only experienced dates which are of an inferior quality such as processing grade fruit in cakes etc.

In order to ensure that quality dates remain a high priced commodity and demand increases, an effective domestic marketing campaign will have to be launched aimed at increasing awareness amongst consumers of the excellent eating and nutritional qualities of dates.

Superior quality dates, both from named varieties and seedlings will replace imports of lower grade processing fruit.

Export markets

Export markets for high quality fresh dates must be developed in conjunction with domestic markets. The demand for dates on overseas markets is high during the March-April period. Singapore imports dates for the Hari Raya (Malay New Year).

Demand in the USA during April is high due to the Jewish Passover and Easter. Australia may have a competitive advantage during this period. Middle Eastern countries are also potential markets for Australian dates. Fruit in the khalal stage meets good demand and commands high prices in many of these countries. Fruit at this stage of maturity has limited storage and shelf life. Demand at this time coincides with the Australian harvest.

Table 4. Fresh date imports to Australia 1989 - 92

	Quantity kg	Value $A	Unit Value $A
1989	828 157	2 170 724	2.62
1990	1 368 112	2 272 826	1.66
1991	1 172 232	2 203 538	1.87
1992	1 157 218	2 853 554	2.46
Total	**3 293 719**	**9 500 642**	**2.88**

** Source - Australia Bureau of Statistics

Table 5. Dried date imports to Australia 1989 - 92

	Quantity kg	Value $A	Unit Value $A
1989	2 396 475	3 413 190	1.42
1990	2 103 812	3 290 477	1.56
1991	2 691 610	3 946 352	1.51
1992	1 076 935	2 022 911	1.88
Total	**8 178 823**	**12 673 010**	**1.55**

** Source - Australia Bureau of Statistics

Table 6. Date imports to Australia 1989 - 92

	Quantity kg	Value $A	Unit Value $A
1989	3 224 632	5 583 914	1.73
1990	3 471 924	5 563 303	1.60
1991	3 773 842	6 149 890	1.63
1992	2 234 153	4 876 545	2.18
Total	**12 704 551**	**22 173 652**	**1.75**

** Source - Australia Bureau of Statistics

Table 7. Date exports from Australia: 1982 - 87

	1982	1983/84	1984/85	1985/86	1986/87
Quantity (tonnes)	0.82	1.64	0.00	0.01	0.00

Australia has exported small quantities of dates in the past. These exports have been on an opportunistic basis. Table 7 details Australian date exports from 1982-87.

Summary

Dates are grown in many parts of the world and are an important food crop in many old world countries.

Dates were first introduced into Australia in the late 1800s. They were not grown commercially until the mid 1900s.

Date plantings are expanding in the Alice Springs area. There are three commercial plantings of dates at the present time.

Dates are suited to a range of soils and respond well to efficient irrigation practices. They do however have specific requirements regarding the duration and degree of heat encountered during the period the palm is sizing and maturing fruit.

Summer rainfall is detrimental from a fruit quality aspect.

Parlatoria Scale is a major impediment to the date industry reaching its full potential in the Northern Territory. A program is in progress to eradicate this pest.

Planting material can be obtained from seed, offshoots and by tissue culture. Seedlings have a number of problems. Offshoots and tissue cultured palms of named varieties are the only recommended means of establishing a commercial planting.

Planting material of named commercial varieties is very scarce within Australia at the present time.

Commercial date production is highly labour intensive.

Date palms begin bearing fruit at around 5 years of age and reach full production at around 11 years of age.

Dates are harvested at various stages of maturity and moisture content depending upon the market requirements.

Large quantities of dried and fresh dates are imported into Australia each year. Australia must target the production of high quality dates and develop sustained export markets in conjunction with an expanded domestic market.

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THE BRAZILNUT

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1. Introduction

The Brazilnut is one of the most valued plants of the Amazonian flora. It produces nuts with highly nutritious kernels, containing an almost complete source of proteins - hence its popular name of 'vegetable meat', with two kernels having the protein equivalent of a hen's egg.

The nuts are one of the major export items of the northern region of Brazil, and contribute significantly to national trade. The trees present an important cultivation option for the Amazon region, whether as a specific crop or as part of an agroforestry system.

2. Climate and Soil

The trees grow in humid regions falling in the Köppen Classification groups Ami and Awi, in other words, those with definite periods of dryness. These two classifications are characterized by mean temperatures of 24.3 and 27.2°C, average annual rainfalls of 1400 and 2800 mm, relative humidities of 66 and 91 %, and dry periods of 2 and 6 months each year.

Trees typically grow on land not subject to flooding, on clay and sandy-clay soils, with most occurrences on medium and heavy-textured soils.

3. Cultivars

Although at present no improved cultivars of Brazilnut have been released, CPATU is currently involved in the selection of high-productivity plants, and after cloning and field testing, this material will be available to those interested.

4. Productive Life

The Brazilnut Tree grows to a great height, averaging 40 metres, and trees centuries old are known which are still in full production.

5. Propagation Methods

Vegetative propagation of Brazilnut by grafting is similar to that of any perennial species.

Propagation by direct seeding in the field is not recommended because of seed germination difficulties and the possibility of damage by rodents and ants.

For successful introduction of Brazilnut into cultivation, two requirements are fundamental. These are, effective breaking of seed dormancy, and vegetative propagation by grafting.

5.1. Breaking Seed Dormancy

A number of matters must be observed for success:

a) Seed selection. Choose seeds with large kernels for preference, as these give higher germination percentages than small ones, and are also easier to handle.

Seeds should be fresh, not dried-out, and preferably large, round, and plump, with a white kernel and no smell of oil. To test this, take a sample from the seed lot and cut it across to check these points.

b) Seed holding. Prior to selection, seed should be kept in the shade and under humid conditions. Seeds exposed to the sun for two days show reduced germination levels.

When sowing is to be carried out all year, seeds are held in a shady place, still in the original 'pods' in which they are produced, and wetted periodically, to prolong germination viability.

c) Water immersion. Before selection, seeds are soaked in water for three days, to condition the shells for easier removal. Shell removal can be done in a press, a vice, or with pliers, or even with just a sharp knife, taking care not to damage the kernel. In so doing, the principal seed dormancy, that of the shell restricting expansion of the seed embryo, is removed.

The water used for soaking should be changed daily, to avoid fermentation occurring.

d) Seed shelling. This is the operation of removing the shell, to allow expansion of the root radicle and the shoot (caulicle). It involves the following stages.

- Cracking. This is a tricky operation, needing some practice for success. The seed is subjected to light pressure from the piston of a press (Fig. 1), always on the principal edge, keeping the back of the seed supported on the lower jaw of the press. The action should be only enough to crack the seed, so that shell can be removed with the pliers.

- Use of pliers. The specially-adapted pliers (Fig. 2) are then used on the seed, with the upper jaw inserted in the crack in the shell. A little pressure with the fingers on the pliers, with the seed being pressed against the opposite jaw of the pliers, will cause the shell to crack. The operation is repeated until the kernel is free of the shell.

- Kernel treatment. After removing the shells, the kernels should be immersed in 0.3% Benomil fungicide (3 gm per litre of water) for 90 minutes. The solution should be stirred every 10 minutes so that the active material does not sink to the bottom. The kernels are then dried in the shade on sheets of newspaper for two hours, making sure that the humidity is kept high, so that germination is not affected.

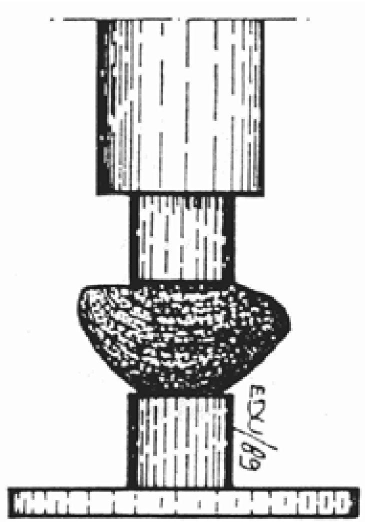
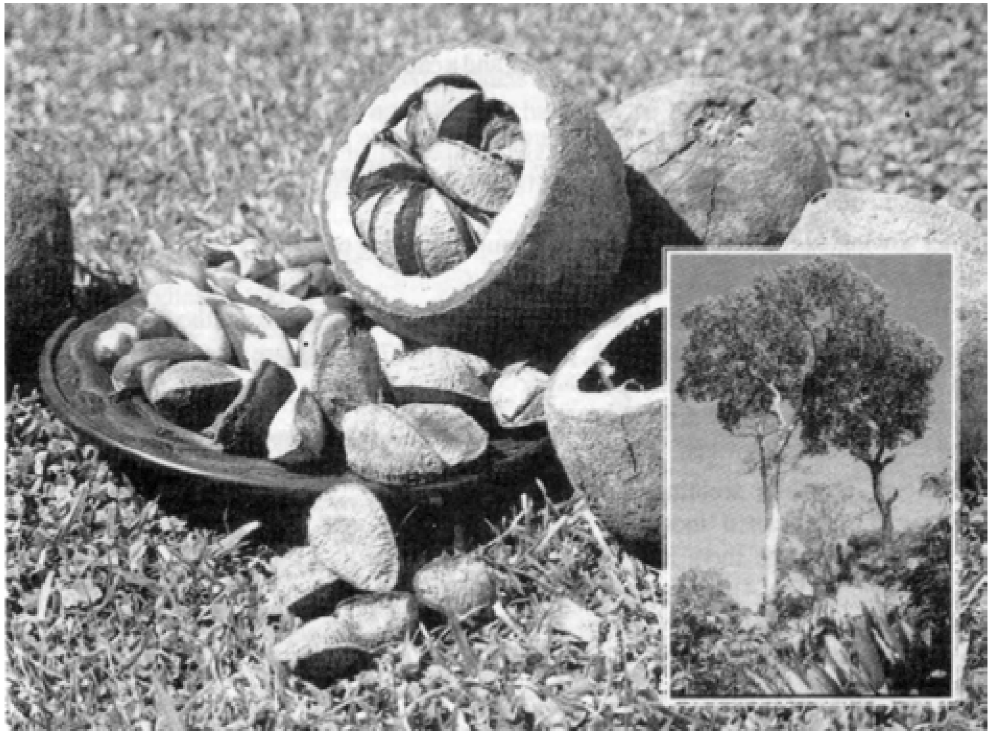


Fig. 1. Cracking the seed in a press

- Kernel selection. A second selection stage is recommended before sowing, to eliminate


Brazilnuts: kernels, nuts, pods, and trees (photo: 'Awake!')

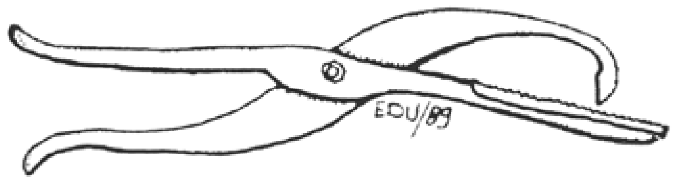
kernels which may have been damaged in the cracking - these will not germinate. This may be done before or after the fungicide treatment.

e) Seedbed and Substrate. The seedbed should be of the raised type, to protect against attack by rodents and ants. Preparation of the seedbed is a critical point in the germination process, as fungal attack on the kernels depends directly on the humidity of the substrate.

The recommended substrate is a mixture of equal parts of fine sawdust and white sand. This should be watered once every two days. The use of fresh organic material should be avoided, as this could cause fermentation and fungal damage to the kernels.

The seedbed should be covered to avoid excess humidity through rainfall. If open seedbeds are used, a substrate of sawdust only should be used, and the germination process begun at the start of the least rainy season.

Fig. 2. Special pliers for removing the shell from brazilnuts.



f) Sowing. In this, an aspect of great importance is that a brazilnut has two different ends, a radicle pole (PR) from which the root emerges, and a caulicle pole (PC) from which the shoot comes - this is the pointy end.

The seed kernel must be sown as in Figure 3, with radicle pole (blunt end) at the bottom, and the caulicle pole at the top, 1 cm below the surface. Seeds can be sown at a density of 1000 per square metre of substrate.

After sowing, strict control of humidity through watering only every two days is vital to avoid the seeds rotting.

g) Pricking Out. This is the operation of moving the plantlets from the seedbed, into previously-prepared plastic bags. Black, perforated bags 17 x 28 cm are recommended, filled with a 1: 1 mixture of fine sawdust and loamy soil. If sandy soil is used, this can be used alone, without sawdust.

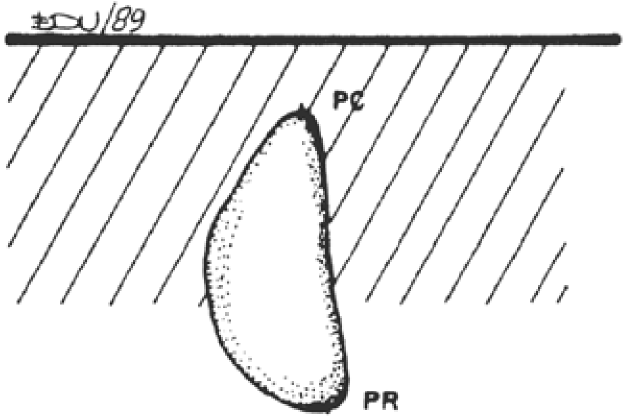


Fig. 3. Depth and position of seed when sown in the seedbed.

Whenever possible, seedlings are pricked out at the so-called 'toothpick' stage, usually when the shoot has become 1-6 cm long (Fig. 4). Only those plantlets which have a radicle as well as a shoot are pricked out, those lacking a radicle must be transplanted into a second seedbed similar to the first, where they are left until their second set of leaves appears - this is an indicator that they now possess a radicle, and can be transferred into plastic bags.

. This practice avoids having plants of very different heights in the same block, since plantlets without radicles can take months before they attain normal growth, which happens only when their radicle appears.

As an alternative, it is also possible to use previously-perforated 300 ml plastic cups to hold the seedlings. However, these would need to be transplanted into their allotted site at a smaller size than those from plastic bags.

- *Pricking-out caution*. The seedbed should be watered before pricking-out seedlings, to ease their extraction, which needs to be done carefully to avoid breaking the new root system or damaging the new shoot.

Occasionally plants to be transferred to plastic bags will be found to have exceptionally long roots. These should be trimmed to about 8-10 cm, rather than curling them in the bag, which is more harmful to future growth than the pruning.

h) Growing On. After pricking out into plastic bags, the seedlings are arranged in solid blocks, with ten bags across and the rest stacked along behind them. Usually 80 bags take up one square metre of space. Various stages are passed through before the seedlings are ready for planting out in the field.

- *Shadehouse*. The newly-bagged plantlets are grown on under medium shade. About a month before planting out, they are gradually hardened off by exposing them to more sun.

- *Weeding*. Weeds appearing in the plant bags are carefully removed by hand. However, by the third month after bagging, because of shading by the new brazilnut plants, few new weeds appear.

- *Watering*. Irrigation is applied periodically, taking care not to flood the plants, which would be damaging to their roots.

i) Planting Out. Brazilnut seedlings are ready for planting when they reach 20-40 cm in height, at which stage they have about 16 leaves. The time needed to reach this stage is between four and eight months, depending on their growing-on treatment. With plants in plastic cups, their maximum height will be 30 cm.

Fig. 4. Brazilnut plantlet with shoot just appeared (a), with first leaves open (c), and complete with second set of leaves (d).

5.2. Budding

Budding is the method used to ensure the replication of plants with desirable characteristics, such as productivity, large fruit size, precocity in fruiting, and low tree form. For preference, scion wood from trees selected for high productivity should be used. Whenever possible, budwood should be selected from immediately below the previous-year inflorescences of material of known productivity.

Brazilnut budding is similar to that of rubber, *Hevea brasiliensis*, however it should be done in the field, on trees planted 18 months to 2 years previously.

The first thing to test is that the bark 'slips', that is, it comes away freely from the underlying wood. The plants are then ready for budding when they are showing new leaves; this indicates that the cambium cells are turgid, so that the bark will separate well.

The scionwood to be used should be of roughly the same diameter as the stock, and leaves should be removed from the scionwood eight days before use. This makes it easier to cut the shield (the piece of bark with bud attached) and promotes growth of the bud.

On the day of budding, the budstick is cut from the parent plant and taken to the budding site, care being taken not to expose it to the sun for any length of time. The bud is then inserted into the stock, about 1 metre above the ground, care being taken to match the upper part of the budshield with a horizontal cut in the stock, so that cambial cells of the stock and scion are in direct contact. The better the contact, the greater will be the 'take' of the buds. A take of 90% is considered good.

- Budding aftercare. Buds are checked for a satisfactory take 30 days after budding. If successful, the stock is ringed 1 cm above the top of the inserted budshield for a width of 3 cm. The stock is not cut off above the bud, as is often done, but only cinctured to break the apical dominance and promote shooting of the inserted bud and gradual decay of the part of the stock above the budding point.

Two types of growth can occur from the bud, giving either vertical growth (orthotropic) or lateral growth (plagiotropic). Shoots which come away laterally need to be tied up against the stock so that they give an upright tree. Buds which shoot from the stock should be carefully removed so that they do not compete with the bud insert.

6. Site Preparation

As the brazilnut is essentially a wild species, attention should be paid to preparation of the planting site to give best conditions for planting .and growth. The site may need felling, clearing, burning, and levelling, or may consist of previously-cropped areas where most of the stumps are already broken down. Intercropping with other species can be considered, to reduce maintenance costs.

7. Tree Spacing and Density

Different approaches can be taken to tree spacing in brazilnut, depending on the overall aim, which may be for nut production alone, or in conjunction with pasture, or even intercropping with other perennial species.

a) Monoculture. The minimum spacing recommended for brazilnut monoculture is 10 m, which corresponds to 115 trees/ha if planted in a staggered (triangular) pattern, or 100 trees/ ha if planted on the square.

b) Trees plus pasture. Spacings recommended for an agroforestry planting with pasture are 10 x 20 m or 15 x 25 m, corresponding to 50 and 26 trees/ha respectively. The purpose of the larger spacing, mainly between the rows, is to allow more light through to the pasture.

c) Intercropping with other perennials. Recommended spacings are 10 x 25 m or 15 x 25 m, corresponding to 46 or 25 trees/ha. This approach is suitable with plants which can grow in partial shade, such as cocoa, guarana, or black pepper.

8. Planting

Seedlings are ready for field planting when 20-40 cm high and showing 16 leaves. They should be planted in holes 40 x 40 x 40 cm, in a mixture of topsoil with 10 litres of matured farmyard manure or compost and 100 gm of triple superphosphate. The best time to plant is in the rainy season, when the plants will establish better.

Suitably-sized plants are placed in the centre of the holes, their containers carefully removed, and the holes filled in with topsoil from the area, pressing this down well. If a dry spell occurs after planting, the area around each plant should be mulched with dry grass; this will keep the soil moist and cool.

9. Culture

Even though brazilnut is a native tree, it still needs care and cultural treatment for good development. Some of the most important matters are as follows.

a) Weed removal. Weeds around the plant can be kept down manually, by hoeing, or by mower, with care not to damage the trunk, or by using herbicide. This should be done every three or four months.

b) Mowing. The rest of the area, principally the spaces between the rows of trees, needs only mowing or clearing at the same time as the weeding.

c) Pruning. There are two phases to this.

- *Trunk formation*. This is applied to plants more than two years old. The lower branches are gradually removed until the trunk is clear to a height of 2 m.

- *Crown formation*. This is done only when the grafted tree is showing little growth. The main trunk is retained with three lateral branches at the top. These are cut back by four or five leaves, to stimulate growth of the laterals.

d) Fertilizer. As well as the fertilizer applied at planting, further applications of 200 and 300 gm of triple superphosphate are applied in the second and third years after planting.

e) Pests and Diseases. There are few recommendations in place, other than periodic checking for problems. The only pest noted is the sauba ant, which is controlled with special baits. No significant disease problems have been noted.

10. Flowering and Fruiting

Flowering in brazilnut is intimately tied in with climatic conditions for each region. In the western Amazon (Acre State), flowering starts before that in the east (Para).

At flowering time, fruiting twigs develop below the inflorescences of the previous year. First leaves develop on these, then flower buds appear at the ends of the twigs.

From the start of fruit initiation to maturity and fall of the seed pod takes about 14 months. Even during flowering and development of the new fruit, the trees will bear ripening and mature pods.

Seedling brazilnuts may start fruiting from their eighth year on, if planted in open, unshaded conditions. Budded plants have been known to fruit after only three and a half years, however the usual time to production is reckoned as six years after budding.

11. Yields

Budded plants have come into production at CPATU at 3.5 to 6 years after budding, with some 8-year old trees yielding 25 litres of nuts each. This result is quite promising when compared with the yields of wild trees, which give 16 to 55 litres/ha in trees more than 50 years old.

Projected yields for budded trees are 300 litres/ha for 6-year old trees, and 700-800 litres/ha for trees budded 8 years previously. Yields are expected to level out at around 5000 litres/ha.

12. Collection and Processing

In the Amazon region, brazilnut collection and processing usually takes place between November and April, depending on the local conditions. Ripe fallen seed pods are collected for later extraction of the nuts. Often the pods are opened at the actual tree sites, and the nuts transported to sheds and collection points for sale and processing.

There are two stages in preparing nuts for sale. The first is a partial drying, where nuts are sorted and dried to 10% moisture content. In the second, the nuts are shelled and dried in ovens till the kernels reach a moisture content of 2-3%.

13. Integrated Culture

At present a number of agroforestry or integrated culture methods have been recommended, including use of brazilnut trees in conjunction with pasture (amazon quicuio grass), with cocoa, black pepper, guarana, etc.

When trees are grown with perennial or semi -perennial crops, it is important to use wide spacings between the rows of brazilnut trees, to avoid competition between the different crops for nutrients and excessive loss of available light.

14. Summary

The brazilnut tree is a native species with good prospects for use in reafforestation, since it yields high-quality timber used widely in civil and marine construction, and also in diverse rural activities; it is one of the major species of the region.

The pods, after the nuts are extracted, are used as fuel, mostly for curing rubber, and in the making of wooden articles. The nut kernels are an important food, referred to as 'vegetable meat' because of the quality and quantity of the amino acids they contain.

The kernels are also the source of the extract 'brazilnut milk', used in making various confections, and the source of an oil used in fine soaps and cosmetics. The residue after the extraction of the oil yields a protein-rich flour which can be mixed with wheat flour to make bread, cakes, etc, and also used in stockfeed.

Based on the publication *Castanha-do-Brasil: Recomendações Basicas 11*, of CPATU, the Centre for Agricultural Research in the Humid Tropics, Belém, Brazil.

Translation from Portuguese: David Noël.

LYCHEE: ITS ORIGIN, DISTRIBUTION AND PRODUCTION AROUND THE WORLD

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Introduction

The lychee or litchi (*Litchi chinensis* Sonn.) which belongs to the Sapindaceae or soapberry family originated in southern China and possibly in northern Vietnam and the Malay Peninsula. Lychee trees grow wild in abundance on Hainan Island near northern Vietnam, mainly at an elevation of 600 to 800 m, and below 500 m in hilly areas in Leizhou Peninsula, in the west of Guangdong and the east of Guangxi. The natural distribution of wild lychee is from south of Shiwan Mountains, Liu Wan Mountains, Yunkai Mountains to Hainan Island. Wild lychees are a major species in several lowland rainforest areas of Hainan Island and may account for 50% of the virgin forest composition.

The first official recording of lychee in China appeared in the 2nd century BC, while unofficial records date back to 1766 BC. A 'Lychee Register' indicated that there were 16 cultivars in Guangdong by 1034 and 30 in Fujian by 1059. These figures had climbed to 100 by 1076 in Guangdong and a similar number, somewhat later in Fujian. There is mention of cultivars in scientific literature before this time (3rd, 4th and 9th century), but morphological description were not provided until the 11th century and the first detailed description did not appear until 1612. The Chinese lychee growers could distinguish the best types for cultivation on the plains, hills or levee banks by the 2nd century BC, but there is no indication of how, when or why they selected certain selections. Certainly, better cultivars could not be disseminated before clonal propagation became available (air layering in the 4th century and grafting in the 14th century). Propagation by seed, however, continued for sometime, but was eventually eliminated by the 16th century.

Some cultivars in China have a very long history of cultivation, while others are relatively new. It is reported that cultivars such as Sum Yee Hong, Haak Yip, Kwai May, No Mai Chee, Wai Chee and Seong Sue Wai have a history of 500 to 600 years or more, while others such as Bah Lup, Heong Lai and Tim Naan date back 200 to 300 years ago. Souey Tung is a relatively young cultivar (about 100 years old).

The lychee was introduced to the tropical and subtropical world from the end of the 17th century and now is found situated within 15-35° latitude in most countries. Large commercial industries have developed in Taiwan, Thailand, India, Vietnam, Madagascar and South Africa. There is substantial interest in the crop in Australia, Mauritius, Reunion, Spain, Bangladesh, Indonesia, Mexico and The United States. Total world production is about 0.5

million metric tons (mMT), similar to that of the related longan (*Dimocarpus longan*) and rambutan and pulasan (*Nephelium lappaceum* and *N. mutabile*), but well below other tropical tree fruit such as citrus (73 mMT), banana (71 mMT), mango (15.7 mMT), papaya (4.4 mMT) and avocado (1.5 mMT). There are collections of lychee cultivars in several of the lychee-growing areas of the world. The major collections are in China, Taiwan, Thailand, Australia and U.S.A. (Florida and Hawaii).

China

Lychee trees are distributed in seven provinces in southern China of which Guangdong and Fujian are the main producing areas following by Guangxi, Sichuan and Yunnan. Guangdong produces about 65% of the crop. There are over 80 counties growing lychees in Guangdong, but lychee production is centred, in and around Guangzhou. The lychee ranks second after citrus as the most important fruit crop in Guangdong. In Fujian, citrus and longan are more important. The area under lychee is about 300000 ha, which is more than the total area under horticulture in Australia. Yields of 10 t/ha are possible in well-managed orchards in Guangdong. Average yields are about 2 t/ha. Yields are lower in Fujian, where lychee is considered a poorer proposition.

There are more than 100 lychee cultivars in China probably because of the long history of cultivation and propagation of the crop by seed. The most important cultivars in Guangdong and Fujian are Sum Yee Hong, Tai So, Chen Zi (Brewster), Souey Tung, Haak Yip, Fay Zee Siu, Kwai May, Wai Chee and No Mai Chee. Wai Chee accounts for over 50% of plantings in Guangdong and bears consistently because it flowers late and avoids the low temperatures of early spring. In Fujian, Haak Yip and Souey Tung dominate plantings. Other cultivars grown commercially include: Bah Lup (pinyin: Bai La), Jin Feng, Chong Yun Hong (Zhuang Yuan Hong), Heong Lai (Xin Xing Xiang Li), Tim Naan (Tian Yan), Kwa Lok (Zheng Cheng Gua Lu), Seong Sue Wai (Shang Shu Huai) and Soot Wai Zee (Xue Huai Zi).

In general, No Mai Chee and Kwai May are very highly regarded for excellent eating quality and a high proportion of chicken tongue (or aborted seed) fruit. Fay Zee Siu is also popular because of its excellent eating and its large size (24-32 g) fruit. Some cultivars are best eaten fresh, others are more suitable for canning or drying. Cultivars for export include Sum Yee Hong, Fay Zee Siu, Haak Yip, Kwai May, Wai Chee and No Mai Chee.

Taiwan

Lychee air-layers, mainly Haak Yip and Chong Yun Hong (pinyin: Zhuang Yuan Hong) were introduced into the northern part of Taiwan from mainland China in 1760 and again in 1860. However, commercial production did not begin until the late 1920s when further introductions of the main Chinese cultivars were grown in southern areas away from strong winds of the Pacific Ocean.

Since the 1920s, lychee plants have been distributed to every district in Taiwan except the north where the weather during winter and spring is cold and wet. The major area of cultivation is the central and southern districts of the island, where there are large areas of alluvial sandy loam. Yields are higher on these soils compared to those on the mountain slopes. Temperature and moisture conditions are ideal for satisfactory flowering during winter, and mature trees may carry 500 kg of fruit in a season.

Haak Yip is the most popular cultivar and accounts for over 80% of plantings. Other important cultivars are Sum Yee Hong, Chong Yun Hong, No Mai Chee and more recently Sah Keng.

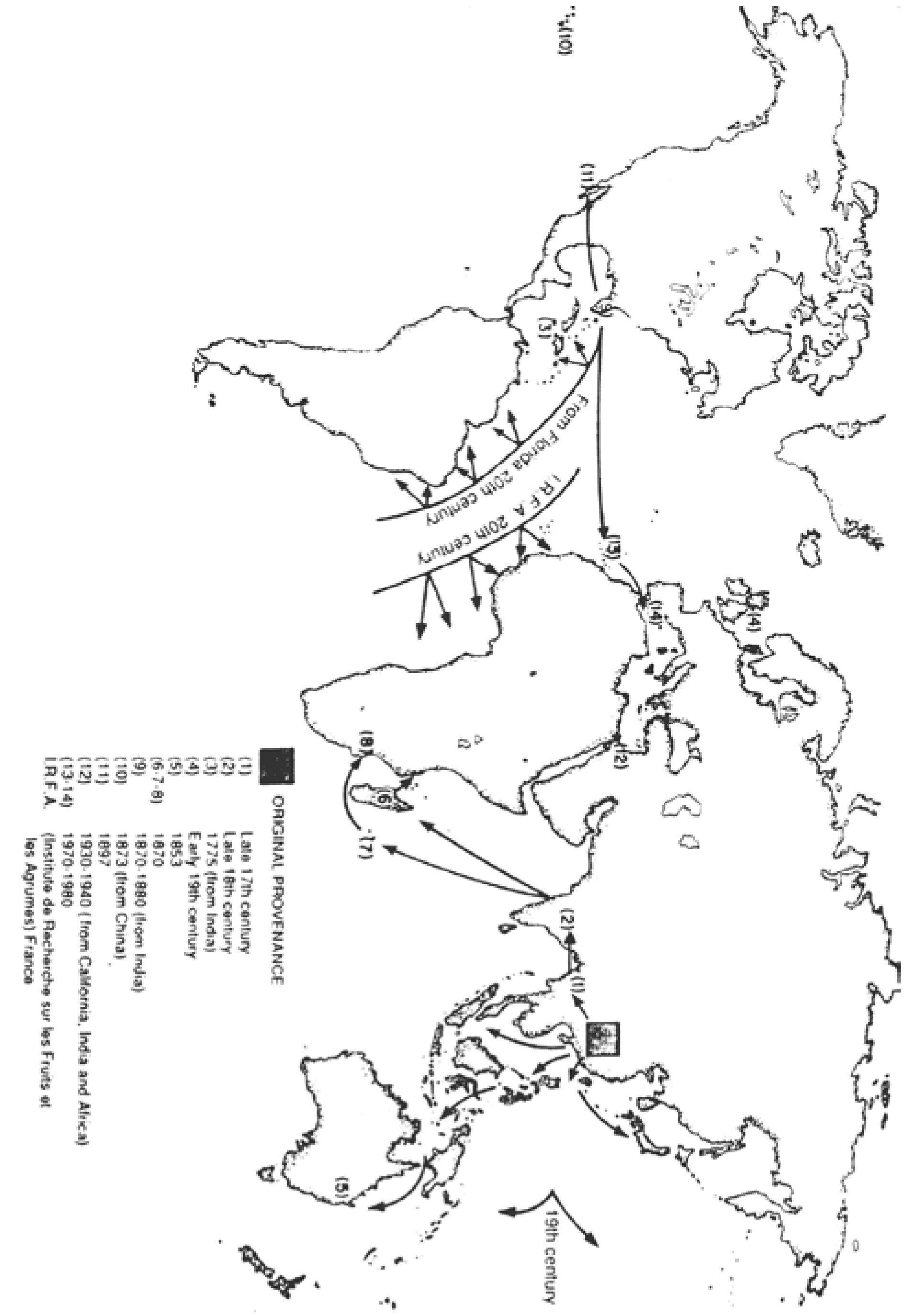

Fig. 1 - SUGGESTED HISTORY OF LITCHI DISSEMINATION WORLDWIDE

(From: V. Calan Saúco & V. G. Menini: Litchi Cultivation. FAO, Rome)

Thailand

Lychee ranks eleven in the list of economic fruit crops in Thailand. The main production centre is in the north at elevations of 300 to 600 m between Chiang Mai, Lamphum and Fang in a monsoonal climate with a distinct dry season. Plantings have also been established in the more tropical humid high rainfall areas north of Bangkok, but flowering is more consistent and yields higher in the cooler elevated areas.

Although the lychee has a long history in Thailand, better cultivars from China were only introduced in the early 1950s. The main cultivars in the Chiang Mai area are Tai So and to a lesser degree Wai Chee, Baidum and Chacapat. A different set of cultivars has been developed for production in the tropical areas, including LukLai, Sampao Kaow, Kaloke Bai Yaow, Kom and Red China. Quality of these seedling selections does not compare favourably to the cultivars grown in northern districts.

Vietnam

Northern Vietnam is part of the original area of distribution of lychee. Current production is about 6000 t from 1500 ha, and is expected to rise to about 40000 t by the year 2000. Production is mainly in the areas radiating from Hanoi in lowland and upland areas up to an elevation of 150 m (Lat. 21°N) where the winters are cool and dry enough to provide reliable flowering. Lychee has a high priority in new tree fruit plantings along with citrus. Increased production will not only increase local consumption, but will also earn much needed foreign exchange. The industry is mainly dependent on one cultivar, Thieu (Vai Thieu) which was introduced from China about 100 to 300 years ago. Several cultivars from Australia have been recently imported, but have not been planted out in commercial orchards as yet.

India

Lychee reached India through Burma about the end of the 17th century, and India now produces nearly as many lychees as China. During the last 200 years, it has spread to several areas. More than 70% of the crop is produced in northern Bihar. Other lychee growing states include West Bengal (15%) and Uttar Pradesh (6%).

Most of the lychee cultivars in India have been developed locally from seedlings from Chinese selections. Although a large number of lychee cultivars are grown, most of them are not widely planted. The same cultivar may be known under several different names in different places. However, few of the Indian cultivars appear to be renamed Chinese cultivars as has happened in Thailand, Hawaii and Australia. Hot and desiccating winds is the main factor limiting lychee cultivation in several districts and cultivars have been selected which can reputedly set and carry fruit under these adverse conditions.

Of the 10 commercial cultivars growing in Bihar, Shahi (Muzaffarpur), Rose-Scented and China are the most popular, due to their large fruit size and excellent quality. Other important cultivars are Deshi, Kasba, Purbi, and Early and Late Bedana. The most popular cultivars in the Punjab are: Saharanpur (Early Large Red), Dehradun,Calcutta (Calcutta, Kalcuttia or Calcutta Late), Shahi, Seedless Late (Late Seedless or Late Bedana) and Rose-Scented.

South Africa

There is evidence that lychee trees were imported into South Africa from Mauritius in the early 1870s. From 1886 onwards, the Durban Botanical gardens distributed air-layers of those introductions within the country, mainly for planting in Natal. Commercial orchards are currently spread on the eastern boundary of South Africa from Levubu and Tzaneen in the north ern Transvaal, the central and southern Lowveld near Hazyview, Nelspruit, Malelane and Barberton down to the North and South Coast of Natal near Durban and Port Shepstone. About half the crop is exported to Europe, and the export market is in direct competition with fruit from Madagascar.

The Lychee (from B E Dahlgren: Tropical & Subtropical Fruits)

The commercial lychee industry in South Africa is mainly dependent on a single cultivar, HLH. Mauritius (80% of plantings), so named because practically all the trees throughout the country are clonal propagules from an original tree imported from Mauritius by H.L. Hood. This cultivar resembles the Chinese cultivar Tai So, and any differences in tree or fruit characteristics are very minor and not agronomically significantly; it may be a seedling or sport of Tai So. The main disadvantage with Tai So is its large seed. Because the industry is dependent on a single cultivar, the production season is unduly short at any location. However, fruit are normally available from the end of November to mid-February due to differences in environmental conditions in the different lychee growing areas. The only other cultivar grown (20% of plantings) to any extent is Bengal (Madras). Chinese, Indian and Australian cultivars have also been imported into South Africa but their performance and yield have yet to be fully evaluated and none have been released for commercial cultivation.

Israel

Lychee was introduced by Professor C. Oppenheimer to Israel in 1934, although commercial production did not start for another 40 to 50 years. Production is about 500 t from about 200 ha, and is nearly all exported to Europe. Lychee orchards are now being established in most areas of Israel, except in the Negev and Arava regions. The main cultivars are Mauritius (early maturity) and Floridian (late), but plantings also include Kaimana, Late Seedless, Garnet, Early Large Red and No Mai Chee. After harvest, the lychees are treated with sulphur dioxide for 20 minutes and after a few hours with hydrochloric acid to maintain the red skin colour, although sometimes the treatment taints the fruit.

Madagascar

The Lychee arrived in Madagascar from Mauritius in 1770. Production is estimated to be about 50 000 t and is mainly confined to the moist eastern seaboard. About 5 000 to 10 000 t are exported to Europe, mostly by ship. Trees grow in a haphazard fashion, with most plantings less than 1 ha. Many of the commercial orchards are 20 to 30 years old. Mauritius (or Tai So) is the most important cultivar. Fruit are usually sulphured by burning sulphur in old shipping containers, although sulphur dioxide fumigation is also being trialled. Fruit generally have a better appearance than those sent from South Africa.

Mauritius

Lychee planting material was first introduced from the Orient in 1764 and production in 1985 was about 1000 t. The Mauritius Lychee was selected from a seedling on the island in the 1870s. Practically all the trees in Mauritius, Malagasy Republic and South Africa are clonal propagules from this tree.

Reunion

The Lychee arrived in Reunion over 200 years ago from Mauritius. Annual production is about 5000 t, of which about 10% is exported to France. The main cultivar is Tai So (Mauritius).

Australia

The Lychee was introduced into Australia by Chinese migrants over 100 years ago. They originally came to work the goldfields in northern Queensland and ate fruit and threw the seeds away. They did not go directly into agriculture or plant crops. Isolated trees of 80 to 100 years are found in these areas. Lychee plants (seedlings?) were growing in the Sydney Botanic Gardens in 1854 and in Brisbane by the late 1850s. Air-layers (Wai Chee) were not introduced until the 1930s. Plant material was subsequently distributed further along the coast and production extends from Cairns and The Atherton Tableland in northern Queensland to Coffs Harbour in northern New South Wales. Tai So and Bengal are the main cultivars. This is because they were the only planting material readily available during the expansion of the industry in the early to mid 1970s. These cultivars have now lost favour and current expansion is mainly based on cultivars such as Kwai May Pink, Salathiel and Wai Chee in cooler areas and Fay Zee Siu in warmer locations.

Hawaii

The first lychee (cv. Tai So) was brought to Hawaii in 1873 and was still growing in 1972. Other introductions were made by the Department of Agriculture and private individuals during the first half of the 20th century. Lychees are grown up to an elevation of about 500 m and occasionally up to 1000 m on the five major islands of Hawaii. Commercial plantings peaked during the late 1960s with about 25,000 trees and production of about 250 t (average yield of 10 kg per tree). About 20% of the crop was exported to the mainland. Production declined during the next decade because of low yields and quarantine restrictions with exported fruit. Since 1980, there has been renewed interest in the crop, mainly due to the availability of better cultivars and improvements in post-harvest technology.

Tai So is the only cultivar grown on a wide scale. Fruit ripen from May to June. Because of the irregular bearing habit and short cropping season of Tai So, other cultivars have been tried, including Brewster, Haak Yip and Sweetcliff (similar to Wai Chee but different to Tim Naan or Sweetcliff from China) which were imported earlier in this century, and Kaimana which is a seedling selection of Haak Yip developed in the 1970s.

Table 1. Major Lychee cultivars around the world

Country	*Production (tonnes)*	*Main growing areas*	*Major cultivars*
China	200000	Guangdong	Wai Chee, Haak Yip, Sum Yee Hong, Kwai May and No Mai Chee
		Fujian	Souey Tung, Haak Yip, Tai So and Brewster
Taiwan	131000	Tai Chung	Haak Yip and Sah Keng
Thailand	10000	Chiang Mai, Lamphun and Fang	Tai So, Wai Chee and Baidum
India	90000	Bihar State	Shahi, Rose Scented and China
Madagascar	50000	eastern coastal belt	Tai So
South Africa	8000	Transvaal·Low-veld Region	Tai So, Bengal (Madras)
Reunion	5000	Wet coastal/sub-coastal areas	Tai So
Mauritius	1000	----------	Tai So
Australia	2000	Eastern coastal strip	Fay Zee Siu, Tai So, Bengal, Wai Chee,
Kwai			May Pink and Salathiel
U.S.A.	500	Hawaii	Tai So and Kaimana

Florida

Southern Florida is well known as the centre of tropical fruit production in the U.S.A. This is the result of an active plant introduction and research program. Florida's commercial lychee plantings reached a peak of about 130 ha in 1957 but declined to less than half these figures in 1966 because of cold damage and urban expansion. Lychee production has been on a steady increase since 1975 when plantings shifted towards the less frost-prone southern areas, but suffered a setback in 1992 with Hurricane Andrew when about a third of the trees were lost. Many factors have contributed to the interests in lychee production including the search for alternative crops to avocado and limes, greater demand for exotics and the opportunity for higher returns.

Brewster has been the main lychee cultivar in Florida since the Reverend W.M. Brewster obtained air-layers of Brewster (or Chen Zi) from Fujian Province in 1903. There are many orchards with mature trees 12 m across. Brewster matures from mid-June to mid-July and has good colour and flavour. Tai So (Mauritius) has become very popular in recent years and is more consistent in bearing compared to Brewster. However, it suffers from wind-damage. There is also the problem of limb breakage after ice-loading. Tai So matures about two weeks before Brewster. Other cultivars under evaluation include Sweetcliff (small fruit and susceptible to micronutrient deficiencies, especially Fe), Bengal (irregular yielding) and Haak Yip. New plantings include Kwai May Pink from Australia.

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CACTUS: SOURCE OF PERHAPS THE PERFECT FRUIT

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Consider cacti. Few other plants can offer so much to gardeners who live in the arid climates so typical of California. Native Americans of the American Southwest and Mexico have for ages known and enjoyed the fruit of at least 14 species from this large and useful family. The Indians of California as well as those of the desert Southwest and Mexico have also used the flowers and stems of some cactus species as food.

The peoples who lived in the desert of the Southwest and California long before Europeans appeared have sustained themselves on the fruits and flesh of cactus since ancient times. Park S Nobel, in his splendid book *Remarkable Agaves and Cacti* cites archaeology that unearthed nine-thousand-year-old mummified human faeces in Mexico that contained fragments of agaves and cacti.

Cactus fruits were eaten fresh or dried, or fermented into wine. Cooked fruits were sometimes boiled, salted and mixed with corn flour. Fruits chosen for wine making are known to have included those of cardon, organ pipe, pitaya agria and saguaro. Fruit-gardening home winemakers in California might wish to experiment for themselves.

The seeds were often removed and eaten separately. Sometimes this occurred after the original fruit had been digested and this practice was known as "the second harvest." Seeds of the prickly pear, or tuna, are still sometimes roasted and ground into meal.

Even the flower petals have been eaten with relish, especially those from the barrel cacti. In fact, again according to Nobel, a "cactus moon was celebrated in early spring when the flower buds of various species of *Opuntia* were cooked or roasted as a special treat."

The flesh of prickly-pear stems, correctly known as cladodes, were, and still are, eaten, sometimes after roasting. Nopales, cactus pads harvested from prickly-pear cactus (*Opuntia ficus-indica*), are an important crop in Mexico. They are also easily available in the United States, particularly in Southern California and throughout the Southwest. They are sold commercially to be braised and eaten as a vegetable, often cooked with onions, peppers, cheese, eggs, spices and even meat, to make fillings for tacos and other dishes.

How to Start

Those with *Opuntia* in their gardens, and who wish to experiment, should start with very tender young cladodes. Choose ones that are thin, dark green and no greater than 12 inches long. The areoles from which the spines and glochids grow are still prominently raised above the otherwise flat surface on a pad this young. (Glochids are basically those 'pesky minute barbed hairs growing out of the prickly-pear cactus pads and fruits, the things that get under your skin and annoy you for days, if you don't take precautions to avoid them. They can also. as I found out to my chagrin, trigger warts in susceptible people.)

Use a sharp knife, moved at a grazing angle to the cladode surface, to scrape off the unwanted bumps while retaining as much of the stem tissue itself as possible. Nobel mentions that a potato peeler can also be used to remove the areoles which, though slower and shows far less flair, requires less skill. Other species of cactus that have historically been eaten for their stems include teddy bear cholla (*Opuntia bigelovii*) and chain-fruit cholla (*Opuntia fulgida*).

Other traditional uses, according to Nobel, include the woody ribs, that the Indians fashioned into poles, as handles for tools, for constructing shelters and as torches. The roots and juices were used in the concoction of remedies for various ills. Juice from saguaro flowers was used as a sealant, and pitch from the stems of organ pipe and pitaya agria was used on boat seams and pottery. Containers were made from barrel cacti, cardon and saguaro. On a somewhat darker note, he cites the use of barrel cactus stems as tables for human sacrifices. Ordinary gardeners, however, are more likely to be attracted to cactus for their sculptural forms, flamboyant flowers and, for those in the know, their delicious fruits. Beekeepers also prize cactus flowers for the splendid honey their nectars can produce.

In California, the only cactus fruit consistently available commercially is the tuna, *Opuntia ficus-indica*, aka prickly pear or Indian fig. The popularity of the prickly-pear cactus in California pretty much echoes sentiments in the entire western hemisphere. In fact, the cultivation of *Opuntia ficus-indica* is worldwide. According to *The Complete Book of Fruits and Vegetables*, by Francesco Bianchini, Francesco Corbetta and Marilena Pistoia, "The Indian fig (*Opuntia ficus-indica* of the cactus family) has been part of the European flora since around the sixteenth century. The Spanish imported it from Mexico to Europe soon after the discovery of America. It is therefore of American origin, and spread rapidly in the temperate and warm regions of Southern Europe and Africa .... [A]round the Mediterranean, the Indian fig has become very much part of the countryside, often making a magnificent display."

According to Popenoe in his classic Manual of Tropical and Subtropical Fruits, "among the aboriginal inhabitants of tropical America, the tuna has long been held in high esteem. Early introduced into Southern California by Franciscan monks, *Opuntia* is found abundantly ... particularly around the old missions .... Now *Opuntia*, particularly *O. ficus-indica*, is cultivated and naturalized throughout the tropics and subtropics."

The ripe fruit of tuna, writes Popenoe, contains 19.66% total solids, 0.40% ash, 0.18% acids, 0.98% protein and 2.79% fibre. Nobel cites cactus fruits as being high in sugars (approx. 70-80% by dry weight). About one-third of the sugar content is fructose, which is better tolerated by diabetics than glucose and sucrose. Cactus fruits are also high in vitamin C and low in fats, although the seeds, often eaten with the fruit itself in many species, prevent these

Spineless cactus pear, a type of Opuntia, is strikingly ornamental as well as good to eat

fruits from being entirely fat-free. The percentage of carbohydrates, almost all assimilable, is around 10%, but this figure is possibly lower than the actual amount to be found in the ripe fruit soon after harvesting. The mineral salts are few, mostly of the same type as found in other fruits.

According to Bianchini, Corbetta and Pistoia, some of the more popular tuna cultivars, at least in Europe, include: "The yellowish Indian fig; the *ficodindia surfarina* of Sicily with very sweet firm pulp; the violet-red Indian or 'bloody' fig of small size; the late *bastarduni* Indian fig, large with sweet pulp and excellent for prolonged storage ... "

In Australia, because of the rampant and once disastrous growth of certain species, including *O. ficus-indica, O. stricta,* and *O. vulgaris*, fruits of the whole genus came to be called "pest pears." After their introduction in 1832, the plants naturalized. Plowing them under only created more of them, because sections could root and grow, and they began to take over new rangeland at the rate of 250 acres an hour! Many futile attempts were made to control and eradicate these plants. It was only after the importation of the moth *Cactoblastis cactorum* that the infestation was brought under control.

Tuna has small but very woody seeds. Although the seeds are innocuous when digested, they are somewhat annoying and can break a tooth of a careless person. Although the glochids are usually brushed off from commercially available tunas, home cactus gardeners learn soon enough to wear gloves when harvesting and to carefully brush away the annoying pricklers before touching them with bare hands.

When ready to eat, peel them by first cutting away a small amount of the top and bottom then making a slit end to end through the rind. Park S Nobel describes many other creative treatments he has seen. In Mexico, for instance, the seeds are often removed by pressing the peeled fruit through a colander. This pulp is then boiled into a thick syrup that can be used as a syrup, or reduced further and sold as a taffy known as *miel de tuna*. The pitted pulp can also be boiled for about 8 hours, reduced, cooled and formed into cakes called *queso de tuna* (literally cactus-pear cheese) sold in a brown, bricklike form. Freshly peeled whole fruits can be hung on a string and, after drying for a couple of weeks, these pulps become coated with a sweet sticky juice that can preserve the dried fruit inside for many months.

Tunas, however, are not the only choice available to Americans, at least not to Californians who can grow alternatives in their mild climate. According to Popenoe, "The fruits of many cacti ... known in tropical America by the name pitaya [also phonetically spelled a variety of other ways] are commonly larger than tunas, and by some are considered superior to the latter in quality, but their use is less extensive. The widely cultivated plant which usually passes under the name of *Cereus triangularis* is properly *Hylocereus undatus* [which, according to Popenoe, in his time, at least, was found only in Jamaica]. All of these plants are climbing in habit, and have triangular stems. They produce large, showy, night-blooming flowers, and oblong or oval fruits, bright pink to red in colour, sometimes more than 3 inches in length with large leaf-like scales on the surface." These will grow outdoors in parts of southern California.

The fruit of *Cereus peruviana*, a white-fleshed fruit with a bright pink skin but lacking the leaf-like surface scales is also known as a pitaya. One reason for the lack of commercial success for these fruits may lie in their fragility. They do not have a long shelf-life. Unless refrigerated, their pulp soon deteriorates into an unpleasant mucus-like texture.

Good for California

A fine cactus fruit especially adapted to California is the fruit of the previously mentioned *Cereus peruviana*. These cacti have hexagonal stems, reaching at maturity a height of 15-20 feet. Their dramatic lily-shaped white blossoms open at night through early morning. From these flowers develop sweet, white-fleshed, perfumed fruits that come with an electric pink skin that must be removed. Their seeds, the size and hardness of chia seeds, are sprinkled through the pulp and can easily be eaten. Spectacular specimens of these are found in the desert section at Huntington Gardens. Those who live farther into the desert also enjoy access to the fruits of barrel cacti (*Ferocactus acanthodes, F. covillei* and *F. wislizenii*) and organ pipe (*Stenocereus thurberi*). According to Nobel, other, perhaps less familiar, fruit-bearing cacti include chain-fruit cholla, desert Christmas cactus (*0. leptocaulis*), Englemann prickly pear (*0. phaecantha*), pencil cholla (*0. arbuscula* and *O. versicolor*), and purple prickly pear (*0. violacea*). Other cactus genera producing edible fruits include: fish-hook cactus (*Mammillaria estebanensis* and *M. microcarpa*), golden hedgehog cactus (*Echinocereus engelmannii*), and pitaya agria (*Stenocereus gummosus*). Somewhat distinct are the pitayas from several species of *Lemaireocereus*, notably *L. griseus* and *L. queretarensis*. These are common wild plants in Mexico and elsewhere. *L. griseus* is often cultivated. The fruits are globose, about 2-1/2 inches in diameter and covered with many small clusters of spines. These

are brushed off the red, fully ripe fruit, leaving it in condition to be eaten. The flesh is dark red to purple, sweet and delicious in flavour. The propagation and culture of these plants resembles that of *Opuntia*. The *Hylocereus* group, however, is much better adapted to a moist tropical climate than the tunas. The most important genus of pitaya in Mexico is *Stenocereus*. After harvesting, these fruits are processed into equivalents of the various food products made from the prickly pears (tunas). A *Stenocereus* relative harvested from the wild, *Escontria chiotilla*, is especially valued for marmalade and ice cream. Less popular cactus fruits, such as strawberry cactus (*Echinocereus stramineus*) and various species of barrel cactus and *Mammillaria* are also harvested. Flower buds of barrel cacti are often fried with eggs or boiled with chilies. In Colombia, increasing acreage is being planted to the delicate and delicious *Hylocereus triangularis* (aka *H. megalanthus* and *H. undatus*).

Flower of Cereus peruvianus monstruosus. Photo: Robert Chambers

Cultivation

One reason for cactus's popularity lies in its ease of cultivation. Popenoe quotes J.W. Tourney, writing in Bailey's Standard Encyclopedia of Horticulture, who points out: "It has been ascertained that some of the best varieties are capable of producing on lean, sandy or rocky soil ill-suited for growing ordinary crops, as much as 18,000 pounds of fruit to the acre. When it is considered that this is equal to 2,500 pounds of sugar, as well as other valuable food constituents, it may be seen that the food value from the standpoint of nutrition is considerable." In other words, an excellent food crop for marginal land in a warm, dry climate.

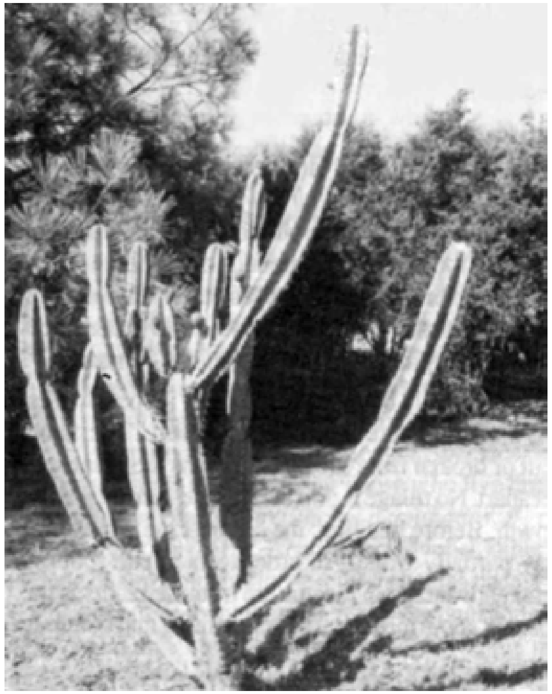
Tourney describes commercial plantations as usually being planted on dry slopes of hills, because the plants do not thrive where there is much moisture or on heavy clay soils. The plants are propagated vegetatively, using joints, cut or broken from the plants. These are planted at distances of 6-8 feet in furrows from 615 feet apart. No tillage is practised as they grow rapidly, and in a few years smother out all other growth. Before planting, the cuttings are exposed in half sunlight from 7-15 days, that they may partially wither, in order to facilitate rooting. Tourney goes on to explain that "An important advantage in the culture of these plants is the regularity of the yearly crop. They begin to bear in about three years after planting and continue bearing for many years."

The roots grow at shallow depths in porous sandy soils because they have been adapted to respond to the light rainfalls that occur in arid regions and do not wet the soil very deeply. Wetting of the soil by rainfall induces the growth of new roots. In the wild, nitrogen is often the soil element most limiting for growth. Fertilization with nitrate-containing inorganic fertilizer or manure almost always enhances the growth of cultivated cacti. A field of *Opuntia* *ficus-indica* raised for nopalitos near Mexico City is fertilized annually with a 9-inch layer of cow manure. Nobel points out that whether applications of phosphorus and potassium increase the growth of cacti depends on the element levels already in the soil. Sufficient boron for growing cacti is present in the form of borate in the soils of the southwestern United States.

Most cacti do not tolerate soil salinity well. This means that gardeners or professional growers using drip irrigation must take care to prevent salts from accumulating in the root zone. Nobel suggests that since cacti graft easily, one solution is to use a rootstock that can tolerate salinity such as *Opuntia quimilo*, a species from Argentina. *Cereus validus* is another Argentine cactus adapted to regions that have salt flats during the dry season. Apparently, its feeder roots succumb to the salinity and drop off during drought. After next season's rain dilutes the sodium, new main roots grow, which in turn are shed during the next dry season. Much more work needs to be done to determine how successful such grafting can be, especially on a commercial level.

Sicilian Revenge

Nobel describes a really outstanding cultivation trick - removing the flowers in early summer to create larger, better fruit later on. Apparently, this technique was discovered in Sicily as the result of someone's desire for revenge. One popular legend has it that a Sicilian farmer, enraged by the advances of another farmer toward his daughter, knocked all the flowers off his neighbour's prickly-pear plants. The other legends all basically follow the same theme, with variations in casting and setting.



Cereus dayami in garden of CRFG co-founder Paul Thomson. Photo: Robert Chambers

Whatever the true origins of this technique, Sicilian farmers know that removing the first flowers causes the cactus to flower again. Although fewer blooms are produced during the second blossoming, these develop into larger, sweeter fruits that ripen in late autumn. This practice is called scozzolatura, which means "to take the buds away." Labourers go through out Sicilian fields of cultivated *Opuntia ficus-indica* with ladders and sticks, deliberately destroying the first fruit crop.

Again according to Nobel, in Sicily, in commercial "groves," each cactus is planted at intervals of 13-15 feet in rows that are 16-23 feet apart. Taking into account the practice of scozzolatura, about 8-10 fruits mature per terminal cladode. In return for that slight effort, a superior crop of fruit is produced.

Cacti, these plants that offer so much to fruit and ornamental gardeners alike, appear, at least in modem times, to be vastly under utilized. As water resources become stretched to satisfy ever greater demands - for instance when other states and Mexico began demanding an ever larger share of the Colorado River water-professional growers and gardeners alike, feeling the pinch of scarcity and higher prices, might start looking with renewed interest at this versatile family of plants.

(Based on an article in the CRFG magazine Fruit Gardener, Vol. 27, No.2, March/April 1995)

Cactus: A Friend in a Fire

If I lived in one of the canyons or in any other fire prone area, I would plant cacti around my house ... lots and lots of big, fat, juicy cacti. Here's why.

A while back, early on a Saturday morning, I was awakened by a loud cracking noise. Imagine my surprise to see instead of the noisy, inconsiderate boob I suspected - my neighbour's garage fully engulfed in a huge fire. I called 911.

By the time the firefighters got there, not too much later, the fire had spread in all directions. After burning down the structure, it blackened my neighbour's yard to the south. It leaped over the back alley and started consuming another neighbour's cedar-stake back fence. It licked across the five foot span between my garage and his, caught mine, and burned it down, too. But...

When the fire reached the venerable Cereus peruviana growing about 8 feet south of my neighbour's late garage, it singed and browned about half that tall, fleshy, water-filled plant, petered out and didn't travel further.

Another neighbour had planted an orange tree that reached over his cedar-board fence, shedding shade, and sometimes oranges, into the back alley. The first five feet of fencing burned so badly he had to replace it. The tree, blackened by the flames, never recovered and had to be removed.

A few feet north of the citrus, he had planted a banana. Under and around it, the fire had burned the fence black, and the banana brown. It eventually came back from its corm in the ground. The blistered and blackened stretch of fence had to be replaced.

More or less in the middle of his back fence, a huge *Opuntia* cascaded over and down, decorating our shared alley with its flowers and fruit. The edges of that cactus closest to the flames ended up browned, but the rest survived, apparently unscathed. More important, the wood directly below and to the north of that cactus remained untouched. The fire never got past the cactus. .

Large cactus plants, I saw, can really make a difference. Which is why, if I lived in Malibu, I'd surround my house with a hedge of the largest cacti I could find.

- Alice Ramirez

NUT PINES

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Introduction

Many species of pines bear edible pine nuts, although the ones you'll find in the shops are nearly always from the Stone Pine, *Pinus pinea*. Some edible pine seeds are very small, fiddly to shell and not really worth troubling with - this article concentrates on the species with large seeds (18 major species).

Propagation

Pine seeds require varying amounts of cold treatment (stratification) before they are sown. Seeds should be sown in a well-drained compost, preferably in deep cells or pots, covered with 1 cm of compost and kept at about 19°C. Very high temperatures can inhibit germination. When germination occurs, a long tap root will grow before the shoot even emerges; if seedlings are to be transplanted out of a seed tray, then care must be taken not to damage the roots.

Beware of rodent damage to seeds - keep pots/trays off the ground. Because of the high risks of rodent damage, it is not recommended to sow seeds outside in beds unless you are sure that rodent control is adequate. Other pests which will eat seeds if they can get to them include squirrels, birds and (in N.America) chipmunks. [In Australia, parrots are a major predator].

Cells or pots with seedlings in should have a thin layer of pine needles or soil added from beneath an established pine tree, to allow for mycorrhizal infection around the seedling roots. These symbiotic fungi are essential for plants to grow and remain healthy. Without such fungal infection, seedlings will simply stop growing after a couple of years and die. The fungi which act symbiotically with Korean pine include *Pisolithus tinctorius* and *Cenococcum graniformae*, while the Siberian pine needs *Amanita muscaria* (Fly agaric).

Seedlings do not need shading except in very hot and sunny locations. If seedlings are planted outside in nursery rows, mulch them in the autumn to avoid problems of frost heave, which can be very damaging.

Harvesting and yields

Most pines flower in June and cones ripen the following year (i.e. 2nd year) or the year after that (3rd year). In some species, cones naturally open and drop their seeds (eg. *P. edulis*. *P. koraiensis*. *P. pinea*); in others, cones fall from the tree intact with the seeds (eg. *P. albicaulis*. *P. cembra*). With the latter kind, cones can simply be gathered from the ground

§ Member, WANATCA

if predation isn't too bad. With the former, seeds can be collected on sheets beneath trees (shaking trees if necessary) or cones must be harvested from trees before they open. There is usually a period of about a month between cones ripening and opening, and in this period cones should be cut or knocked off the tree with a long pole hook and collected - take care not to damage the tree as rough harvesting can significantly reduce the tree's productivity. Some pines are adapted to release their seeds after a forest fire and these (eg. *P. gerardiana*. *P. sabiniana*) may need to have their cones heated to open.

Once the cones are collected, they can either be air dried immediately - 2 to 4 weeks of dry warm weather are required for cones to open - or they can be stored in a cool airy shed over the winter until the following summer, when they can be air dried. Beware of rodent, squirrel and bird predation on cones - they are all very fond of pine nuts.

Yields are hard to quantify for most species because of lack of any data. Most species do not start to produce cones until they are 20-25 years old (the main reason that few people can be tempted to plant nut pines), although *P. pinea* starts production at about 10 years of age and *P. armandii* at about 12 years. Yields for *P. pinea* in Italy are 5-15 kg per tree per year - with 100 trees per hectare this gives yields of 500-1500 kg per hectare.

Uses of pine nuts

Pine nuts can be used in many ways. The species with nuts high in carbohydrates (starch) like *P. monophylla* and *P. quadrifolia* are best eaten cooked; the others can be eaten raw or cooked. They make good snacks and add valuable protein to salads. To cook, they are usually roasted but they can be included in dishes, confections etc. The low carbohydrate species make an excellent nut butter simply by mashing up the nuts. All species can have nuts ground into a flour (in the same way chestnuts can) and be used in recipes, breads etc. A high quality oil can be pressed from the nuts and used in salads or for cooking; the cake residue is a good livestock feed. Another use which is popular in Siberia is to steep nuts in vodka to make a stimulating tonic!

Recommended nut pines for Britain

The following are all known to grow well in Britain and bear cones: *P. albicaulis, P. armandii, P. ayacahuite* (and var.*veitchii*) (prefers E), *P. cembra* (prefers N & W), *P. cembroides* (prefers SE), *P. flexilis* (prefers E), *P. jeffreyi, P. pinea* (prefers S, W & maritime areas), *P. sibirica* (prefers N & W). In addition, *P. gerardiana* (in S), *P. koraiensis* (in N & W), *P. sabiniana* (in S) and *P. torreyana* (in S) all have good potential. *P. coulteri* doesn't bear cones very often, neither are the other pinyon pines likely to, although they will do best in the SE.

Pinus albicaulis

White bark pine

A tree, usually small and reaching 10 m but occasionally to double that, and shrubby at low altitudes. Bark of young trees is smooth, white and peeling; branches spreading. Needles are in 5's, persisting 4-8 years, about 5 cm long, stiff but flexible, dark green. Cones are borne singly at the end of branches; they are oval, 4-7 cm long by 4-6 cm wide, dull purple at first but ripening brown, with short thick scales. The cones do not open when ripe, but instead fall intact from the tree; they must be broken up to release the seeds. Seeds are wingless. Native to western north America from California to British Columbia. Hardy to zone 3 (-35°C).

Pinus armandii

Chinese white pine, Armand's pine, David's pine

A large tree, reaching 20 m high, with widely spreading, horizontal, branches. Bark is thin, greyish green. Needles in 5's, persisting for 2-3 years, thin and limp, yellowish-green to bright green. Cones are borne in groups of 1-3 on stalks, 10-20 cm long by 4-6 cm wide, erect but becoming pendulous, cylindrical, green at first ripening yellowish-brown, with thick woody seed scales; they ripen in their second year. Seeds are reddish-brown, wingless. Native to the mountains of western and central China, especially in wooded ravines. Hardy to zone 5 (- 23°C).

Grows well in Britain. Seeds are regularly collected and sold in markets in its native region, and regarded as a delicacy. Flowering begins quite early, around 12 years of age.

Pinus ayacahuite

Mexican white pine

A large tree reaching 30 m high and 1 m in diameter, with a spreading head of branches. Bark is light grey, smooth on young trees becoming rough and scaly later. Needles in 5's, persisting for 3 years, are thin and limp, glaucous green. Cones are borne singly or in clusters of 2-3 on stalks at the end of branches; they are cylindrical, curved, 25-45 cm long by 6-14 cm wide at the base. Cones gape open when ripe, releasing seeds which are brown with dark stripes and wings 25 mm long. Flowering begins at an early age. Native to Mexico, hardy to zone 7 (-15°C).

Two naturally occurring varieties, var. *brachyptera* and var. *veitchii*, have larger seeds than the type (both about 12 mm long).

Pinus cembra

Swiss stone pine, Arolla pine, Russian cedar

Usually a small or medium sized tree, growing 10-20 m high; occasionally more. It has a wide, picturesque often broken crown in the mountains but in cultivation usually narrowly conical with branches down to the ground. Bark is grey-green and smooth at first, becoming grey-brown and fissured with age. Needles in 5's, in dense brush-like clusters, persisting 3- 5 years, stiff and straight, dark green. Cones are borne on short stalks at the end of branches, 6-8 cm long by 5 cm wide, egg shaped, violet becoming brown when ripe. Cones do not open, but fall from the tree with their seeds in the spring of their 3rd year. Seeds are reddish-brown, unwinged. Native to the European Alps, hardy to zone 4 (-25°C).

The Arolla pine is slow growing to begin with and long lived. Fruiting is regular by the age of 25-30 years (though some authorities say not until 60-80 years). Seeds are not freed until the cone disintegrates, thus the cones must be mechanically broken up. Does well in open areas, on North slopes on light, well-drained soils. Susceptible to honey fungus.

Table 1. Seed Data for Nut Pines

Species	Seed length mm	Seed width mm	Seed shape	Seeds /Kg	Germ'n % (av)	Recommended stratification
Pinus albicaulis	8-12	8		8,000	55%	4 wks
Pinus armandii	10-12		oval	c.8,000		13 wks improves germination
Pinus ayacahuite	9	7	oval	3,400	70%	Prob. not dormant
Pinus cembra	12	6-7	tri	4,000	60%	6 mths or sow late summer
Pinus cembroides	20		oblong	2,500	62%	4 wks
Pinus coulteri	18-22	9-10	oval	3,000	84%	
Pinus edulis	20		oblong	c.4,000	83%	4 wks
Pinus flexilis	10-15	8-10	oval	8,900	76%	4 wks
Pinus gerardiana	20-25	8-9	cyl	3,300	66%	13 wks
Pinus jeffreyi	10-15	7-8	oval	8,000	72%	
Pinus koraiensis	15-17	9-11	tri	2,000	60%	13 wks
Pinus lambertiana	15	9-10	oval	5,000	65%	6 mths or sow late summer
Pinus monophylla	20		cyl	2,600	47%	4 wks improves germination
Pinus pinea	15-20	9-11	cyl,flat	1,400	70%	4 wks
Pinus quadrifolia	13			c.4,000		4 wks
Pinus sabiniana	20-30		cyl	1,600	44%	4 wks
Pinus sibirica	12-15	7-10	tri	c.3,000		13 wks
Pinus torreyana	20-25	10	oval	1,200	75%	4 wks

(cyl = cylindrical, tri = triangular/angular)

Pinus cembroides

Mexican pinyon, Mexican stone pine, Mexican nut pine

A small tree, to 8 m high, with a rounded crown, short stem and outspread branches. Needles in groups of 1-5, persisting 3-5 years, sickle shaped, dark green. Cones are short stalked, roundish, 3-5 cm long by 3-4 cm wide, yellowish to reddish-brown, with only a few scales which open widely when ripe. Seeds are blackish and wingless, thick-shelled. Native to SW US A and Mexico on hot, arid mountain slopes and canyons. Hardy to zone 7 (-15°C).

A pinyon pine, of commercial importance second only to *P. edulis*, intolerant of competition. Slow growing and very long lived, not reaching maturity until 250-350 years.

Table 2. Kernel Data for Pine Nuts

Species	Kernel	% Fat	Protein	Carbo-hydrate	Fibre	High amounts Vitamins
Pinus cembra	38%	59%	19%	17%	1 %	
Pinus cembroides		65%	19%	low		
Pinus edulis	58%	61-71%	14.5%	19%	1%	A, B
Pinus gerardiana		high		low		
Pinus koraiensis		65%	17%	12%		B
Pinus lambertiana		high		low		
Pinus monophylla	70%			54%		
Pinus pinea		48%	34%	6.5%	1.4%	
Pinus quadrifolia		37%	11 %	44%		
Pinus sabiniana	77%	54%	28%	8%		
Pinus sibirica		60-64%	17%	12%		B, E, F

Pinus coulteri

Coulter's pine, Big cone pine

A large, straight-stemmed tree to 25-30 m high with a loose, open, pyramidal crown and very stout, wide-spreading branches. The bark is thick and very dark brown. Needles are in 3's, persisting for 2- 3 years, long, stiff, dark bluish-green. Cones are borne on short stalks and are very large and heavy, 25-35 cm long and up to 15 cm wide, a shining yellow-brown; they are very persistent. Most cones do not open to release their seeds. Seeds are black with a 25 mm wing. Native to California and Mexico on coastal mountains; hardy to zone 7 (-15°C).

Trees are quite fast growing and drought tolerant.

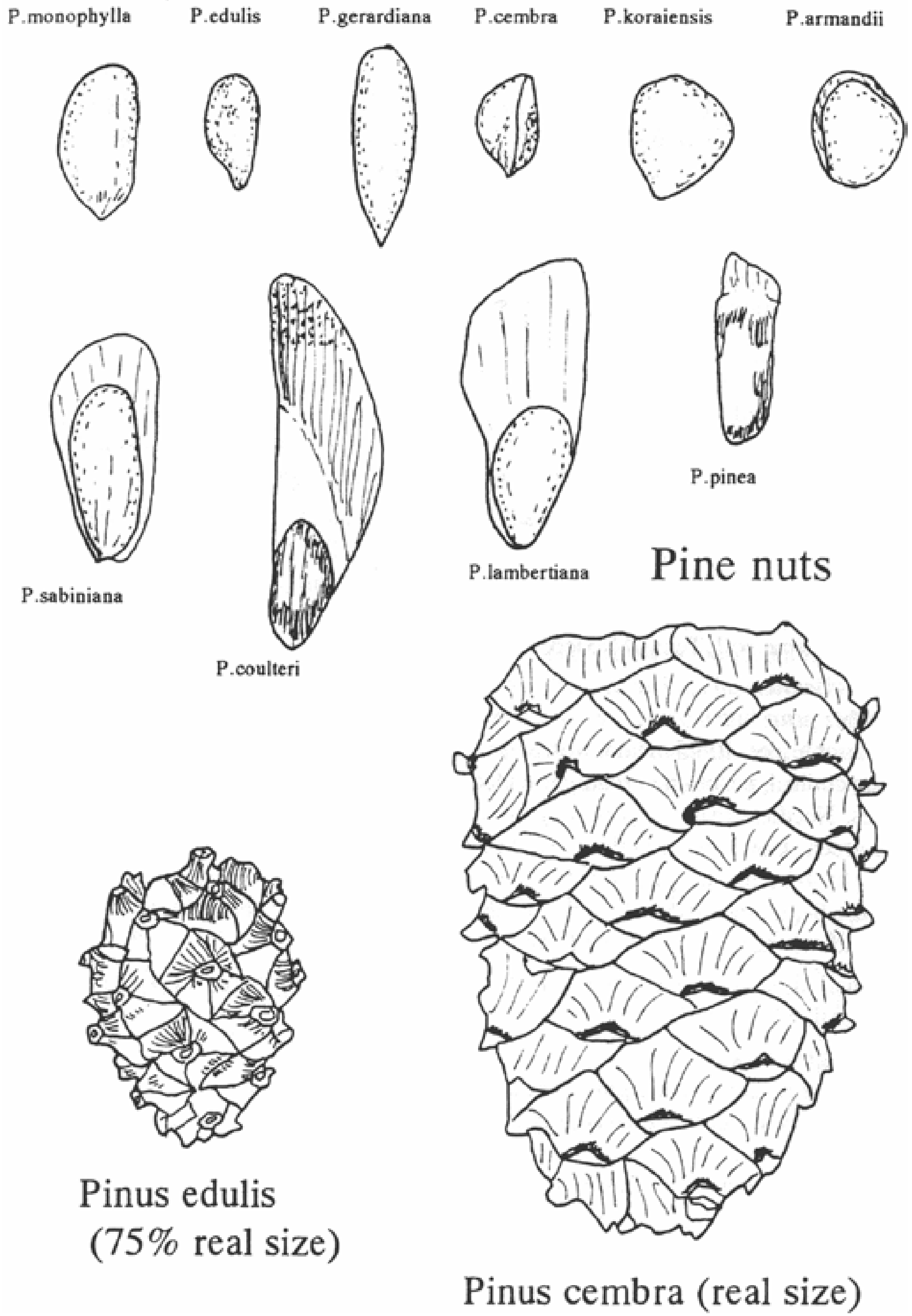
Pinus edulis (Syn P. cembroides var. edulis)

Piñon pine, Pinyon pine, Colorado Pinon, Nut pine, Two leaved nut pine, Two needle pinyon, Silver pine, Rocky Mountain Nut pine

A medium sized tree to 15 m high, usually multi-stemmed with an irregular habit. Needles in 2's or 3's, are stiff and dark green. Cones usually open in September or October after a frost, the seeds falling out over a period of 2 weeks. Seeds are thick shelled. Native to high mountain slopes in SW, USA and Mexico; hardy to zone 5 (-22°C).

A slow-growing straggling tree which is adapted to a dry climate (requiring 30-45 cm of annual rainfall). Trees under 25 cm diameter appear to be dioecious, producing fewer cones but many seeds per cone; while larger trees seem to be monoecious and produce many cones, with fewer seeds per cone.

Young trees start to bear nuts when they are about 25 years old and 1.5-3 m high; heavy crops are not borne until trees are about 75 years old. This time factor is responsible for there



being no cultivated orchards of pinyons. Cone production varies greatly from year to year, with large crops every 4-7 years; cones take 2 or 3 years to mature and successive good seasons are required for a good yield. Seeds are called pinyon nuts when sold.

Trees can be shaken over plastic sheets to encourage nuts to fall. Nuts are then collected by hand. (A traditional harvest method in the native area is to allow kangaroo rats, of which there are large populations, to collect the nuts and store them in tunnels a few inches underground; at the end of the harvest season, these stores are raided!)

Unshelled nuts have excellent keeping qualities, storing for 3 years even in warm conditions. Shelled nuts must be used within 3 months, though. Pinyon nut protein is easily digested and contains all 20 essential amino acids. Pinyons have been used in the US for centuries as a source of food and demand always exceeds supply.

Other minor pinyon pines from the same region include *P. johannis* (Johann's pinyon) - shrubby, Mexico, hardy to zone 7-8; *P. maximartinezii* (Big cone pinyon) - large tree, has very large cones and nuts, Mexico, hardy to zone 7; *P. nelsonii* (Nelson's pinyon); *P. pinceana* (pince's pinyon); P. remota (paper shell pinyon) - shrub or small tree, seeds with papery shells, likes lime soil, Texas/Mexico, hardy to zone 7-8;

Pinus flexilis

Limber pine

A variable tree, 10-25 m high with a trunk up to 1-1.5 m in diameter. The crowns of young trees are conical, becoming broadly rounded with age; the bark is dark grey and furrowed on old trees. Needles are in 5's, persisting 5-6 years, stiff and densely crowded at the branch tips, bluish-green. Cones borne at the end of branches, becoming pendulous, are cylindrical, 7-15 cm long by 4-6 cm wide, glossy and light brown with thick woody seed scales. Cones mature in August-September and scales open when ripe about a month later; seeds are reddish-brown with a rudimentary wing. Native to W. USA, hardy to zone 2-3.

A gnarled, slow-growing pine which is wind and drought hardy. Likes a moist, well-drained soil. Good in UK.

Pinus gerardiana

Chilgoza pine, Gerard's pine, Nepal nut pine

A small tree in cultivation reaching 10 m high, but double that in its native region. Dense, rounded crown and short, spreading branches. The bark is thin, silvery-grey and peeling. Needles in 3's, green, persisting 3 years. Cones are oblong, 12-20 cm long by 7-11 cm wide, very resinous, ripening in their 2nd year. Native to the Himalayas, Tibet, Kashmir and N. Afghanistan, where it grows on dry gravelly soils high in the mountains (usually above 2000 m/6600 ft). Hardy to zone 7 (-15°C).

Some 15-20 cones are produced per tree, each cone containing 100 or more seeds. After collecting, cones are traditionally heated by a fire to loosen the scales and release the nuts. The shell around the kernel is papery and much thinner than in the Stone pine. The flavour is slightly turpentiny but quite pleasant.

Range of the genus Pinus *[from Krüssman]*

Pinus jeffreyi

Jeffrey pine

A large tree, reaching 30-60 m or more in some areas with a trunk of over 1 m diameter. Cinnamon-brown bark splits into plates on older trees. The crown is rounded and branches are stout, outspreading, often somewhat pendulous. Needles are in 3's, clustered at the shoot tips, persisting for 2 years, long, stiff and grey-green. Cones are conical and short stalked at the end of branches, 14-20 cm long by 4-8 cm wide, spreading horizontally, light brown, with thorny seed scales. Seeds have 3 cm wings. Native to the mountains of western north America; hardy to zone 5 (-23°C).

Pinus koraiensis

Korean pine, Korean white pine, Korean nut pine, Chinese nut pine

A medium or large pyramidal tree of loose conical habit, reaching 20- 30 m (65 -100 ft) high with a trunk up to 2.5 m in diameter. Branches are strongly horizontal to erect. Needles are in 5's, loosely arranged, stiff, green one side and bluish-white the other. Cones are borne at or near the end of branches in groups of 1-3, are cylindrical and erect, 9-14 cm long by 5-6 cm wide, bright yellowish-brown when ripe, with woody scales. Cones ripen in their 2nd year in September and seeds fall a month later. Seeds are greyish-brown, unwinged. Native to Manchuria, Korea and N. Japan, on mountains, usually on well drained sandy soils, in mixtures of conifers and hardwoods. Hardy to zone 3 (-35°C).

Trees start to bear cones at 20-25 years of age, heavy seed years occurring every 2- 3 years.

Cones contain on average 160 seeds. Highly valued in Asia, where numerous improved selections exist. In N America, two improved selections, 'Grimo' and 'Morgan' are available. Not good on wet sites.

Pinus lambertiana

Sugar pine, Lambert pine

A very large tree, reaching 100 m in its native habitat when it is about 500 years old, with a huge trunk 3-6 m in diameter; a medium sized tree in Britain. Very straight stemmed, often with the first branches way up the stem. Branches are horizontal or somewhat nodding. Needles are in 5's, very stiff and wide, persisting 2-3 years, dark green. Cones are borne at the end of branches on stalks 9 cm long; they are cylindrical, pendulous, 30-50 cm long by 8-11 cm wide (the largest of all pines), a shining light brown with leathery scales. The cones ripen and fall off in their 3rd year. Seeds are nearly black with 2 cm long brown wings. Native to western north America; hardy to zone 7 (-15°C). Susceptible to white pine blister rust.

Pinus monophylla (Syn P. cembroides var. monophylla)

Singleleaf pinyon

A medium-sized tree to 15 m high, usually multi-stemmed, with a flat crown. Needles are borne in 1's, thick, stiff and prickly, grey -green and striped. Cones are 5-8 cm long and very wide, with woody scales; they fall in winter or early spring. Native to SW USA on dry mountain slopes and plains. Hardy to zone 6-7 (-15°C).

Another pinyon pine from SW USA which has been used for food for at least 7500 years.

Drought-tolerant. Reaches maturity in 100-225 years. Needs a hot, dry position.

Pinus pinea

Stone pine, Umbrella pine, Italian stone pine

A medium or large tree reaching 15-25 m high, with a broadly arched, umbrella-shaped crown and horizontal branches. Needles are in 2's, persisting 2 years, stiff and light green. Cones are usually borne singly (occasionally in 2's or 3's) at the ends of branches on stout stalks, inclined downwards, nearly round, 8-15 cm long by up to 10 cm wide; they ripen in their 3rd year. Seeds are thick-shelled, dull brown with variably-sized wings (3-20 mm), native to the whole Mediterranean; hardy to zone 8 (-12°C).

This is the most important source of pine kernels for commerce, being especially valuable in Spain, Portugal and Italy. The seeds are called pignolias. They have been used for many centuries; shells have been found in Britain in the refuse heaps of Roman encampments.

It is an easy tree to grow, being pest and disease free and tolerating most soils except very wet and alkaline areas; sandy soils are ideal, chalky soils are tolerated. The trees thrive in wind and are often planted in shelterbelts with plants around 5 m apart. If they are grown specifically for pine nut production, then plant at 10 m apart. Trees are slow growing. It can be advantageous to keep the trees to a single trunk as they can develop large low branches; excess stems can be singled, allowing trees to develop a parasol shape. This allows for height to walk underneath to gather cones.

Cones are produced from about ten years onwards, with full crops produced by 40 years. A heavy crop (mast) is produced every 3-4 years. Each cone holds about 50-100 nuts and 100 kg of cones holds about 20 kg of nuts; annual yields are about 5 kg per tree (500 kg per hectare), but 15 kg per tree (1500kg per hectare) in a mast year. Harvesting is done by means of a long pole or hook, which is used to pull the cones off the tree. (In Italy, mechanical harvesting using tree shakers is being introduced.) In commercial production, the nuts are crushed between cylinders to crack the shells which are separated off by sieving, then the kernels are sieved again to remove the brown skin on the kernel, which separates easily. Seeds have a unique, sweet, 'turpentine' flavour. The main areas of commercial production are Spain (Huelva) and Italy (Marches, Tuscany, Abruzzi).

Work is being done in Italy to propagate superior fruiting plants by grafting. Rootstocks (*P. pinea*, also *P. radiata, P. halepensis, P. sabiniana, P. pinaster*) need to be at least 18 months old and a cleft graft or veneer side graft are used.

Thin shelled varieties exist. The cultivar 'Fragilis' has thin shelled seeds and is cultivated for this reason. Good in S & W Britain. Young plants are susceptible to frost damage.

Pinus quadrifolia (Syns P. parrayana, P. cembroides var. parrayana)

Parry pinyon, Four-leaved nut pine

A pyramidal, becoming flat-crowned tree to 15 m high, with thick spreading branches. Needles usually in 4's, borne densely, short, stiff and bluish-green. Cones are nearly round, 5 cm across, ripening in their 2nd year and bearing a few dark brown seeds with thin, brittle shells. Native to dry mountain slopes in California. Hardy to zone 7 (-15°C).

Another pinyon pine, which likes an acid soil; very drought resistant. Large seed crops occur at intervals of 1-5 years.

Pinus sabiniana

Digger pine

A medium or large tree, growing 12-21 m high, often multi-stemmed. Has an open, rounded crown and grey-brown, thick, deeply fissured bark. Branches are irregularly arranged. Needles are in 3's, persisting for 3 years, long, light blue-green. Cones are oval, borne in 1's, 2's or 3's on stalks at the end of branches , 15-25 cm long by 10-18 cm across and weighing up to 1.8 kg each, reddish-brown with large woody scales armed with spines; they persist on the tree for up to 7 years after the seeds have been shed. Seeds are dark brown with 1 cm long wings. Native to dry hills in California; hardy to zone 7 (-15°C).

Long used for food by the Digger Indians of California. Drought resistant. After collecting, cones are heated by a fire to loosen the scales and release the nuts.

Pinus sibirica (Syn P. cembra var. sibirica)

Siberian pine, Siberian cedar, Cedar pine

A large narrowly conical tree to 33 m high and 2 m in diameter, often with a more rounded crown as a young tree. Cones are 6-12 cm long by 5-7 cm wide. Seeds are dark brown with an easily broken shell. Native to NE European Russia, Siberia and N Mongolia, where it forms pure stands and mixed forests with spruce, fir and larch. It occurs both on dry sandy sites and on wet bogs; hardy to zone 3 (-35 ° C).

Trees are long-lived, up to 900 years old. The tree forms a shallow root system on wet sites and a deep tap root on dry sandy and stony sites. Trees start to bear cones at 20-25 years of age. Heavy seed years occur every 2-3 years. Cones contain about 150 seeds. Called 'cedar nuts', their proteins and are more easily digested than those of walnut and hazel. They also contain 10 essential amino acids. The oil pressed from nuts is high in polyunsaturated fatty acids.

Pinus torreyana

Torrey pine, Soledad pine

A small to medium tree, 6-15 m high, broad, open, irregular and similar to *P. sabiniana*, with a trunk 30-60 cm in diameter with deeply and irregularly furrowed bark. Needles in 5's, persisting for several years, are clustered at the branch tips, very tough, large and dark green. Oval cones are 10-15 cm long by 9 cm wide on stalks, horizontal or drooping, dark violet when young becoming a shining chocolate brown when ripe. Cones ripen in their 3rd year and fall off the year after. Seeds are dark brown, speckled, very large, with a ring-like wing. Native to southern California; hardy to zone 7 (-15°C).

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(Based on an article in *Agroforestry News*, Vol. 3 No.1, October 1994)

THE POTENTIAL FOR AN AUSTRALIAN OLIVE INDUSTRY:

RESEARCH, VARIETIES, PROPAGATION AND MECHANIZATION

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Australia imported 23 million litres of olive oil, landed value $61 million, in 1992. The 1989 figures were 16 million litres which were valued at $32 million. Olive oil imports have grown substantially in recent years, and with changing consumer demands the market for vegetable oils, including olive oil, will most likely increase. Imports of table olive oil also increased during this period. In 1989,5,989 tonnes of oil were imported at the value of $11 million; and in 1992, 6,800 tonnes were imported at the value of $20 million (Australian Bureau of Statistics data). An Australian olive industry could contribute significantly to our balance of payments through import substitution.

Olives are well suited to extensive areas of southern Australia which have a Mediterranean type of climate and neutral to slightly alkaline soils. Olives have been grown in Australia for a considerable time, and at the beginning of this century the SA and NSW Departments of Agriculture conducted trial work primarily on olives for oil production.

Why didn't the industry develop? There was more than one reason, for example, the markets were small, hand harvesting was expensive, and other crops were more profitable.

Hand harvesting of olives either for table or oil has been the norm in olive growing countries. They usually had an abundance of cheap labour and could therefore successfully and profitably grow olives. This is no longer the case, labour in Italy is as expensive as in Australia and Spain's costs are not far behind. Hand harvesting accounts for approximately 70% of the variable costs in growing olives and there was therefore an incentive to mechanise harvesting. Both Italy and Spain recognise that for olive growing to exist as an industry, harvesting costs must be reduced and mechanical harvesting of fruit is the obvious way to achieve this. They have a done a considerable amount of development work and mechanical harvesting has been used in some orchards for more than 10 years. Olive oils are harvested when the fruit is ripe and little force is required to cause dislodgement. The same is the case with ripe black table olives.

Green table olives may be a different story, the fruit is firmly attached to the tree and more force is required to cause dislodgement. Bruising is a problem especially with some cultivars, e.g. Ascolano. Spanish research workers informed me on a recent study tour [1] that bruising was easily arrested by immersing the olives in a brine solution within 6 hours after harvest. This seems a long time and needs to be verified under Australian conditions.

Mechanical harvesters are available with different features, e.g. shaker only, shaker plus catching umbrella with collection trays and others. One machine I saw on a commercial property was shaking one tree every 30 seconds. An extensive range is now available. Prices vary depending on the features and size, the range is approximately A$28,999 to A$1 00,000:

To summarise, there are large markets within Australia for olive oil and table olives. Mechanical harvesting developed in Italy and Spain is used commercially and reduces substantially the harvesting costs, which with hand harvesting are prohibitive. The major production constraint hindering process has been removed.

Orchards are now designed for mechanical harvesting. The ideal tree has a 1 m straight stem which is held firmly by the shaking head of the mechanical harvesting during the harvesting process. The single stem plant system is advocated as the method for future modern plantings. Figure 1 illustrates the tree training sequence to achieve a single stem plant.

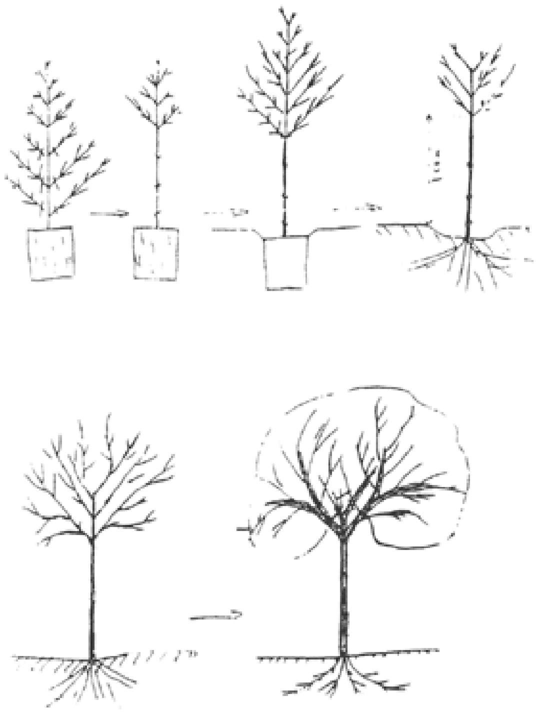


Fig. 1. Tree training sequence

Processing oil olives is a simple straight forward process. Traditionally oil has been squeezed out in presses and the factory operation has been a batch process, i.e. labour intensive. The continuous system, based on centrifuging to separate, oil, water and pulp, is increasingly being used to save time, space and reduce costs. There are advocates for each system and it may be that one produces better olive oil than the other. This is in the area of fine detail and of use where boutique specialised markets are being serviced; it is of little consequence where normal markets are being developed and serviced. In Italy I saw numerous factories using the centrifuge system, it works well, produces an excellent product and has stood the test of time. The factories are available in different sizes and the baby of the line costs in the order of A$70,000 and processes 0.4 tonnes of olive fruit per hour. A larger factory, which extracts more oil from the fruit, processes about 1.0 tonne of olive fruit per hour and costs in the order of A$225,000.

Olives are usually grown without irrigation and are planted extensively in areas with 500 mm minimum yearly rainfall. Table 1 presents climatic data for Loxton SA, Roseworthy SA, and Tortosa, Spain (the Spanish figures have been transposed 6 months to bring them in phase with the southern hemisphere). This table can be used to give some idea of the suitability of olives for various regions in Australia.

Table 1. Climate data for Loxton and Roseworthy, South Australia, and Tortosa, Spain

T max °C	J	F	M	A	M	J	J	A	S	O	N	D	Yr
Tortosa	30.1	30.2	27.6	22.6	17.7	13.8	13.6	15.2	18.1	20.6	23.5	27.3	21.1
Loxton	31.4	31.0	27.4	24.0	18.6	16.0	15.5	16.6	19.7	24.2	26.6	29.1	23.3
Roseworthy	29.8	29.5	26.9	23.0	18.5	16.1	14.9	15.8	18.1	21.8	25.2	27.4	22.3
T mean °C													
Tortosa	24.9	25.1	22.6	17.8	13.3	9.9	9.2	10.3	12.9	15.4	18.3	22.2	16.8
Loxton	23.1	23.1	19.7	16.7	12.5	10.1	9.7	10.5	12.9	16.5	18.7	20.6	16.2
Roseworthy	22.5	22.5	20.3	17.2	13.7	11.5	10.6	11.1	12.7	15.6	18.4	20.6	16.9
T min °C													
Tortosa	19.8	20.0	17.7	13.0	8.9	6.0	4.8	5.4	7.7	10.1	13.0	17.1	11.9
Loxton	14.7	15.1	12.0	9.4	6.3	4.1	3.8	4.4	6.1	8.7	10.7	12.1	9.0
Roseworthy	15.2	15.5	13.7	11.4	8.8	6.9	6.2	6.4	7.3	9.4	11.6	13.8	10.5
Precip. mm													
Tortosa	24	16	84	74	43	59	26	25	42	45	67	51	576
Loxton	18	23	13	17	28	27	25	28	28	28	21	19	275
Roseworthy	21	20	19	38	49	53	49	52	45	43	27	24	440
Evapotranspiration mm													
Tortosa	152	142	106	66	35	19	18	22	40	57	90	124	871
Loxton	272	219	179	105	62	42	51	76	118	167	219	268	1778
Roseworthy	319	263	211	136	84	58	63	82	117	164	233	301	2031

Table 2. Yields in kg/ha/yr for irrigated vs rainfed olives over 12 years

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
'Full' irrigated	0	0	0	3192	4446	6375	13218	7582	14000	7582	14000	7582	14000
Rainfed 500mm	0	0	0	0	1060	1385	2000	4150	2690	5620	3380	6400	3600

With irrigation olives can be grown in drier areas. Under full irrigation, yields are approximately double those in 500 mm rainfall only areas (see Table 2).

Effect of tree density on yield

Table 4 shows the results of a trial carried out in Spain to test the effect of density on yields and fruit characteristics. Although yields per hectare for both olives and oil tend to be higher at higher densities, one must consider if these densities make for efficient management of the grove (traffic for mechanical harvest etc). Figure 2 illustrates the difference in planting positions and likely yield between a traditional grove and one trained for mechanical harvesting (single trunked trees).

Economic analysis of olive growing

Table 3 presents the areas of olive growers required to satisfy the current (1992) Australian demand for oil and table olives if grown under rainfed or irrigated conditions.

Table 3. Local plantings needed to satisfy 1992 Australian demand

Water regime	*Area of oil olives (ha)*	*Area of table olives (ha)*
Rainfed 500mm	23,000	1,360
Irrigated, i.e. 900 mm + rain	10,657	630

Information has been compiled for the economic analysis of olive growing, under rain fed and irrigation growing regimes. The results are presented in Tables 5-10.

1: **As an investment on 100 ha of olives with own harvest and factory**: Rainfed (Table 5); Irrigated (Table 6).

2. **As an addition to present horticultural/farming enterprises**: Rainfed, 20 ha, contract harvested, contract oil production (Table 7); Irrigated, 20 ha, contract harvested, contract oil production (Table 8); Rainfed, 20 ha, contract harvested, sold as fresh fruit to oil factory (Table 9); Irrigated, 20 ha, contract harvested, sold as fresh fruit to oil factory (Table 10).

These summary sheets detail the costs and returns for each olive enterprise growing oil olives. They are a guide and provide an estimate of the investment. Development budgets, with associated analyses and a full economic report are currently being prepared. Table olive production on a large commercial scale will depend on the feasibility of harvesting olives mechanically without unacceptable bruising. Although reports indicate it is possible I consider more data are required.

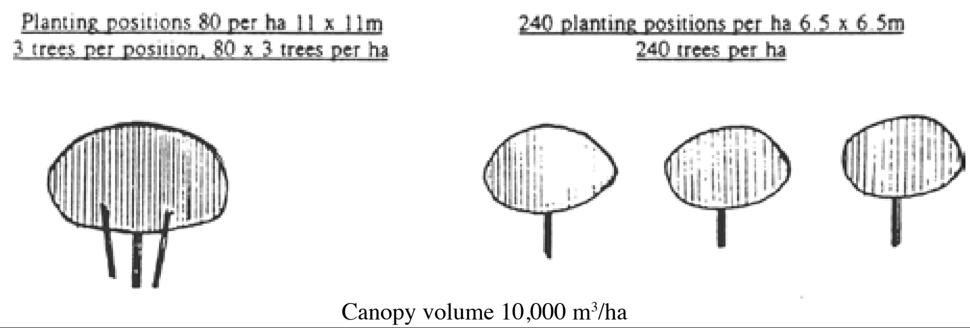
I completed recently a study tour on the olive industries in central Italy and southern Spain as a part of a project jointly funded by Rural Industries Research and Department Co-operation, (RIRDC) and the South Australian department of Primary Industries. A copy of the study tour report is available [1]

Constraints to development

Presently there is a lack of detailed information on the various cultivars. However a start has been made on assessing olive oil characteristics and yields of different cultivars and this work must continue.

Table.4. Results of a density trial planted in 1984 with the variety Arbeqina showing yields of olive fruits and oil, and percentage oil content.

Plant Density no/ha	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*Total*	*Ave*	*Ave, 3 most recent years*
Olives Kg/tree, 50% moisture									
200	10.46	12.1	24.44	46.08	32.39	51.93	177.4	29.6	43.47
250	13.93	13.39	27.05	51.71	29.67	54.19	189.94	31.7	45.19
300	13.30	17.43	25.01	51.84	29.74	54.91	192.23	32.0	45.50
350	13.25	11.25	22.14	42.69	23.61	45.67	158.61	26.4	37.32
400	12.15	11.87	18.99	39.39	22.35	39.01	143.76	24.0	33.58
450	12.02	12.84	21.12	38.12	22.96	40.62	147.68	24.6	33.90
Olives Kg/ha, 50% moisture									
200	2093	2420	4888	9218	6478	10386	35480	5913	8693
250	3483	3348	6763	12928	7418	13548	47488	7915	11298
300	3990	5229	7503	15552	8922	16473	57669	9612	13649
350	4638	3938	7749	14942	8264	15985	55516	9253	13064
400	4860	4748	7596	15756	8940	15504	57504	9584	13433
450	5409	5778	9504	17154	10332	18279	66456	11076	15255
Olive oil Kg/tree									
200	2.33	2.65	5.25	9.37	6.25	11.28	37.13	6.2	8.97
250	3.18	2.92	5.88	10.85	6.13	10.68	39.64	6.6	9.22
300	3.13	3.72	5.38	10.57	5.78	11.10	39.68	6.6	9.15
350	3.10	2.40	4.83	8.70	5.02	8.98	33.03	5.5	7.57
400	2.82	2.70	4.23	7.75	4.73	8.43	30.66	5.1	6.97
450	2.85	2.62	4.52	7.35	4.43	8.22	29.99	5.0	6.67
Olive oil, Kg/ha									
200	466	530	1050	1874	1250	2256	7426	1238	1793
250	795	730	1470	2713	1533	2670	9911	1652	2305
300	939	1116	1614	3171	1734	3330	11904	1984	2745
350	1085	840	1691	3045	1757	3143	11561	1927	2648
400	1128	1080	1692	3100	1892	3372	12264	2044	2788
450	1283	1179	2034	3308	1994	3699	13497	2250	3000
Oil %, moisture content of fruit 50 %									
200	22.3	21.9	21.5	20.3	19.3	21.7		20.9	20.6
250	22.8	21.8	21.7	21.0	20.7	19.7		20.8	20.4
300	23.5	21.3	21.5	20.4	19.4	20.2		20.6	20.1
350	23.4	21.3	21.8	20.4	21.3	19.7		20.8	20.3
400	23.2	22.7	22.3	19.7	21.2	21.6		21.3	20.8
450	23.7	20.4	21.4	19.3	19.3	20.2		20.3	19.7



Vol = 125 m^3 per position (3 trees)	Vol = 41.7 m^3/tree
Foliage surface area = 125 m^2 per position	Foliage surface area = 60.2 m^2 per tree
= 10,000 m^2 per ha	= 14,448 m^2 per ha
Yield = 0.3 Kg/m^2	
37.5 Kg per position (3 trees)	18.1 Kg per tree
3,000 Kg per ha	4,340 Kg per ha

Fig. 2. Planting positions

There is a limited quantity of overseas oil cultivars and the sooner a collection is put together the better. Oil characterisations are more cultivar-dependent than climate-dependent. Climate has only a small influence on quality. This implies that fully proven oil olive cultivars can be imported into Australia and retain the same characteristics as in their natural environment. This augers well for the development of the industry.

Finally, a shortage of plant material will in the short term curtail any large expansions of olive growing in Australia.

Reference

1. **Hobman**, Farnell (1994): *The Olive Industry in Central Italy and Southern Spain*. RIRDC, Canberra. Research Paper Series: No. 94/7.

(Based on a paper presented at a National Symposium on *Olives and Carobs for Landcare and for Profit*, University of Adelaide Roseworthy Campus, April 17-18 1994)

Table 5. Rainfed (500 mm) oil olive orchard, 100 ha
Summary of financial statement

Capital and establishment costs ($)

Year 0	
Land costs	12,500
Olive plants	240,000
Machine shed & office	20,000
Land preparation, planting and watering	50,000
Utility	11,000
Fertiliser spreader	2,000
Herbicide spraying equipment	2,000
Tractor	19,000
Total	**356,500**
Year 4	
Factory building	11,300
Mechanical harvester	90,000
Factory machinery	225,000
Tractor	19,000
Total	**345,300**

Gross production and values ($)

Olive fruit, av/yr, kg	500,000	
Olive oil, litres	112,500	
		450,000
Gross Return		**450,000**

Variable and operating costs

Pruning	20,000
Fertiliser and herbicides	30,600
Harvesting	16,000
Processing, power and bottling	24,700
Freight	2.500
Repairs and maintenance	18.200
Admin & Management	45,000
Total	**157,000**
Gross Margin	**293,000**
	450,000

Internal Rate of Return, 14%
Net Present Value (gross at 10%),

Table 6. Irrigated oil olive orchard, 100 ha
Summary of financial statement

Capital and establishment costs ($)

Year 0	
Land costs	12,500
Irrigated headworks	400,000
Water licence	240,000
Sprinklers	350,000
Olive plants	240,000
Machine shed & office	20,000
Land preparation, planting and watering	50,000
Utility	11,000
Fertiliser spreader	2,000
Herbicide spraying equipment	2,000
Tractor	19,000
Total	**1,346,500**
Year 3	
Factory building	11,300
Mechanical harvester	90,000
Factory machinery	225,000
Tractor	19,000
Total	**345,300**

Gross production and values ($)

Olive fruit, av/yr, kg	1,079,100	
Olive oil, litres	218,000	
		872,000
Gross Return		**872,000**

Variable and operating costs

Pruning	20,000
Fertiliser and herbicides	44,700
Water & power	12,000
Harvesting	22,050
Processing, power and bottling	52,600
Freight	4,800
Repairs and maintenance	18.200
Admin & Management	45,000
Total	**219,350**
Gross Margin	**652,650**

Internal Rate of Return, 18%

Table 7. Rainfed (500 mm) oil olive orchard, 20 ha
Summary of financial statement
Contract harvesting and crushing

Capital and establishment costs ($)	
Year 0	
Land costs	0
Olive plants	48,000
Machine shed & office	0
Land preparation, planting and watering	10,000
Utility	0
Fertiliser spreader	0
Herbicide spraying equipment	0
Tractor	0
Total	**58,000**
Year 4	
Tractor	0
Total	**0**
Gross production and values ($)	
Olive fruit, av/yr, kg 100,000	
Olive oil, litres 22,500	90,000
Gross Return	**90,000**
Variable and operating costs	
Pruning	4,000
Fertiliser and herbicides	6,120
Contract Harvesting	15,000
Contract Processing, power and bottling	13,640
Freight on fresh fruit	1,000
Freight on olive oil	500
Repairs and maintenance	18.200
Admin & Management	1,000
Total	**41,260**
Gross Margin	**48,740**
	90,000

Table 8. Irrigated oil olive orchard, 20 ha
Summary of financial statement
Contract harvesting and crushing

Capital and establishment costs ($)	
Year 0	
Land costs	0
Machine shed & office	0
Irrigation headwork	0
Water licence	0
Sprinklers	70,000
Land preparation, planting and watering	10,000
Olive plants	240,000
Utility	0
Fertiliser spreader	0
Total	**128,000**
Year 3	**0**
Gross production and values ($)	
Olive fruit, av/yr, kg 215,820	
Olive oil, litres 43,600	
	174,380
Gross Return	**174,380**
Variable and operating costs	
Pruning	4,000
Fertiliser and herbicides	8,940
Water & power	7,200
Contract Harvesting	15,000
Contract Processing, power and bottling	28,660
Freight on fresh fruit	2,160
Freight on olive oil	960
Admin & Management	67,920
Total	**106,460**
Gross Margin	**174,380**

Table 9. Rainfed (500 mm) oil olive orchard, 20 ha
Summary of financial statement
Contract harvesting and sale of olive fruit

Capital and establishment costs ($)	
Year 0	
Land costs	0
Olive plants	48,000
Machine shed & office	0
Land preparation, planting and watering	10,000
Utility	0
Fertiliser spreader	0
Herbicide spraying equipment	0
Tractor	0
Total	**58,000**
Year 4	
Tractor	0
Total	**0**
Gross production and values ($)	
Olive fruit, av/yr, kg	
@$0.40/kg 100,000	40,000
Gross Return	**40,000**
Variable and operating costs	
Pruning	4,000
Fertiliser and herbicides	8,940
Harvesting	15,000
Freight on fresh fruit	1,000
Admin & Management	1,000
Total	**27,120**
Gross Margin	**12,880**
	40,000

Table 10. Irrigated oil olive orchard, 20 ha
Summary of financial statement
Contract harvesting and sale of olive fruit

Capital and establishment costs ($)	
Year 0	
Land costs	0
Machine shed & office	0
Irrigation headwork	0
Water licence	0
Sprinklers	70,000
Land preparation, planting and watering	10,000
Olive plants	48,000
Herbicide spraying equipment	0
Fertiliser spreader	0
Total	**128,000**
Year 3	
Capital costs	0
Gross production and values	
Olive fruit, av/yr, kg 215,820	
@$0.40/kg	86,330
Gross Return	**86,330**
Variable and operating costs	
Pruning	4,000
Fertiliser and herbicides	8,940
Water & power	7,200
Contract Harvesting	15,000
Freight on fresh fruit	2,160
Admin & Management	1,000
Total	**38,300**
Gross Margin	**48,030**
	86,330

PECAN NUT CULTIVAR EVALUATION IN THE SUNDAYS RIVER VALLEY, SOUTH AFRICA

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Introduction

The pecan nut tree originates from the central southern states of the USA. It requires a climate with short, very cold winters and long, hot summers with no early or late frost (Oosthuizen, 1992). Based on these criteria, it would appear that the deep alluvial soils along the Fish and Sundays River Valleys (recently opened by the Orange River Irrigation Scheme) are climatically suitable for pecan production (Whittle & Miller, 1992). As these areas are semi-arid with low rainfall and humidity, there is the advantage that scab disease should present little or no problem. Cultivar choice is thus not limited to scab tolerant cultivars, as in other subtropical areas in South Africa, and nut quality is often superior.

To date little research has been conducted in determining the adaptability and performance of the various pecan nut cultivars in these areas. A knowledge of the important horticultural characteristics of the various cultivars, relative to the locality is thus essential. According to Sparks (1992) the following characteristics can be used to evaluate cultivar suitability:

i) Time of budbreak to determine the susceptibility of a cultivar to late spring frosts.

ii) Dichogamy (the maturation of pistillate and staminate flowers at different times within a cultivar) to ensure effective cross pollination. When pollen shedding precedes stigma receptivity, the cultivar is protandrous (type I) and when stigma receptivity pre cedes pollen shedding, the cultivar is protogynous (type II). Pollen shedding and stigma receptivity often overlap, in which case dichogamy is incomplete. Catkin production may be sparse or prolific, and stigma colour may vary according to cultivar.

iii) Yield and alternate bearing.

iv) Nut quality (nut size, kernel and oil percentage, kernel colour, shell thickness and storage potential).

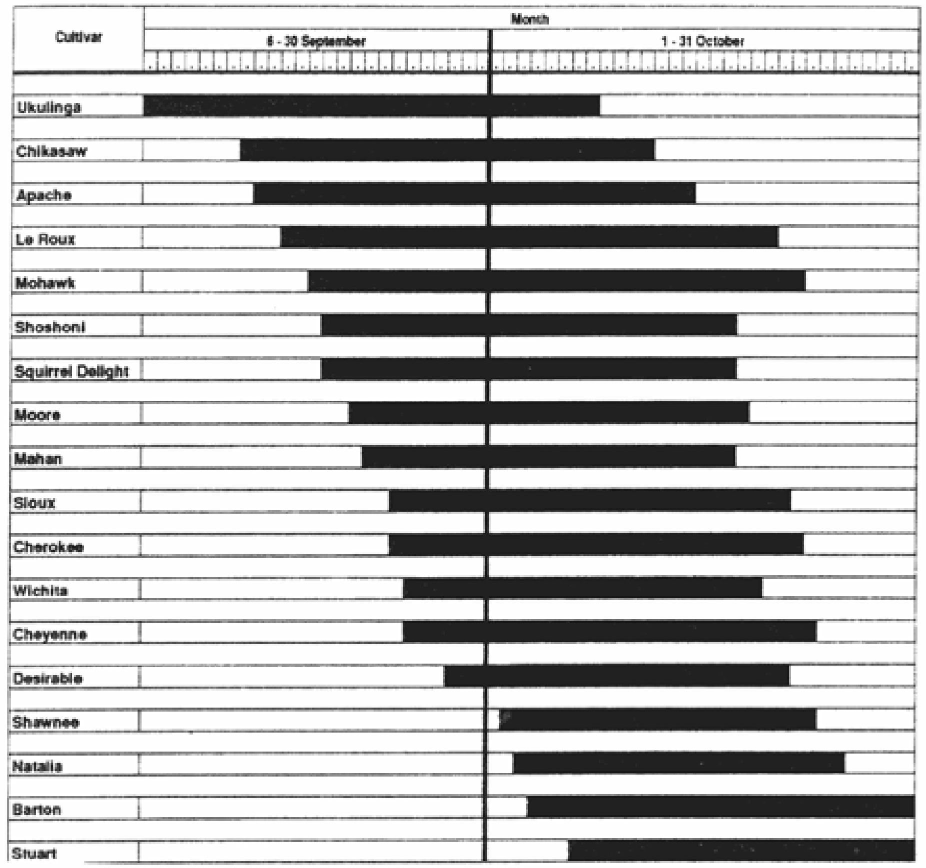
v) Disease (scab) and pest (yellow pecan aphid) resistance.

Materials and Methods

A cultivar trial, consisting of 16 pecan nut cultivars and two selections (four single tree replications) was established at the Addo Research Station in 1982. The tree characteristics (time of bud break and leaf expansion, dichogamy, stigma colour and catkin production), yield (kg/ha) and nut characteristics (nut size and kernel percentage) of these were evaluated.

§ Member, WANATCA

Table 1. Period from budbreak to full leaf expansion for 18 pecan cultivars at Addo Research Station.



Results

Tree Characteristics

Time of budbreak

Budbreak occurred earliest in Ukulinga (6 September) (Table I), while most other cultivars had intermediate (13 to 27 September) budbreak times. Natalia, Barton and Stuart were latebreaking cultivars (4 to 7 October) (Table 1). In general, similar patterns occurred for leaf expansion (Table 1).

Flowering characteristics

Dichogamy was incomplete for all cultivars except for Mahan and Sioux (Table 2). Moore, Cherokee and Squirrel's Delight appear to be early season pollinators, while Shawnee, Natalia and Stuart are late season pollinators (Table 2).

Table 3 gives dichogamy, catkin production and stigma colour for the cultivars.

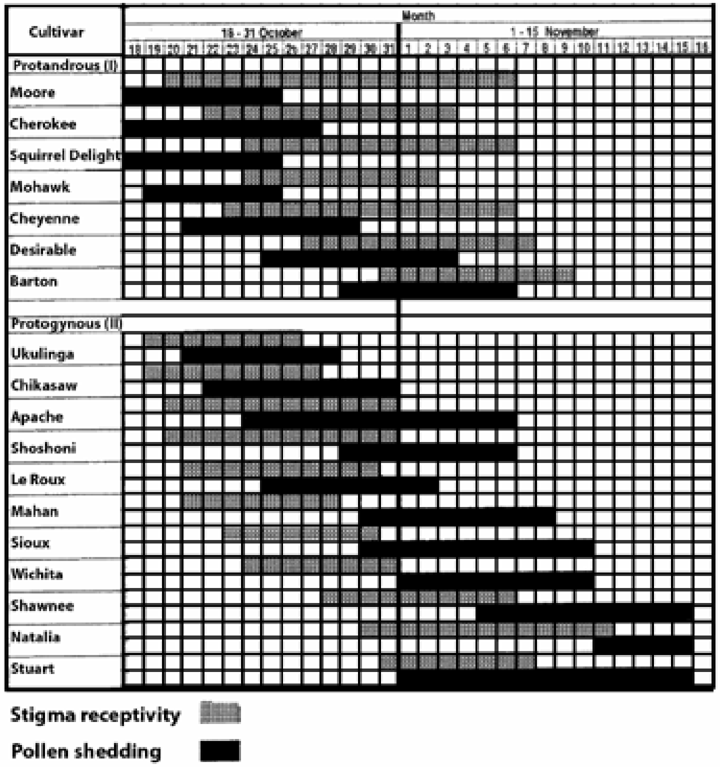
Yield

The yields (kg/ha with 100 trees per hectare) for 1992 and 1993 of the various cultivars are presented in Fig. 1. Shoshoni gave significantly higher yields on average (1298 kg/ha) than the other cultivars. Sioux, Wichita, Moore, Cherokee and Apache produced more than 800 kg/ha. The remaining cultivars produced lower (500 to 800 kg/ha) yields.

Nut Quality

Size

Mohawk, Mahan and Shoshoni yielded large nuts (101 to 120 nuts per kg). Most of the other cultivars had a medium nut size (121 to 165 nuts per kg) with the exception of Sioux, Moore and Chikasaw, which were classed as small (166 to 200 nuts per kg) (Fig. 2).



Kernel percentage

Mohawk and Cheyenne were the only cultivars to produce nuts of excellent kernel percentage (60 % or more). The majority of the cultivars yielded nuts with a high kernel percentage (52 % or more). Le Roux had acceptable kernel percentages (48 to 51 %), while only Stuart and Moore fell into the poor kernel percentage class (43 to 47 %) (Fig. 3).

Discussion

Knowledge of the horticulturally important characteristics of pecan cultivars is important in order to make intelligent decisions regarding cultivar selection.

Ukulinga is an early sprouting cultivar and may therefore be more susceptible to the late spring frosts which occur sporadically in the Sundays River Valley.

Table 3. Type of dichogamy (flower type), catkin production and stigma colour of 18 different pecan cultivars at Addo Research Station

Cultivar	*Flower type*	*Catkin production*	*Stigma colour*
Barton	I	Intermediate	Rose-green
Cherokee	I	Prolific	Ox-blood red
Cheyenne	I	Prolific	Maroon
Desirable	I	Prolific	Rose-green
Mohawk	I	Prolific	Maroon
Moore	I	Sparse	Bottle-green
Squirrel's Delight	I	Prolific	Rose
Apache	II	Prolific	Light green
Chikasaw	II	Intermediate	Rose-green
Le Roux	II	Prolific	Light green
Mahan	II	Intermediate	Light green
Shawnee	II	Sparse	Light green
Shoshoni	II	Sparse	Light green
Sioux	II	Sparse	Light green
Stuart	II	Sparse	Yellow-green
Ukulinga	II	Prolific	Light green
Wichita	II	Intermediate	Light green

As the degree of dichogamy varies from year to year, and because self pollination is undesirable because of increased fruit abortion and decreased kernel percentage (Sparks, 1992), selection of suitable cultivar combinations to ensure adequate cross pollination is an important aspect of orchard planning. Cherokee, Moore and Squirrel's Delight appear to be good early season pollinators, although they are otherwise not good cultivars. Shawnee appears to be a good late season pollinator.

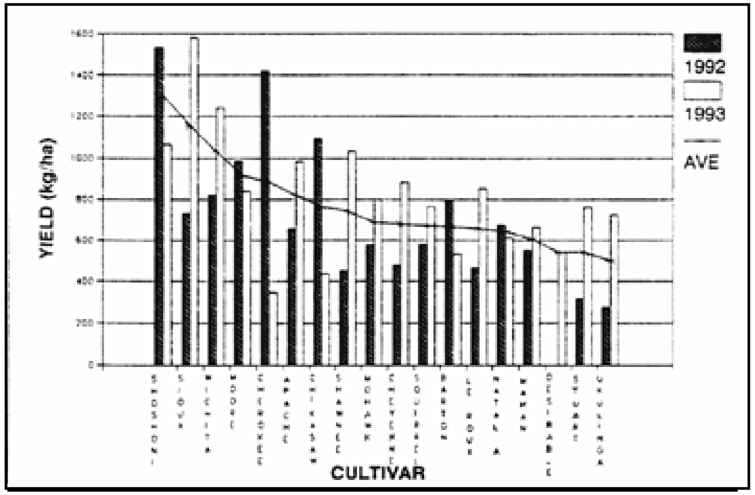


Fig. 1. Yield data (kg/ha with 100 trees per ha) of 18 different pecan cultivars harvested at Addo Research Station

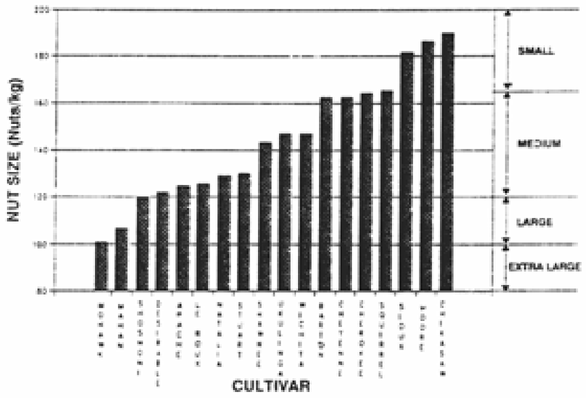


Fig. 2. Nut Size (nuts per kg) of 18 different pecan cultivars at Addo Research Station

The preliminary results indicate that Shoshoni and Mohawk have the most potential as commercial cultivars in the Sundays River Valley as they yield well with a good nut quality. However, as Mohawk produces large nuts, kernel filling may be a problem in older, heavily

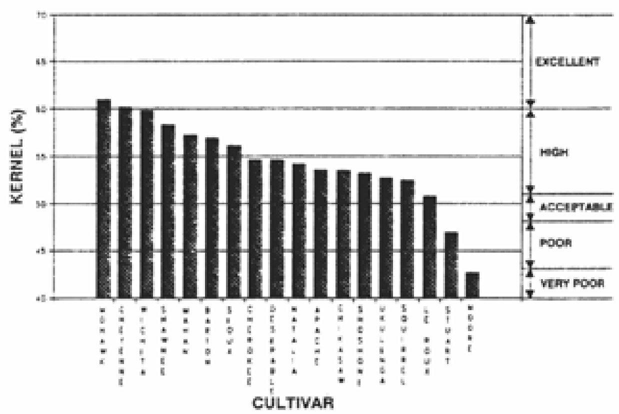


Fig. 2. Kernel percentage of 18 different pecan cultivars at Addo Research Station

bearing trees. Before any recommendations can be made, the further performance of these cultivars over a number of seasons needs to be established.

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(Based on an article in ITSC Information Bulletin, November 1994.)

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, this is greatly appreciated. Text and enquiries can also be sent by fax or e-mail.

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

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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.

Membership fees cover subscriptions to all WANATCA publications. Currently these are: a quarterly magazine, **Quandong**; the **WANATCA Yearbook**; and the **Australasian Tree Crops Sourcebook**.

Quandong has details of forthcoming Association meetings, events, and field trips, book reviews, news items of interest, reprints of short articles drawn from world-wide sources, members' comments and queries, and notes on sources of trees, seed, materials and services.

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