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The Cashew, *Anacardium occidentale*
(see article page 62)

West Australian Nut and Tree Crop Association (Inc.)

Yearbook 25 • 2001

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References to the ATCROS Directory

Organizations which have their names underlined in the articles contained herein are listed in the ATCROS Directory at the website address <www. AOI.com.au/atcros>. Each organisation's ATCROS reference (eg <A4321>) is given at the end of the relevant article.

This provides a route for checking current contact details of relevant tree crop organisations at any time.

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Publications
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Membership
For current details of membership contact the Secretary, WANATCA, P0 Box 565, Subiaco, WA 6008, Australia (e-mail: wanatca@AOI.com.au, website www.AOI.com.au/wanatca). 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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IN SEARCH OF THE CINNAMON PERSIMMON

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My fascination with persimmons began on a chilly December morning two years ago, when Ignacio Sanchez, a farmer in the Central Valley, took me to the yard of a Japanese neighbour. He pointed out a tree, bare of leaves, with small, round, bright orange fruits blazing against the azure sky. When he cut one open, it had speckled brown flesh that was juicy and sweet, with an intriguing cinnamon flavour. "It's a Maru persimmon," Sanchez said. "That's best kind. Lots of Japanese have them in their yards - but you can't find them anywhere else."

Most Southern Californians know about the two main types of persimmon - the flat, crunchy Fuyu and the acorn-shaped Hachiya, which is edible only when ripe and soft. But there hundreds of other varieties. Furthermore, the persimmon has the power to command an almost mystical devotion. In Japan, it enjoys much the same cultural significance as the apple does in the United States.

This reverence is not limited to Japan. In Westwood, the late Art Schroeder, professor emeritus of subtropical horticulture at UCLA, supervised a comprehensive collection of persimmon trees until they were cut down in 1960 to make way for the UCLA A Medical Centre. At his home in Santa Monica's Rustic Canyon, he maintained a file of agricultural bulletins and treatises dating back to the 1910s and 1920s, many written in Japanese, and accompanied by exquisitely detailed drawings and handwritten translations - labours of love from boosters and philosophers of the persimmon.

From these fragile, yellowing pages and faded images emerged a vision of the glory years: California persimmons in the 1920s, when growers offered dozens of rare and fine varieties, and devotees immersed themselves in esoteric lore. Could there be even a faint echo of those riches in today's California? Were there more Marus waiting to be discovered? To find out, I set off on a two-week, 3,000-mile tour of the state's persimmon producers, both commercial and unconventional.

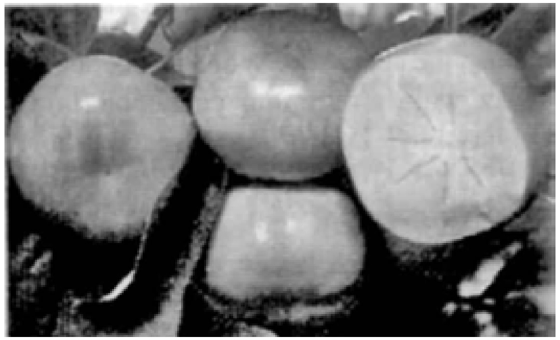
The first stop was at the Valley Centre orchard of Jim Bathgate, president of the California Fuyu Growers Association. His family began growing Hachiyas in San Juan Capistrano in the 1920s; after selling the land to developers in the 1970s, he moved to his current location, 35 (miles north of San Diego, where he grows three acres of Fuyus.

§ Member, WANATCA

Are Fuyus really Jiros?

"What got this area going in the mid 1970s was the arrival of the Vietnamese boat people, who were more familiar with Fuyus than Hachiyas," said Bathgate, threading his way through a jungle of trees, their limbs sagging to the ground with golden fruit. In season, which reaches its peak in November and early December, he said, many Asians drive to the area to pick their own Fuyus.

It turns out, however, that almost none of these fruits are actually of the true Fuyu variety. Though it is still the most popular variety in Japan, where it originated around 1900, the true Fuyu, Bathgate explained, is incompatible with the rootstock preferred by American nurseries. So they offer the Jiro, which is similar but flatter and squarer, and has faint lines running down the middle portion of the sides. "The true Fuyu has a slightly softer texture, but it's less sweet," said Bathgate. "I don't consider it a better fruit. "



Jiro persimmons, the standard non-astringent variety, sold as Fuyu

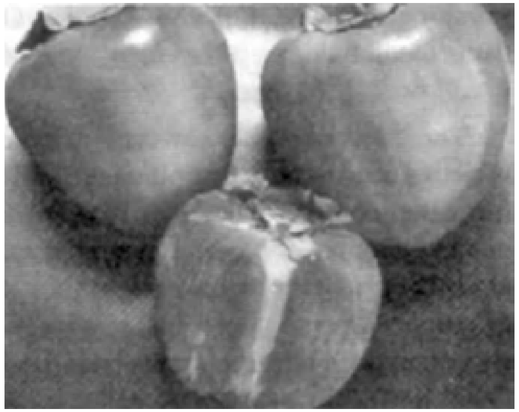
For marketing to the public, the Fuyu name now stands generically for all similar varieties of non-astringent persimmons - so when you buy fruits marketed as Fuyus, they're probably really Jiros. At an early stage of ripeness, Fuyus are pale yellow and crunchy-hard, like a firm apple, with a mild pumpkin flavour. Later they turn deep orange and are softer, juicier and sweeter.

Most are seedless, though a few seeds can sometimes be found. One notable variation on the theme is the Giant Fuyu, a large, round, extra-sweet variety that's mostly sold at farmers markets because it doesn't have the shelf life required for commercial shipments.

Those Old-Time Hachiyas

The Hachiya is an entirely different animal. It's the archetype of astringent persimmons, which, when unripe, pucker the mouth with the soluble tannins in their flesh. This astringency disappears when the fruit ripens, as its golden-orange pulp softens to a custardy, almost gelatinous consistency, with a honey-sweet flavour. Hachiyas can be eaten fresh, with a spoon, but are mostly used in the kitchen, in puddings, ice creams, breads and cookies.

The centre of Hachiya production is in the San Joaquin Valley. In the fall, the orchards are a riot of flaming orange conical fruit. When I stopped by to see Art Wiebe in Reedley on a hot afternoon at the beginning of harvest, he was hitching a 1948 Ford tractor to his "bucket wagon," hauling just-picked fruit to his old-fashioned wooden packing shed. Crusty and vigorous at age 79, he hardly broke a sweat as he toted buckets for the women to pack, stacked boxes of persimmons and operated the forklift. "I started out with a few trees in 1960, when growing persimmons was just a hobby for most people, and gradually built it up to 17 acres," he said.



Ripe Hachiya persimmons

In this country, most Hachiyas are sold to be eaten fresh, but in Japan, they are primarily raised for drying. Probably a half dozen farms in California still practice this ancient, intricate art today.

At Takasaki Farms in Parlier, a few miles from Reedley, the driveway and yard were covered with trays of Hachiyas in various stages of drying, from the yellow beehives of the recently peeled fruit to the dark, wizened shapes of the half-finished product. Even more remarkable, however, was the Takasakis" house, fastened with strands of drying persimmons.

Jon Takasaki, a cheerful man of 39 who makes his living as a peach and nectarine farmer, explained that when the persimmons are to be strung up along the wall in this traditional manner, they are clipped from the tree with a T shaped bit of stem attached so that a plastic fishing line can be slip-knotted to the stems. Either tray drying or wall drying is really labour-intensive, he said, because everything has to be done by hand. Luckily, he had his family to help.

The Art of Hachiya Massage

Sure enough, Jon's Uncle Nob and Aunt Fusa came out and started to knead the persimmons between their thumbs and forefingers to break down the fibres and facilitate evaporation. "The more you massage them, the better they come out," said Nob. "It helps keep the meat inside tender, a little like Kobe beef cattle. We massage them maybe once a week for four or five weeks." Over this time, the persimmon skin exudes sugar crystals, and a fine white powder covers the final product: a fruit with doughy texture, tasting somewhat like figs or dates.

As it grew dark the Takasakis covered the trays with plastic tarps. "We have to cover them or bring them indoors every night," said Nob. "Otherwise the fruits will soak up the dew like a sponge. It's a big gamble, drying fruit during the rainy season. It's scary - you can lose everything in one week. "

Nob started drying Hachiyas 50 years ago, just a few strings for his own and his family's use, and to give to friends for Christmas and New Year's. He and his nephew began selling their surplus to the Los Angeles market 10 years ago, found there was money to be made and started drying more. Such dried persimmons, "hoshigaki," were once a major food source and sweetener in Japan, since sugar cane and sugar beet were not grown there. Almost every Japanese garden had its persimmon tree, and the trees are still ubiquitous.

Chocolate and Cinnamon

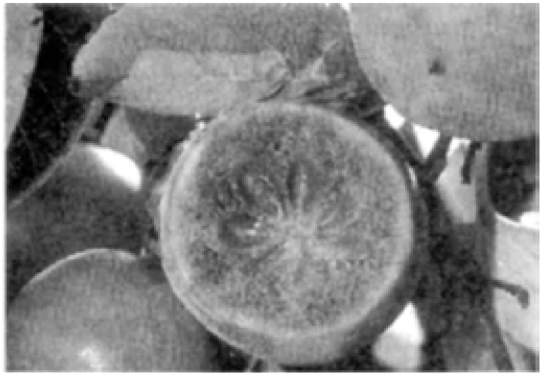
But all of this was bringing me no closer to the elusive cinnamon- and chocolate- flavoured persimmons that started my search. In California, it seemed that home gardens were the only sources. Everyone loved the fruits, but no one sold them. The reasons varied. Some growers had problems with customers who thought the dark fleshed fruits were spoiled, said Craig Ito, a major grower and shipper in Reedley. On the other hand, some unwanted customers find the fruits too delicious - Mits Kawahara of Riverside says opossums and raccoons devour his Chocolate persimmons if he doesn't pick them under-ripe.

The major obstacle, however, is more technical. To develop sweet, dark flesh, the darker varieties need to be fully pollinated, and this doesn't always happen. If only one or two seeds form, the seeded portion of the fruit will be brown and delicious, while the unseeded part will be inedibly puckery. For commercial sales, such unpredictability is the kiss of death. Most often, the growers who have a few trees, such as Toshi and Yaeko Got of Gardena, keep crates of coloured persimmons in their truck when they sell at farmers markets, reserved for customers who already know about them.

Kay Ryugo, a retired professor of pomology (fruit science) at UC Davis, is one such persimmon connoisseur. A gentle, scholarly man of 80, he spends his time building violins, making ceramics and tending his elegant Japanese garden, which includes several dark-fleshed persimmon trees. The Japanese term for dark-fleshed varieties, he said, is "goma," literally sesame seed, though it usually means black sesame seed - easy to visualise in the speckling of the flesh.

And the Chocolate variety, a pointy, intensely dark cultivar common in California, is actually the old Japanese Tsurunoko, the "Child of a Stork." In the kitchen of his home just off campus, he offered me a Maru, still crunchy but sweet. "I think the Maru is at its best when it starts to soften," he said. "It should be buttery and juicy, but not gelatinous like a Hachiya. In an ideal world, you'd wait for them to get softer than this, but if you did, birds would get them." He also explained why dark-fleshed persimmons need to be pollinated, and why they taste so good: one of his students found that alcohol exuding from the seeds causes the astringent tannins in the flesh to clump together, turn brown and develop more flavour.

Ryugo showed me a Japanese umbrella varnished with green persimmon juice; his wife, Masako, offered tea made with persimmon leaves and told Japanese folk tales about persimmons. Then we drove out to the University's persimmon collection at the Wolfskill Farm in Winters. No one else pays much attention to the grand old trees (modern pomologists focus on more commercially important crops), but Ryugo at least enjoys the harvest from the best of the several dozen varieties each fall.


Maru persimmons, which have coloured flesh when pollinated

We tasted a lusciously honeyed, ripe Saijo, one of the main astringent varieties in parts of Japan, but unknown here because of its small size. We saw one tree with leaves already turning yellow: an American persimmon, *Diospyros virginiana*, native to the Eastern United States, bearing ripe golden fruits; they were small and seedy, but soft, and tasted like flowery caramel pudding. But with all of these persimmons to choose from, Ryugo said his favourite was still a goma from his childhood, the Hyakume. "When I was young, my father was in the wholesale produce business in Sacramento," he said. "He used to buy Hyakume from small plantings in Placer County, all grown by first-generation Japanese-Americans. But no one grows them any more."

The Goma at the End of the Rainbow

The clue was tantalising: any chance of finding the elusive cinnamon persimmons might be in this traditional growing area - or what remained of it. Searching the Internet, I found a certain Howard Nakae of Newcastle, who grew persimmons that he called "Howard's Amagaki" in the foothills east of Sacramento, the heart of Placer County's old persimmon belt. As soon as we got out to his orchard, I recognized, from the drawings in my Japanese books, the roundish, buff-yellow fruits, marked with distinctive fine russet lines: Hyakume! But when I cut one open and was about to take a bite, I realized something was wrong: the flesh was yellow and astringent, not brown and sweet: it hadn't been pollinated!

The State of Persimmons

The Oriental persimmon, Diospyros kaki, is native to China. In Japan, where it is particulariy appreciated, it has been grown for 1,000 years. California's recorded persimmon cultivation began with the importation of grafted trees from Japan in the 1870s, but in the early years, persimmons mostly served as a sideline, rather than a major crop. As the Asian-American population grew, however, small producers found they could sell their harvests at good prices.

In the I 920s, as part of a general boom in subtropicals, including avocados, dates and loquats, persimmon plantings surged from 500 acres to more than 3,000. Substantial orchards were planted in Placer County and the Sacramento valley, but three quarters of the state's persimmon production was in Southern California, mostly in Orange and Los Angeles counties, where the trees were commonly interset in citrus groves. While Los Angeles consumed a large share, shippers sent half the crop to eastern markets. The astringent Hachiya was the leading variety.

Growers also experimented with dozens of others, such as the non-astringent Fuyu and the Hyakume, a brown-fleshed type renowned for its superb flavour. As production increased, the Southern California Persimmon Growers Association formed in 1927, tried to promote persimmons to mainstream markets with recipe booklets, billboards and radio advertising. The fntit never became staple, however, and in the 1930s, as a result of the Depression, overproduction, and real estate development, persimmon plantings collapsed back to 500 acres, where they held through 1975.

In the mid-70s to mid-80s, Asian immigration sparked the state's second persimmon boom, as it had the first. This time, plantings of the snackable Fuyu predominated over the Hachiya, and most went into the San Joaquin Valley and North San Diego County. In the US Department of Agriculture's 1997 Census, the latest count, the state had 3,459 acres of persimmons.

Nakae did manage to find me a few seeded, cinnamon-fleshed fruits, which were as exquisite and rich-flavoured as I had dreamed. But only five percent of the 10-acre orchard was goma, he said. What did he do with the rest?

"When my family bought this orchard in 1934," Nakae said, "there were a few Hyakume trees, but we couldn't do anything with them because they were puckery - you could only eat them soft like Hachiyas. My mother said that in Japan they had ways to get the pucker out. We started treating them with alcohol, but the fruit got soft, and it left a smell. Over the years, though, we finally got it right."

At his packing house, Nakae showed me the closet-like room where he carried out this process, but declined to reveal how it was done. Perhaps it's a variation on the old Japanese method of de-puckering astringent persimmons in sake barrels. However, it was done, the de-puckered, yellow-fleshed Hyakume, which Nakae sells wholesale and by mail order, are delicious.

Then I had an inspiration: From Art Schroeder's archive, which I had carried to Newcastle with me, I showed Nakae a 1910 treatise by a Japanese marquis, telling how to pollinate the Hyakume. His eyes grew wide. Then I put him on the phone with Kay Ryugo, the expert. They spoke excitedly. It's a small start, but the glory days of California persimmons may be coming back, or at least a taste of them.

Know your persimmons - they're not all alike

Persimmon varieties are classed either as pollination-constant - meaning that their flesh remains the same colour whether they have seeds or not - or pollination-variant - meaning that they develop brown flesh when seeded. Persimmons are also classed either as astringent like the Hyakume, or non-astringent like the Fuyu.

American or Native, *Diospyros virginiana* - Pollination-constant astringent. A different species from the Oriental persimmon (*Diospyros kaki*), indigenous to the Eastern US, south of a line from Connecticut to Kansas. Very astringent when unripe; rich sweet and custardy when soft. Traditionally harvested from small-fruited wild seedlings used for puddings and baking in the East, where they're sometimes known as 'possum apples'.

Izu persimmons, an early maturing non-astringent variety

Chocolate persimmon, Tsurunoko, "Child of a Stork" - Pollination-variant non-astringent. Medium to small; cylindrical tapering; skin orange-red; flesh dark brown when seeded, sweet and rich. Mid-season. One of the best-known coloured-fleshed varieties.

Fuyu , "Wealthy" - Pollination-constant non-astringent. Medium-large; plump oblate; skin deep orange to orange-red; flesh light orange; texture a bit softer than the Jiro, not quite as sweet. Season mid-late. Introduced to US in 1910 from Japan where it originated in Gifu prefecture, in 1902. Generic term for non-astringent persimmons.

Giant Fuyu, Hana Fuyu - Pollination-constant non-astringent. Large; round-oblate; skin yellow orange; flesh dark yellow-orange more intense around the seed cavities; sweet and juicy, softens soon after harvest. Originated in Korea or China, introduced to the US in 1930. Sold mostly at farmers markets.

Hachiya, "Beekeeper"- Pollination-constant astringent. Large; acorn-shaped; skin deep orange-red, thin and almost transparent; flesh deep yellow-orange to golden orange of custard like consistency and honeyed sweetness. Leading variety in California for many years, second after the Jiro today. Originated long ago in Mino province Japan.

Hyakume (name is an old Japanese unit of weight equivalent to 5/6 of a pound) - Pollination-variant non-astringent. Medium to large; roundish; skin buff-yellow to orange, often with fine russet lines around the apex; when seeded and flesh dark cinnamon, considered the best in flavour; unseeded fruits are yellow-fleshed and astringent unless treated or allowed to soften. Midseason. Ancient Japanese variety once widely grown in California.

Jiro (name of a man) - Pollination-constant non-astringent. Large; oblate, flatter and squarer than a true Fuyu; skin deep orange to orange-red with four shallow incised lines that appear on the sides; flesh light orange; texture crisp to tender and juicy depending on maturity; sweet. Midseason. Originated in Shizuoka province Japan about 1844; introduced to the US before 1918, already being called Fuyu by the 1920s. The leading persimmon variety in California.

Maru, "Round" - Pollination-variant non-astringent. Small; round; skin dark orange red; flesh dark cinnamon when seeded, sweet and rich. Maru is used as a suffix for several variety names such as Zengi Maru, Daidai Maru, so the name Maru should properly be used as a type rather than a variety.

Tamopan, "Large grindstone" - Pollination-constant astringent. Large; flat with a constriction around the middle giving it an unusual appearance; skin thick tough reddish orange; flesh light orange very juicy but not rich. Late season introduced from China in 1905 by agricultural explorer Frank Meyer.

Triumph (Sharon Fruit) - Pollination-constant astringent. Medium; flat; skin orange red; flesh deep orange. Grown in Israel, imported to much of the US; looks and tastes like a Fuyu but is treated with carbon dioxide to remove astringency. Late season.

[Based on an article in Fruit Gardener (California Rare Fruit Growers), 2001 September-October]

Fruit Gardener:A2886

California Rare Fruit Growers: A1115

MACADAMIAS AT THE CROSSROADS

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Introduction

Macadamias are indigenous to the fringes of rainforest that once covered large coastal areas of Northern New South Wales and Southern Queensland. Macadamia integrifolia evolved in Queensland, whilst Macadamia tetraphylla evolved in New South Wales with a certain degree of hybridisation and overlap in border regions. It would appear that a higher percentage of M. tetraphylla or M. integrifolia x tetraphylla hybrid varieties or seedlings perform better under low light levels and cooler temperatures, such as in New Zealand. They also perform better under more extreme temperatures and low humidity experienced in California, than M. integrifolia varieties or seedlings.

A study of heat and desiccation in Macadamia trees was done more than thirty years ago by Dr Lois James at Riverside University, California. In preliminary tests it was found that leaf tips, petiole sections, pieces from the centre of the leaf, sections of stem with bark, sections of stem with bark peeled off, and sections of both old and young roots, when taken from a given plant all 'killed' at a temperature that did not vary more than 1 deg C. Leaf samples from 50 trees were then subjected to various temperatures in a water bath in steps of one degree. The nine trees showing the least resistance were all M. integrifolia and included HAES 333 and HAES 246 (1). Western Australia with a Mediterranean type climate would be well advised to look at varieties selected for a harsher climate, rather than Hawaiian integrifolia varieties which were selected for totally different climatic conditions.

It appears from our own observations in other countries where we have varietal trials that some of the A series hybrids are better able to withstand low temperatures than most integrifolia varieties, this also appears to apply in the southern areas of Northern N.S.W. coastal regions where Macadamias are now grown commercially. This is not surprising if one considers that M. tetraphylla evolved in a cooler climate and that A series hybrids have a limited number of tetraphylla genes.

It is also my belief that M. tetraphylla evolved at lower light levels in the rainforest than integrifolia species in Queensland, which would account for the high anthocyanin level in juvenile growth of many tetraphylla seedlings. This discussion paper is not intended to promote A series varieties, but to ask growers and processors to take an unbiased approach and to ask themselves where future direction for Industry lies, if it is going to survive. We are all aware that most of the population of Australia is on the East Coast where Macadamias grow, as urbanisation increases Macadamias are being pushed out into hotter and colder regions. Varieties and present farming methods must change if the Industry is to survive. This paper has been divided into three sections: The Past, the Present and the Future.

The Past

The Australian Industry has been built on Hawaiian varieties selected for Hawaiian conditions. HVP contributions have been small because we started much later than the Hawaiian breeding program which began in the nineteen thirties. However in the Australian Regional varietal trials initiated in 1984, the first of our varieties, A4 and A16 were represented with forty other selections which included the best Hawaiian cultivars, both of our selections finished up among the top fourteen varieties recommended and in the top ten at three of the four trial sites (2).

The results of these trials indicated that no variety performs in the same manner at different sites, in relation to yield, kernel quality and morphological characteristics. As an example, A16 remains a much more open tree where it was selected at Hidden Valley, when compared with A16 trees in N.S.W. which are much denser. The answer of course is to let more light in. A16 trees are susceptible to Husk Spot which is another good reason to open up the canopy to allow better spray penetration. If the trees are irrigated, they should be watered for longer periods closer to harvest time to avoid excessive stress. Our own experience has been that in a dry year A16 trees carrying heavy crop that are not irrigated on a dry ridge will produce 'stick tights'. Lower down the ridge where there is more moisture, it is not a problem. In most cases: Heavy crop + Stress = 'Stick tights'. This can apply in any high yielding variety.

In a recent A.M.S. News Bulletin report (3) relating to Husk Spot tolerance and drop pattern, two of the most widely planted more recent Hawaiian varieties HAES 842 and HAES 849 fit into the same late to very late drop pattern as A16 and Daddow. It is interesting to also note that the following are classed as very intolerant cultivars (measured as reduction in % kernel oil in relation to nut drop patterns). Own Venture, HAES 781, Daddow, HAES 705, HAES 849, HAES 246, HAES 741. The only tolerant cultivars are NG7 (very Late) and HAES 815 and HAES 791, both mid-late season fall. The remaining 13 varieties tested, which include A4 and A16 fit in the area between tolerant and very intolerant. In our assess-

Macadamia leaves, flowers, fruits: upper single leaf, M. integrifolia, lower, M. tetraphylla. From "El Arbol al Servicio del Agricultor", by Frans Geilfus ment, we would class A16 as highly susceptible to Husk Spot and A4 as being not susceptible, however this has no relationship to tolerance measured in oil content of kernel. It is very unlikely that a variety resistant to Husk Spot, to the extent of showing no symptoms after being inoculated with spores will be discovered. However we can live with varieties that are infected, if they don't drop their nuts until the kernel is mature.

In the more recent varietal trials initiated at Forest Glen in 1992 (4), the ranked accumulated kernel yield, tree/kernel (Kg) between 1996 and 2000 were as in Table 1.

The mean for 1st grade kernel % for all varieties during these years was between 94.5% and 99.3%, (within acceptable limits). Table 2 shows a summary of yield data (1997-2000) taken from the trial initiated at Worrell Creek, Stuarts Point, NSW in 1992. The mean 1st grade K and accumulated K yield per tree has been ranked between 1997- 2000 (5).

Table 1
Accumulated kernel yield per tree (kg)

A29	27.24
A38	26.8
A16	25.22
A268	24.32
A4	21.20
A203	20.46
H2	17.12
344	16.67
772	16.42
741	12.37

The Present

Interpretation of the results to date on the above trials give quite a different result from what we believe will be the correct interpretation in the future. Looking first at the Forest Glen trial, one can safely say that all varieties measure up to existing first grade kernel standards, which leaves us with the accumulated kernel yield per tree, or better - kernel per hectare. One has to ask the question, why is it that the two Industry standards HAES 246 and 344 and the high yielding Australian H2 are at the bottom of the list and A series varieties all have higher yields? One would expect some of them to be higher, but not all of them. We have always believed that A series varieties may well require slightly different cultural practices, particularly in relation to fertilizer application and timing. Many Hawaiian varieties flower and crop earlier in the season than some A series and other Australian varieties, fertilizer timing could well hold the key to crop and also quality. This is an area that should be looked at more closely in the future and Forest Glen would be a good place to start, looking at past fertilizer records.

Looking at the Worrell Creek trial site, 1st Grade K % is of concern. Any variety with % 1st grade K below 90% should be treated with caution in that environment. This leaves A29, A4, A38, A16 and HAES 344. The old Industry Standard HAES 246 seems to perform well there, however the 1st Grade K % is low. Here again, nutrition and timing may well influence kernel quality.

The Future

The future we believe lies in high density planting, which is happening or has already happened in citrus, stone fruit and pome fruit crops. Smaller areas and much higher net returns. We already know that it is possible to grow Macadamias successfully at a spacing of 5m x 2m (1000 to ha), whether it is possible to increase that level as has happened in other tree crops remains to be seen. We believe that inter row space will be limited to a minimum of 5m between rows for tractor access, the height of the trees will not exceed 5m and that the trees will have open limb structure with high light levels within the canopy. Tractors and farm machinery will be much smaller than on many present day farms. The planted areas are more likely to be situated on flat or near flat ground, rather than on well drained ridges. Initial capital costs are much higher and some growers will probably follow our example and propagate their trees from cuttings (6). Trees grown from cuttings correctly, are equal to or better in some respects than grafted trees, and are less labour intensive to grow.

Table 2

Mean 1st grade K %		Accumulated K./Tree Kg	
A199	98.62	A29	21.73
A4	98.47	A268	17.84
A38	98.09	A4	17.30
A16	95.80	H246	16.29
H344	93.94	A38	16.10
A29	92.28	A203	14.80
Bmont	91.71	A16	14.68
Fernleigh	89.27	A323	14.67
A203	88.12	Bmont	13.36
A268	87.28	H344	12.92
A323	86.73	A199	12.33
H246	86.55	H508	11.80
H508	85.55	A192	10.21

The life of a high density orchard is unknown at this stage. It is quite possible that because the height and canopy width will be strictly controlled and the yield per tree much lower than in a wide spaced orchard (which has a much higher yield per tree), high density orchards will be less susceptible to stress when they reach full production and maturity. Choice of site we believe will be very important.

This year at HVP we laser levelled a low lying area and have put in slotted drain pipe in the inter row spaces. Plantings are at 2.5m between trees and 5m between rows (800 per ha). A small section of some rows has been allocated to Tatura trellis with a tree spacing of 1m between trees in the row, or 2000 trees per ha. The trees are planted in a straight row with the trunk of the first tree bent outwards at an angle of 18 degrees in one direction and the next one in the opposite direction, alternately down the rows. The trunks are tied to the trellis and trained to grow outwards at an angle of 18 degrees. The concern with Macadamias being whether apical dominance will take over and the exposed top side of the trunk produce a mass of shoots - time will tell. The initial objective is to test selections for precocity, yield and light levels and how they respond under these conditions.

Selections considered at this stage are shown in Table 3.

Some of the Hawaiian varieties planted in the Experimental Block are also being observed, however most of these we believe will not retain an open limb structure which is essential. It is possible that some A series selections that have been discarded in the past because the limb structure was too open, could be alright under the new concept.

The trial sites covered in The Present section of this paper, if analysed in relation to the direction the Industry must take in The Future in order to survive, give very different results. The varieties will be limited to ones that are able to withstand hotter and colder temperatures, some of these conclusions are based on information from overseas trial sites where the trees are growing under more extreme conditions. They will also need to be precocious, have an open limb structure, respond to mechanical pruning and have good kernel quality in what will be a different environment. The height of the canopy will be strictly controlled and the root system restricted.

Table 3. Behaviour of selections

A4	May be O.K.
A16	Probably too dense.
A38	O.K. on past experience.
A29	Probably OK. Like A38 bears crop within canopy. Not precocious.
A104	May be OK. Too open when grafted but may be O.K. when pruned regularly.
A 199	Very doubtful. Good shape but bears crop over long period.
A268	Probably too spreading.

It is important for those Growers and Processors who are in for the long haul and looking to the future, that they are made aware that they would be making a grave mistake if they pin themselves entirely to Hawaiian varieties, which were selected in and for different climatic conditions, different tree spacing and different light levels. This may not apply so much now but it will certainly be so in the future. Consider the following points:

• Most integrifolias are not as tolerant to heat and cold as tetraphyllas or varieties of hybrid origin. What is considered high density planting at 8m x 4m by many growers, will be low density in the future.

• Most Hawaiian varieties will not be suitable in future high density plantings because the canopy is dense and most of the crop is borne close to the outside of the tree. They are slower to bear commercially which is crucial in high density.

• At last count at the end of 1998, over half a million A Series trees had been sold in Australia, it would be now closer to one million - too many for any processor to ignore. Particularly in marginal areas.

Consideration for Processors

There is a huge difference in roasting colour requirements. Some processors roast kernel so lightly that it looks no different from raw kernel and tastes not very different either. This is done for good reason because there are less rejects, but may mean a less palatable end product. Other markets require well-coloured roasted kernel with a stronger roasted flavour.

Some processors who have a niche market are throwing out sound kernel that doesn't measure up to their colour standards. A good example being the division line between the cotyledons, which is more prominent in some varieties than others, particularly in A38 in some years. They should take a look at cashew nuts selling for about the same price in the supermarkets. If they were penalised on the same basis, there wouldn't be any cashew nuts for sale.

If supplying roasted bulk kernel to buyers, would it not be a simple solution to colour-sort to standard A and ones that were too dark would then go to standard B for a different market? They have already been sorted for quality before roasting, so why throw out kernel that can supply a different market? Last year the South Africans raised the issue of roasting colour relating to varieties. It is not possible to differentiate roasting times in relation to species, there is overlap within the species which means that you can't simply separate out roasting times between hybrids and integrifolia. In recent DNA typing, it has been found that there are tetraphylla genes in some of the later Hawaiian selections; this may account for the differences in roasting times. The day may well come when certain varieties when sold as raw kernel will have stamped on the box recommended roasting time and temperature. However before this can be done, standard methods have to be set in place. It is more difficult to arrive at a standard procedure for dry roasting than oil roasting, different processors use different equipment.

Future pressure from large supermarket chains: It is important for processors or buyers to resist pressure from this direction in relation to end product, not regarding quality which is all important, but regarding varieties. It has already happened in many sections of the fruit and vegetable industry where large outlet chains will only take certain varieties of fruit or vegetable. If we allow ourselves to be talked into the situation where we are selling Macadamias as a variety, we are putting huge limitations and constraints on the Industry as a whole, particularly in the area of varietal improvement. Macadamia varieties perform quite differently under different climatic conditions, if we are limited to selling nuts from half a dozen varieties, we will also be reducing the viable commercial growing area in Australia.

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Hidden Valley Plantations: A 1684

Australian Macadamia Society: A 1055

WILD FRUITS OF AUSTRALIA

JOHN M. RILEY

Most of the native Australian fruit seed distributed by the California Rare Fruit Growers have come from the generous donations of Paul Recher, Dave Higham and Geoffrey Scarrott. With the organization of the Rare Fruit Council of Australia, perhaps additional seed will become available in the future. Most of these Australian fruit are not described in common literature. This paper suggests that many of these native fruits should be grown in California.

Australia was uninhabited by man until about 10,000 years ago when the Aborigines came in from the tropics. When Captain Cook discovered Australia, he found a very small population of Aborigines who wandered about this harsh land as predators on just about anything organic. Consequently Australian fruit was not improved by man but was possibly further degraded by man's continued forays. Had the country remained isolated after settlement by immigrants, the better fruit would have come into cultivation and been improved. Instead, already established Western-world fruit were imported. Except for the Macadamia nut, none of the native fruits have entered the world markets.

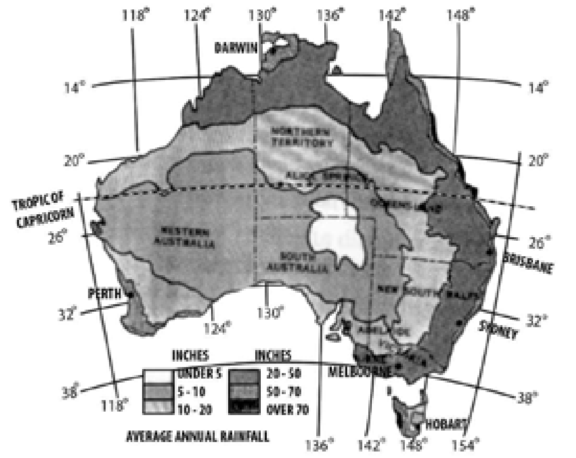
Some Geographical Considerations

In the very beginning Australia was an outlying region of Southern Gondwanaland. Its climate was warm-temperate to subtropical and humid. Contiguous lands included Antarctica, India, South America and Africa. Australia drifted north about 50 million years ago on a very stable geological plate. Consequently, it is considered to be the oldest and most stable continent. As Australia drifted through the rainy latitudes its soil was depleted of nutrients and minerals. Particular soil deficiencies are copper, molybdenum and zinc. Today Australia lies squarely astride the arid Horse Latitudes.

Australia is also the flattest of the continents. About three quarters of the land mass is a vast ancient plateau averaging about 1,000 ft. above sea level. A central portion is lowland with an elevation of less than 500 ft., and in one place, it is below sea level. The eastern portion of the country is a highlands plateau with an elevation averaging less than 3,000 ft. with a few peaks above 5000 ft.

Climate

Although Australia is completely encircled by warm ocean currents and is the lowest, flattest continent, it is quite arid. The major reason is that it lies in a region typified by high pressure and descending air currents of low velocity. There is no mechanism to carry the warm, moist ocean air inland to produce rain. During the winter, this high pressure band of air crosses the interior of Australia and all except the southernmost parts of the continent are dry. In summer this pressure belt has moved south of the continent, still giving dry conditions over the southern and western areas. Thus the total annual precipitation is less than 20



inches except in the extreme southwest and in a strip circling from southeast to northwest. The average precipitation is less than 10 inches in a large south-central area. In the south, the winter precipitation is of the cyclonic type; in the north, heavy summer rains are of monsoon origin; the rainfall of the eastern regions is due to the immediate presence of the highlands in the vicinity of the ocean.

Because of Australia's location, severe freezing temperatures are found only in a small region of the south at high elevations. In the arid interior, summer temperatures are very high; these rank with the hottest regions of the earth. The following are typical weather features in Australian regions of interest to gardeners:

Location	Elevation (feet)	Temperature (deg. F)		Precipitation (inches avg.)				
		max	min	Jan	April	July	Oct	Annual
Adelaide	140	116	32	0.72	1.75	2.51	1.74	21.22
Alice Springs	1926	117	23	1.74	0.85	0.43	0.68	10.71
Brisbane	137	109	36	6.29	3.56	2.30	2.52	45.07
Darwin	97	104	56	15.64	4.28	0.07	2.08	61.37
Melbourne	115	111	27	1.91	2.19	1.85	2.63	25.58
Perth	197	108	34	0.34	1.65	6.57	2.21	34.32
Sydney	138	108	36	3.67	5.33	4.86	2.84	47.46
San Diego, USA	50	110	25	1.97	0.71	0.04	0.52	10.11

Australia and Gondwanaland had similar flowering plants that appeared about 70 million years ago. Subsequently Australia drifted away from its motherland. This voyage was northward away from a warm, gentle climate. The primitive, evergreen plants grew in long isolation, and were challenged by an arid climate and particularly poor soil. This resulted in a vegetation predominantly very different from that of the rest of the world. Among the Successful plants are the Myrtaceae family of which Australia has 45 genera and nearly 1,200 species. The EucaLyptus genus is dominant with more than 500 species. More than 600 species of Acacia are found in Australia. There are 37 primitive members of the conifer family, but no true pines. As the northern end of the continent pushed into the tropical latitudes occasional plant species entered from the tropics and spread southward until limited by the desert. Today most native Australian plants are unique and specialized for their environment.

Fruits of Interest

Since the Australian climate is in many ways similar to that of California the native Australian fruits should readily adapt to our conditions. Cribbs lists 178 fruit and nuts which are in some fashion edible. There is a preponderance of large-seeded, tropical trees whose seed may be eaten as 'nuts' after they are leached or boiled to remove toxins. There are numerous small 'conservation' fruits that are not of much value in their present state. These are deliberately omitted here in favour of fruit with obvious potential for development in California.

In the following list, the letters in parentheses following the plant name refer to the Australian province in which the plant is found.

Antidesma is represented by seven species in Australia. *A. bunius* and *A. dallachyanum* (QLD) are commonly found as shrubs or small trees with simple, alternate leaves bearing inconspicuous male and female flowers on different plants. The rounded fruits, mostly 6 to 12 mm across, vary in colour from cream to red and purple-black. They have a very acid pulp surrounding a central stone. A characteristic is that the fruit are densely borne on the stalk. *A. dallyachyanum* may reach 2 cm across. These plants are relatively tender and suffer damage below about 30 degrees.

Austromyrtus dulcis (NSW, QLD) is a low straggly, highly ornamental shrub producing one of the best of the edible native fruits. The young leaves, about 2 cm long, are pink and silky. Its white flowers are borne singly in the leaf axils and are followed by currant-like fruits that are pale lilac or almost white with darker purple flecks, and about 1 cm across. The soft pulp has an aromatic, delicious flavour. The skin is very soft and seeds small so the whole fruit can be eaten with pleasure. The plant is said to be a prolific fruiting plant, easy to grow from seed.

Araucaria bidwillii 'Bunya Nut' (QLD) is a large growing pine valuable as an ornamental and a timber tree. The Bunya nut is extracted from large cones. Its taste is a blend of chestnuts and pine nuts. The nuts are pierced and then roasted. Fruiting trees are known in California.

Billardiera 'Appleberry' is a genus of about eight species of small evergreen vines bearing edible fruit. The small bell-shaped flowers are inconspicuous but the fruit is very ornamental. *B longiflora* is commonly grown for its blue fruit. Other species are *B. scandens* with yellow or red berries, *B. cymosa* with reddish berries, and *B. mutabilis*. Seed should be germinated at about 55°F.

Capparis mitchelli 'Small Native Pomegranate' (AUS) The fruit is from 1 to 2 inches in diameter and the pulp, which has an agreeable perfume, is eaten by the natives. *Capparis nobilis* 'Native pomegranate' (NSW, QLD) has fruit, 1 to 2 inches in diameter, which is eaten by the natives.

Citrus is widely cultivated in Australia. The native Citrus species are notably different from all other species of citrus, suggesting an isolated and diverging evolution. These are of special interest as ornamentals having great vigour and unusual fruit and foliage. Additionally they represent Citrus relatives adapted to unusual soil conditions, extreme drought or rain forest conditions.

Eremocitrus glauca 'Desert Lime' (QLD) is a pronounced xerophyte, growing in dry areas and dropping its leaves under the stress of drought. In the summer it bears heavy crops of rounded yellow fruits 1 to 2 cm broad. Since its rind is soft and less bitter than most members of the citrus group, the fruit makes an excellent marmalade.

Microcitrus australasica 'Finger Lime' (QLD, NSW) is one of five subspecies in Australia. It produces curious pickle-shaped fruit about an inch in diameter and 4 inches long. These can be sliced into rings and preserved. The very acrid pulp has a harsh aftertaste.

Microcitrus australis 'Round Lime' (QLD, NSW) bears fruit the size of a large walnut. The flavour is lemon-like with a harsh aftertaste. Both *Microcitrus* species are very vigorous and good candidates as rootstocks for citrus grown in arid California lands.

Microcitrus garrowayi (QLD) is a rare species similar to *M. australasica*.

Microcitrus inodora (QLD) is a rainforest species with fruit of good flavour.

Davidsonia pruriens 'Davidson's Plum' (QLD) is one of the best native fruits. Its fruit is blue-black, plum-like, with loose hairs on the surface. The flesh is soft, juicy, purple and contains small flattened seed with a fibrous coating. The fruit is very acid, but stewed with sugar or made into jam or jelly, it provides a distinctive and most enjoyable food for anyone who likes a sharp taste in preserves. The plant is striking in form and foliage.

Diploglottis australis 'Native Tamarind' (QLD, NSW) is a relative of the litchi found in the Australian rain forest. The plant has a crown of very large, coarse-looking pinnate leaves sometimes reaching 60 cm long. The yellow fruit has three rounded lobes each about 1 to 2 cm broad and contains a single seed enclosed in an orange, juicy, jelly-like pulp. This is very acid but pleasant and refreshing. For those who find the taste too sour, a good drink can be made by boiling the fruits with sugar and water. They can also be made into jam. *Diploglottis campbellii* is very rare and much superior to *D. australis*. The fruit is a capsule, usually three-lobed. Each lobe is 4 cm in diameter, smooth, hard, and enclosing a single round seed. The pulp, a pleasantly acid, juicy red aril, encloses the single seed.

Eugenia is well represented in Australia. The botanists are busy splitting this large family into a number of genera, but the plants are closely related and for convenience are lumped together here. Typically these fruit vary from 1 to 6 cm in diameter and are usually round to pear-shaped. The majority have pleasant, crisp or pithy flesh which is sour and aromatic. In some, the uninteresting fresh fruit develops an excellent flavour when cooked. Paul Recher mentions *E. suborbicularis* and *E. carissoides* as their best.

Acmena smithii (*E. smithii*) Lilly Pilly (QLD, NSW, NT) is grown for its evergreen foliage and showy berries. Fruit is 1/4 to 1/2 inch in diameter, depressed, globular, edible and slightly acid.

Cleistocalyx (*E. operculata*) is a tree with ovate-elliptic leaves, 5 to 8 inches long. The edible fruit is pea-like, ripening from dark red to purple.

Eugenia suborbicularis has large, red fruit with a small stone and good flavour.

Syzygium coolminianum (*E. cyanocarpa*) 'Blue Lilly Pilly' (QLD, NSW) is a shrub or small tree to 18 ft. The 1/2-inch fruit is edible and of an unusual blue colour.

Syzygium luehmannii 'Cherry Alder' (QLD, NSW) is common in rainforests near the beach. The small pear-shaped fruits are edible.

Syzygium moorei 'Robby' or 'Durobby' (NSW) has large cream coloured fruit to 5 cm.

Syzygium paniculatum (*E. myrtifolia, E. paniculata*) 'Brush Cherry' is commonly grown in California as an ornamental. The fruit is not often eaten. No improved fruiting varieties are known.

Hicksbeachia pinnatifolia (QLD, NSW) is a stunning ornamental relative of the macadamia. It bears large strap leaves up to 60 cm long growing straight like a palm. Its fruit is bright red and 2 to 3 cm wide. The seed encased in a bony shell is edible, though inferior to the macadamia nut. The bright red rind is said to numb the mouth if bitten in the mistaken idea that it is a fruit.

Macadamia integrifolia (QLD) is probably the most common species in cultivation. Its leaves usually occur in whorls of three and often it has leaves which are without marginal teeth. *M. tetraphylla* (QLD) bears leaves mostly in whorls of four and leaf margins are always toothed. *M. whelandi* (QLD) is a rainforest tree that resembles the macadamia nut, but its kernel is poisonous and extremely bitter. *M. praealta* (QLD, NSW) is a rainforest tree with round fruits, up to 5 cm across, containing one or two nuts with shells thinner than the macadamia nut. The nut is said to have been popular with the Aborigines. Other species are *M. ternifolia* and *M. heyana*.

Nitraria schoberi 'Karambi' (AUS) is a dryland shrub which produces fruit the size of an olive, of a red colour and agreeable flavour.

Owenia acidula (QLD, NSW, NT) is an attractive small tree from the interior regions. It has pendulous branches and pinnate foliage reminding one of the pepper tree.

Owenia cerasifera, 'Queensland Plum' (QLD) is a plant which bears a fine juicy red fruit with a large stone. When eaten fresh it is very acid, but after storage it becomes palatable and refreshing.

Physalis peruviana 'Cape Gooseberry' is common and is a weed in some places. The fruit is popular for jams and pies. They are better when cooked with an equal amount of apple. Scarrott reports that jam made with ginger added is particularly good. Fully ripe fruit can be dried into an attractive 'raisin.' A striking feature is that the berry has an inflated papery calyx completely enclosing it. Despite the small size and seediness, the intense flavour recommends this for annual planting.

Pleiogynium timorense 'Burdekin Plum' (QLD) is a spreading tree with glossy pinnate leaves and purple-black fruits 3 to 4 cm broad, a little like flattened plums. The flesh around the large, ribbed stone is acid and of reasonable flavour only if completely ripe. At this time they are said to taste like 'indifferent Damsons.'

Podocarpus elatus 'Brown Pine' (QLD, NSW) is a common rainforest tree belonging to the pine family, differing from most other members by lacking an obvious cone. The round, greenish seed is seated at the apex of a larger fleshy stalk which resembles a purple-black grape with a waxy bloom. This stalk is edible, but is rather mucilaginous and resinous in flavour. It makes jam or jelly more acceptable than the raw stalks.

Psidium guineense 'Guava' has been naturalized in parts of Australia and is regarded as a good fruit. (It has been distributed in the CRFG Seed Exchange under the mistaken name of *Rhodomyrtus psidioides*.) The fruit is said to resemble *P. guajava*, though more sour. Germination takes 10 to 12 weeks or longer.

Santalum acuminatum 'Sweet Quandong' (AUS) is a good eating fruit and nut. Native to the drier parts of Australia, it regularly fruits without supplemental water. The rounded, pendulous fruits, 2 to 3 cm across change from green to bright red. The firm, fleshy layer surrounding the stone is edible when quite ripe; this stage is usually indicated by the fruits falling to the ground or rattling when shaken. Although it is rather acid, the flesh can be eaten raw. It is more often made into highly prized pies, jams, and jellies. The stones are easily removed and the flesh can be dried for later use. The seed is said to also be edible and to contain enough oil to burn like a candle. The seedlings are partially parasitic and are best germinated with a host such as grasses, Acacias or even Citrus. A related species, *Santalum album*, is grown in India with *Zizyphus oenoplia* as a host. To germinate *Santalum* seed they are cracked in a vise and the kernel removed. The surface is sterilized with sodium hypochlorite, stored in slightly damp vermiculite, and put in a darkened area at 60 to 68 deg. F. Germination is erratic.

Zizyphus oenoplia (QLD) from the northernmost part of Australia is a spiny, sprawling shrub with black, acid, edible fruit less than 1 cm broad. It is a candidate fruit for the Florida area where other *Zizyphus* do not thrive. *Zizyphus mauritiana* and *Z. jujuba* are grown in Australia though not common.

General Comments

The value of native citrus species has been recognized and some development is underway using these as rootstock and blood lines for commercial citrus. While the Australian *Eugenias* are widely planted as ornamentals, no selections for fruit are known to the author. About 40 years ago there was a fad for *Eugenias*. Many were brought into California and grown as street trees. Some may yet survive. The *Eugenia* is an attractive candidate for hybridizing to make it more variable in the interest of selecting good fruit.

Plants from the areas of extreme climate may be rather specialized in their requirements for growing-on from seed. Scattered hints suggest that the desert types may germinate better at lower temperatures (55 to 60 deg. F) rather than high temperatures. Special treatment to overcome dormancy may be important. Among these is soaking seed in small amounts of very hot water and the use of gibberellins. The author has had frustrating experience with damping off subsequent to germination of the rare plants. Careful attention to sanitation and use of systemic fungicides (Subdue) has helped. Of particular importance are soil media and watering. Overwatering is a particular problem. The *Santalum* is a root-parasite during its early growth. My few successes with its seed came when the plant was germinated together with citrus seedlings.

This paper is a brief and imperfect survey of a very broad subject. Should you care to correspond regularly on Australian (and New Zealand) plants, your letters will be answered and a 'round robin' established.

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California Rare Fruit Growers: A1115.

MASS CLONING OF *SANTALUM ALBUM* L. THROUGH SOMATIC EMBRYOGENISIS

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Abstract

Santalum album L., the East Indian Sandalwood, enjoys acceptance worldwide because of the unique fragrance in its oil and wood. The natural propagation of this important plant faces twin threats - spike disease and poaching. Regeneration by silvicultural methods being insufficient to meet the demand, several biotechnological routes of propagation have been tried. Somatic embryogenesis offers highest clonal propagation efficiency. Scale up in air-lift bioreactor improves embryo quality, saves laboratory space and minimises incubation time as well as production cost.

Introduction

Santalum album L., the East Indian Sandalwood, is among the oldest known perfumery material and is highly acclaimed worldwide. Its use in toiletries was mentioned in Buddhist Jataka Stories in 7th Century BC (Srinivasan et al. 1992). It is regarded to be native to Peninsular India and is deeply connected with many events of rich cultural heritage in this country. It is distributed within about 9600 km2 in India, mainly in two southern state Karnataka and Tamil Nadu.

Owing to its unique persistent sweet and woody fragrance, its heartwood oil is widely used in internationally reputed brands of perfumes. The heartwood is commercially important, its close grains making it high quality wood for carving in fabricating costly handicraft items that are fragrant, elegant and are largely self-protected from termites and woodborers.

'The average annual Indian export is about 2000 tonnes of wood and 100 tonnes of oil (Gupta 1998). The demand is ever increasing but the supply is decreasing gradually. This alarming situation has cropped up due to dual factors: loss of significant number of mature plants by spike disease and illegal cutting.

The replenishment by conventional silvicultural methods of vegetative propagation and by seed propagation was not very helpful because the former was slow and the latter resulted in heterozygosity in the population. Biotechnological methods of clonal propagation are thought to be the acceptable alternative. Plant biotechnological studies have been carried out for nearly four decades (Rangaswamy & Rao 1963, Lakshmi Sita 1986, Mujib et al. 1998).

In view of the poor plantlet production efficiency via multiple shoot formation, followed by rooting, somatic embryogenesis is a much more efficient process for mass cloning through somatic seedling production. Somatic embryogenesis in solid medium displayed the following problems

- very high asynchrony in somatic embryo development
- frequent developmental abnormalities.
- multiple embryo clumping
- much lower somatic seedling production potential of embryogenic cell mass.

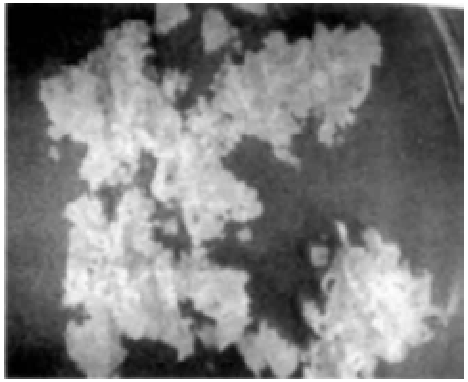
Fig. 1: Embryogenic cell mass

Somatic embryo production in bioreactor was shown to improve the situation (Bapat et al. 1990). Our laboratory has been investigating (Das et al. 1998; Das et al. 2001) on this aspect for nearly a decade, with the major objective of scale up of the process of cultivation in bioreactors, for developing sandalwood plantation in nontraditional areas (e.g., West Bengal, Assam). Major part of the work has been done in collaboration with a reputed plantation industry, under a Technology Development Mission Project. A highlight of the methods and results is presented here.

Materials and methods

Embryogenic cell mass (Figure 1) was produced by growing callus in the presence of indole acetic acid (0.5ppm) in MS (Murashige & Skoog 1962) agar medium for about 3 weeks. Somatic embryos were produced in bioreactor (Eyela; 12 litres airlift type) by inoculating embryogenic cell mass g 10 gms per litre medium (MS medium with 3% sucrose; 0.5 ppm benzyl adenine), incubated for 4 weeks. Mature somatic embryos, produced in bioreactor, were germinated in Petri plates containing MS solid medium with 3% sucrose, 0.1 ppm gibberellic acid and 0.1 ppm benzyl adenine. These somatic seedlings, after hardening for 2 months in a green house, were transferred to the field.

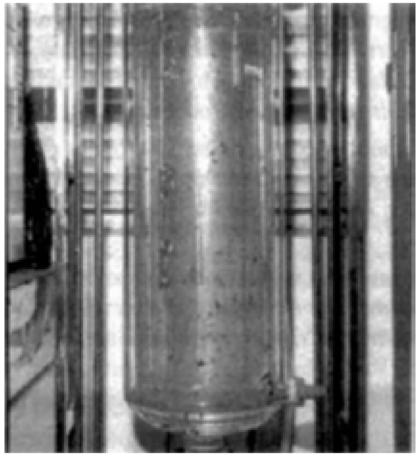
Fig. 2: Somatic embryo production in bioreactor

Results and Discussion

Specific somatic embryo production efficiency (number of morphologically normal mature embryo produced per gram of embryogenic cell mass) improved drastically (8-20 times, depending on culture conditions) as a result of cultivation in bioreactors (Figure-2).

In every batch a minimum of 2 weeks time was saved. Developing embryos (Figure-3) were more synchronous and minimally clumped (Das

et al. 1999). This dramatic improvement is due to desirable agitation and uniform access of embryos to the medium. The somatic seedlings are now growing in field conditions in their 5th year (Figure 4). The bio-process saves time, minimises production cost per somatic seedling (one third to one fourth) and require less space (nearly one-third) during embryo maturation. Certain problems exist due to developmental abnormalities in the somatic seedlings. Subsequently, the survival during green house hardening and field adaptation reduces. The anatomical and molecular biological reasons for such abnormalities are under probe in our laboratory. A solution to such problems will make the process viable for commercial agro-forestry.


Fig. 3: Somatic embryo harvested from bioreactor

The process should be applicable to other species of sandalwood. The author proposes collaboration with scientists/ industries in other countries for the application of the above bio-process for in vitro mass propagation of other species of Santalum.

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Fig. 4: A five year old plant

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ALMOND GROWING IN TURKEY

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Production

Almond is one of the most important nut species in Mediterranean countries and more than half of the world production is placed in this region. Major almond producing countries and their productions are given in Table 1.

Turkey is an important nut producing country in the world. It produces approximately 4% of world production (Koksal et al 1995). In Turkey, almond production which ranks as the 4th among nuts has increased by 39% in the last 15 years (Sengul and Emeksiz 1999). Almond production according to years is presented in Table 2. Almond production in Turkey showed some fluctuations during 1978-1987 period, whereas an increase occurred between 1988- 1994. Similar fluctuations were observed during the last few years (Anonymous, 1997). Generally, average yield per tree and per hectare is low owing to different factors as late spring frosts, lack of vegetative propagation and inefficient management. The number of mono-crop almond orchards is limited and most almond trees are planted at field borders. This has made it impossible to give a definite figure for the amount of land devoted to almond culture.

Production could not reach the expected level due to both limiting ecological conditions and self or cross incompatibility. Therefore, there are no regularly established orchards except in Datca township of Mugla province. Irrigated conditions will be provided for almond growing within the Southeast Anatolia Project. Thanks to this irrigation project, increases in production are expected in the near future.

Growing districts

Almond is grown almost in every region of Turkey, except the North-East and higher elevations in Eastern Anatolia (Dokuzoguz and Golcan, 1979). However, it is widely spread in the Aegean, Mediterranean and South-Eastern regions where dry climate and poor soil conditions determine the fruit species to be grown. Recently, the number of trees has been increasing especially in the western part of Turkey. Izmir, Mugla and Denizli are the most important almond growing provinces in this region. Mugla is the most conspicuous among the others with regard to production of almond. Almond trees are widely grown in Datca district of Mugla. They are one of the main sources of agricultural income for the growers in the region. In some microclimates such as Datca, there are still some problems in almond growing even though the temperature decreases to below zero very rarely and most of the orchards have been established using grafted trees. One of the reasons of unsuccessful almond growing in this area is the bacterial cancer disease, *Pseudomonas amygdali* (Gundogdu, 1990).

The important production areas of the Aegean and Marmara regions are Aydin, Izmir, Denizli, Isparta, Burdur and Canakkale. There are almond populations which have thick hull in Acipayam and Tavas township of DenizIi provinces and Keciborlu, Uluborlu and Senirkent township of Isparta province. Thin hull and good kernels are obtained from the production areas in Cesme, Menemen and Foca in Izmir, and Didim in Aydin and Umurlu in Canakkale provinces. Almond types which have thin and hard shell are found in Dose-mealti, Side, Alanya and Gazipasa towns in Antalya (Dokuzoguz et al., 1968; Dokuzoguz and Golcan, 1972). On the other hand, almonds in central Anatolia have very thick hull and are small. The important production areas of Southeastern Anatolia are Mardin, Elazig and Diyarbakir.

There are good prospects for almond growing in Harran Plain in Sanliurfa. Drying, de-hulling, shelling, storing and transportation of almonds are much easier due to suitable eco-logical conditions (Kaska, 1999). In addition, Upper Firat river basin and Coruh valley are the most important micro climate areas in the North Eastern Anatolia (Aslantas and Guleryoz 1999).

Climate

Temperature: Turkey is situated between 36°N and 42°N latitude and extends for nearly 2000 kilometres in the east-west direction, and is a transition between the temperate and sub-tropical climates. This has made it possible to grow many fruit species in this country.

The almond requires less winter chilling than most of the other deciduous fruit species. A relatively short and mild winter exists in those regions. Temperature in November and December is adequate for the dormancy period in coastal areas of the Mediterranean region. Average temperatures in January and February cause early flowering. For this reason, most almond trees bloom in January. Thus, this crop is consumed as green fresh almond. The first green almonds come to the market from this area. The lowest temperature ranges from -1. 6°C (Finike) to -6. 2°C (Adana) in that region every 10 years (Golcan, I 982). It is seen

Almond orcchard growing under dry conditions

Table 1 Main almond producing countries and their production (t)

	1989-91	1997	1998
World	1 288 000	1 598 000	1 268 000
USA	414 000	574 000	393 000
Spain	278 000	367 000	217 000
Italy	1 06 000	105 000	88 000
Iran	67 000	76 000	76 000
Syria	27 000	26 000	67 000
Morocco	61 000	87 000	66 000
Tunisia	42 000	51 000	59 000
Pakistan	31 000	49 000	49 000
Lebanon	13 000	38 000	39 000
Greece	57 000	43 000	35 000
Turkey	46 000	33 000	34 000

that flowers and green almond are not generally damaged by frost. On the other hand, in the areas except those at sea level, precaution must be taken to prevent frost damage for almond growing. In these areas such as Osmaniye, lslahiye and Mut, choosing late flowering types is necessary. Spring frost always occurs in important growing districts such as Akseki, Burdur and Isparta. Thus, it is determined that production losses occur quite often. Controversy, Southeastern Anatolia is too safe in terms of late spring frosts.

Rainfall: Regarding almond production, the Aegean and Mediterranean regions are of great importance. In the Aegean region, the amount of annual rainfall varies from 600 to 900 mm, and the larger amount of the rain occurs during the period from October to May. Besides, being dry, the temperature is very high during July and August. Almond trees can tolerate very limited summer rainfall.

Although, 65% of the precipitation is in winter in the western part of the Mediterranean, it is 45 % and 35 % in Adana and Hatay respectively. Spring rainfall is 15%, 25% and 29% in these places respectively. The distribution of summer rainfall in the three districts is 2%, 5% and 12%, respectively (Golcan 1982).

The amount of annual rainfall is adequate for water requirement of almond. Water re-quirement starts to increase in April and reaches maximum in July. Taking this into consid-eration, it may be accepted that Adana and Hatay districts are more suitable than the other provinces. Almond trees are well adapted to the dry hot climates and especially to the stony and calcareous soils of the western and southern of Turkey.

Cultivar situation

Almonds have been cultivated in Turkey by seeds since the beginning. The existence of a large number of bearing trees grown from seeds under various ecological conditions provides an invaluable source for varietal selections.

Because of the heterozygosity and the need for cross fertilisation, vegetative propagation is necessary to obtain a uniform crop in almond. In Turkey, almond has been grown from seeds thus hindering the possibilities of producing a standard product.

In Turkey, the first attempt for selection was made in 1966 with the aim of improving and standardising production through selected clones (Dokuzoguz et al., 1968). The existing trees in various localities differ widely from each other in such characters as vigour, yield, nut quality and flowering time. The aim of the first project was to select the best individuals among the almond trees of the Aegean and Marmara regions which are all propagated by seeds and to look for late flowering types which are very important in almond production. During 1966 and 1967 harvest seasons, 167 individual trees were marked. Sixteen types of these have been selected for their better commercial characters.

In order to improve the yield and quality by vegetative propagation with selected cultivars, trials were established in Western Anatolia including Izmir, Manisa, Aydin, Mugla, Denizli, Canakkale and Tekirdag. In this project, standard almond cultivars with high agricultural and commercial values and late flowering types were selected. 38-44 days of differences have been observed between the first and the last flower of the selections (Dokuzoguz and Golcan, 1972).

In another project on the selected clones pollination requirements, yield and vigour were searched. Some other important characteristics of the selected clones were determined (Dokuzoguz et al., 1979). In addition, selected clones were propagated by the state's own nurseries and distributed to growers in the regions where they were selected, the Aegean and the Mediterranean regions.

Selection programmes still continue in different regions. For instance, 28 types were selected from wild almonds grown in Tokat and studies are continued on this matter (Gercek, Cioglu and Gones, 1999).

Table 2. Number of bearing and non-bearing almond trees and production values between 1987 and 1997

Year	Nr. of bearing trees (x 1000)	Nr. of non-bearing trees (x 1000)	Production (t)
1987	4054	761	33 000
1988	4034	735	42 000
1989	4040	752	46 000
1990	4040	775	46 000
1991	4019	755	6 000
1992	3980	747	47 000
1993	3965	730	48 000
1994	3906	723	47 000
1995	3865	700	37 000
1996	3825	677	43 000
1997	3775	640	33 000

Similarly, a selection programme was conducted to select late flowering in the North Eastern Anatolia during 1992-1995 and 1996-1997. As a result, a collection was established at the Horticultural Research Institute in Erzincan (Aslantas and Goleryoz, 1999). In addition almond species are scattered all over Turkey. For example, *Amygdalus orientalis* and *Amygdalus turcomanica* grow naturally in Southeastern Anatolia (Ak et al. 1999).

There are some investigations in relation to foreign cultivars as in the case of an experiment which was carried out during 1988-1993 in Adana and Pozanti, where 16 foreign and 3 local almond types and cultivars were tested. Generally, the trees showed a better growth and development in Adana than in Pozanti. As a result of this study, some cultivars such as 'Ferragnes', 'Ferraduel', 'Cristomorto', 'Drake', 'Texas' and 'Nonpareil' were found promising. It will be useful if these cultivars are grown in different locations of the Aegean and Mediterranean regions (Kaska et al., 1993).

Another experiment was carried out with about 25 almond cultivars (Turkish, French, Spanish, Italian and American) at three locations in Southeastern Anatolia and Eastern Mediterranean region. Another trial was started by a private firm (NURMET) with foreign cultivars and all plants are drip irrigated (Kaska, 1999). In another study, the performance of local types and foreign cultivars was determined in Hatay under the Mediterranean region conditions (Polat et al., 1999).

Cultural practices

Orchard establishment: Most existing almond trees have been grown either as border trees or scattered in grain fields or vineyards. Trees are grown from seeds and are receiving regular care.

In recent years, very few plantations were established with nursery stocks budded with selected clones. Trees are spaced at 7-10 m distance depending upon soil, rainfall and irrigation conditions.

Propagation and rootstocks: In Turkey, up to now almond production is almost totally based on trees propagated by seeds. Recently, some of the native and foreign cultivars are being reproduced by budding in the western part of Turkey.

In propagating almonds, budding is practised either at the seed beds or at the nursery. "In situ" budding is the method that is used in Datca, the main almond growing district in Turkey. In the other regions, almond is propagated by budding seedlings. Due to the tap root formation, bud taking is low in this way of establishing the orchard. However, this method is not widely spread. Even though to a lesser extent, in propagation by budding, the rootstocks generally used are seedlings of bitter almond or other almond cultivars.

Thus, in Turkey there is not a standard seedling rootstock. Almond seedling is the only rootstock used for the time being. In grafted tree propagation, some clones such as 17-2, 2-32, 6-1 and 'Texas' cultivar is used for seedling propagation (Dokuzoguz and Golcan, 1979). The outstanding feature of soil in Turkey is the high calcium content in the majority of the regions.

Therefore attention has been given to this fact in rootstock studies. In the experiment in which some features of almond cultivars 'Afyon sivri', 'Afyon bitter', 'Mordogan bitter', 'Texas', 01- 12, 21-10, 47-10, 48-4 and 104-1 were investigated as rootstock, 'Texas' and 484 were found to be superior in quality due to seedling growth, the distance up to the first shoot and root branching. However, 47-10 which was unacceptable due to its low ratio of root branching displayed better results in terms of other parameters.

Bitter cultivars together with 01-12 formed primarily carrot roots. Carrot rooted seedlings present a lower performance in orchard establishment. However, this criterion looses its value if the seedlings are field budded. 'Afyon sivri' and 'Afyon bitter' cultivars, despite their low performance in terms of most of the assessed characters, could be considered as suitable because of the low number of shoots formed on the seedlings (Unal et al, 1994).

In addition, it can be said that the best time of budding in Erzincan condition was 15-25 August (Aslantas and Guleryoz, 1999). In Bursa, about 10,000 grafted almond seedlings are propagated and nearly all of them are produced by private sectors (Barut et al, 1999).

Soil management: The soil management is seldom carried out in arid and hot regions due to lost of organic material from the soil. The clean cultivation system has generally been used for many orchards. Deeply ploughing of the soil in late fall is the general practise. The soil may be cultivated once or twice throughout the spring and tillage is generally stopped at early summer.

Fertilisation: Manure has been the universal fertiliser for almond trees in Turkey. Fall or winter application is the general practise especially in the Aegean and Mediterranean regions. It is applied as a ring around the tree trunk. Many almond trees show symptoms of nitrogen deficiency. The use of fertilisers will raise with the increasing acreage of mono-crop almond orchards.

Irrigation: Irrigation is not practised for most almond trees grown throughout the country. Water is the limiting factor in many regions of Turkey and the almond has been considered as a drought tolerant nut species although it produces larger and better crop where irrigation is possible. Many regions of the country have very little or no rain during summer months. The almond is one of the few tree fruit species grown in rain-fed orchard systems in dry regions of Turkey. Recently, drip irrigation is being applied in some places.

Pruning: Generally, young almond trees are trained to form a leader system. It is observed that almond trees are not pruned during the productive stage.

Diseases: In some microclimates such as Datca, one of the reasons of unsuccessful almond growing is the bacterial cancer disease. According to Gundogdu and Kaya (1976), 13 % of the existing trees in this area are infected by the bacteria producing damage to the twigs, branches and trunks of the tree. Taking into account the important damages caused in almond orchards in Turkey, an experiment was carried out by Gundogdu and Demir (1990), on the control measures and the susceptibility of some economically important almond cultivars.

According to their results, 48-2 and 48-5 almond clones are found susceptible, 101-23 clone being resistant to *Pseudomonas amygdali*. In addition, breeding work was carried out in order to combine the unique characteristics of 482, 48-5 and 'Nonpareil' with resistance to *P. amygdali* and late flowering of 101 -23 (Misirli et al, 1999).

Harvesting

Almond harvest starts from middle of July in coastal line of the Aegean and Mediterranean regions. For example, harvest period is between 15-20 July and the first week of August in Alanya, Finike, Kas, Fethiye and Datca. Harvest is later in the places above the sea level. In Burdur, Isparta and Denizli harvest starts during the second half of August and ends in the first week of September. In South-eastern Anatolia, almonds are harvested in August. Almond harvest can take place in September in Central and Eastern Anatolia.

Utilization

Largest part of almond production in Turkey is domestic consumed and a limited amount is exported. The almond is a unique nut species that can be consumed at different stages of maturity from the green fruit stage to fully ripe. It is common usage in Turkey, to eat the green nuts with salt when the kernel is still crispy before the endocarp hardening occurs. The second stage for almond consumption is the time when embryos are completely developed, however, the use of this way is very limited. It is largely consumed as an edible nut either raw or dry roasted with salt, the kernel is eaten without blanching.

Almond is a major ingredient in confectionery and pastry for making various kinds of products. In confectionery, kernels are blanched and coated with sugar or chocolate. Another important use of almond in confectionery is the almond paste. The blanched kernels are ground and made into a paste with sugar, then it is prepared as candies in various kinds.

Export

Turkey's almond export, which was negligible anyway, has declined from 500 t in 1980-1982 period to 300 t in 1992-1994 period. In the same period, however, almond production has increased considerably. The domestic consumption and industrial use of almond has not increased even if nuts can be utilised in 500 to 1000 different products in nut-related industries (Sengul and Emeksiz, 1999). Almond export of Turkey is given in Table 3.

Table 3. Almond exports of Turkey

	1995 Quantity*	1995 Value#	1996 Quantity*	1996 Value#	1997 Quantity*	1997 Value#
Almond (shell)	74	95	202	747	299	1 103
Almond (kernel)	140	654	233	1 164	267	1 110

(*tonnes # US$ 1000)

Conclusion

Although Turkey has a big potential there is not an industrialised almond production. Thus the almond growing should be carried out under irrigated conditions and with standard cultivars. An important part of South-Eastern region will be irrigated. Considering this condition, this region is foreseen as an almond production centre in the future.

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APPLYING GENETIC TRANSFORMATION TECHNOLOGY TO ALMOND

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Conventional breeding of woody fruit species is a slow and difficult process due to high variation and long generation cycles. This makes them ideal targets for gene transfer technologies that have the potential to hasten the production of new cultivars and broaden the gene pool available for crop improvement. Over the past four years the application of this technology to almond has been investigated at Adelaide University as part of the Australian almond improvement project. The aim of this research has been to develop techniques that in the long term can be used to complement the currently used traditional breeding methodologies and assist in the improvement of this important nut species.

Whilst there are many steps in the production of genetically modified plants, two of the most important include a method for introducing the DNA that codes the characteristic of interest, and a method for regenerating plants expressing the introduced trait. To facilitate this, a series of experiments was conducted using almond cultivars that are commercially grown throughout Australia and the United States of America. In addition, experiments to induce rooting under tissue culture conditions were also conducted.

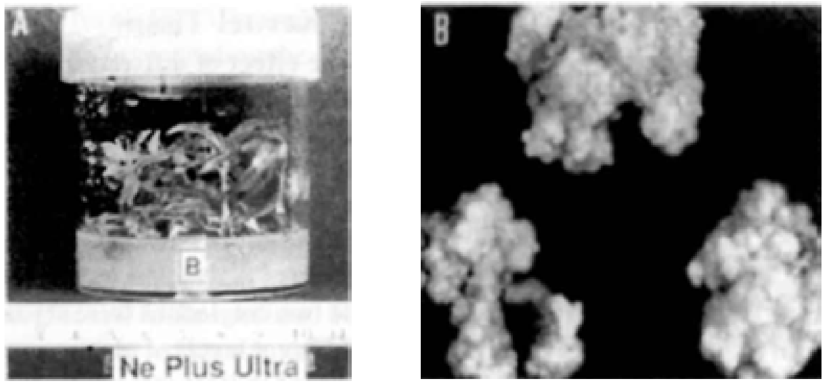
Regenerating Plants Under Tissue Culture Conditions

One application of tissue culture is the ability to regenerate plantlets from cell or tissue cultures. This is a prerequisite for plant transformation research, allowing the recovery of genetically modified plants following the introduction of the foreign DNA. Experiments investigated the ability of leaf sections and immature kernels to be regenerated under tissue culture conditions. Plants derived from leaf tissue are identical to the mother tree, which ensures that clonal purity is maintained. In comparison, plants derived from immature kernels are the result of cross pollination with a pollinator variety, and hence, any plants regenerated from this type of tissue would not be true to type. However, immature tissue has proven highly regenerative in other fruit species, and was included for comparative reasons in the study at Adelaide University.

Leaf Tissue

A series of experiments was conducted to look at the effect of different plant growth regulators on the ability of leaf tissue to produce new shoots via adventitious regeneration. Plant

Figure 1



(A) Four-week-old micropropagated shoot culture of the almond cultivar Ne Plus Ultra

(B) Callus formation of the nodular type on leaf tissue after three weeks

growth regulators are chemicals that affect the way plants grow, and when incorporated into tissue culture media can promote shoot regeneration. Two classes of plant growth regulators were tested, auxins and cytokinins. Experiments were initiated by excising leaves from micropropagated shoot cultures (Figure 1A) of the almond cultivars Ne Plus Ultra and Nonpareil (Californian Papershell). The leaves were dissected into small sections and placed on tissue culture medium that was supplemented with different combinations and concentrations of plant growth regulators.

Three auxins, 2,4-dichlorophenoxyacetic acid (2,4D), naphthaleneacetic acid (NAA) and indole butyric acid (IBA), and two cytokinins, benzyladenine (BA) and thidiazuron (TDZ), were tested. In addition, the effect of the medium additive casein hydrolysate was investigated. Leaf sections were maintained under dark conditions for three weeks, then transferred to a growth room with controlled light at 25°C for the remaining time.

The first indication of shoot regeneration was observed after between seven and ten days with the formation of callus on the leaf sections. The morphology of the callus varied depending on the combination and concentration of the plant growth regulators. Of the different types observed, nodular callus (Figure 1B) was the most conducive to the regeneration of shoots. Within three weeks adventitious shoots arising from the callus structures (Figure 1C) were visible. These shoots continued to develop (Figure 1D), and after six weeks could be separated from the leaf tissue and transferred to micropropagation medium.

Of the auxins tested, IBA was most conducive to the formation of shoots. For the cytokinins, whilst both BA and TDZ promoted the formation of shoots, TDZ was significantly better for both cultivars. The inclusion of casein hydrolysate in the medium improved callus morphology and increased the level of regeneration. Under optimum conditions, up to 45% of the Ne Plus Ultra leaf sections produced shoots, with the number of shoots per leaf section ranging from one to six. Nonpareil was more recalcitrant to these procedures, with less than 10% of the leaf sections producing shoots.

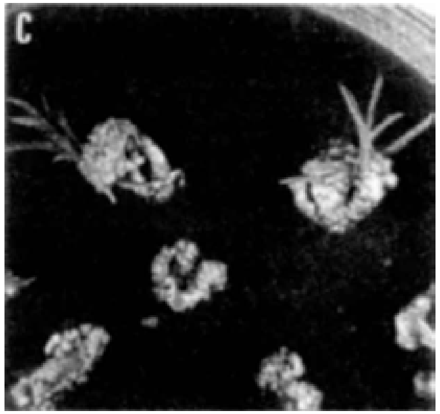
Immature Kernel Tissue

A series of experiments investigating the effect of different concentrations of the plant growth regulators TDZ (a cytokinin) and IBA (an auxin) on the regeneration of shoots from immature kernel tissue was conducted over a two year period. This aspect of the project was undertaken in collaboration with Professor Freddi Hammerschlag of the United States Department of Agriculture. For these experiments, open-pollinated fruits were collected from the cultivars Ne Plus Ultra, Nonpareil, Carmel and Parkinson, 100 - 115 days after full bloom from orchard-grown trees at the Waite Campus of Adelaide University. After removing hulls and shells, the seeds were sterilised, and the two cotyledons were separated. The seed halves were placed on tissue culture media with different levels of plant growth regulators and kept in the dark for seven days before being exposed to light in a controlled environment growth room for the remaining time.

After one to two weeks in culture, regenerating cotyledons began to swell. This was followed by the development of nodular callus. Regeneration was first evident after four weeks with the formation of clusters of adventitious buds on the cotyledon surface. At this stage, the cotyledons were transferred to a medium that was free of plant growth regulators to allow the buds to develop into shoots. For all four cultivars, the cytokinin TDZ promoted the regeneration of shoots. In comparison, IBA was inhibitory to regeneration at the levels tested. Under optimum conditions, at least 80% of the seed cotyledons developed shoots, with the number of shoots per seed cotyledon ranging from one to 23.

Rooting Almond Under Tissue Culture Conditions

The induction of roots under tissue culture conditions is an important step in plant micropropagation and genetic transformation protocols, but has often proved difficult, particularly when attempted with shoots of mature woody plants. Most previous attempts at root induction in woody plant species have involved treatments with auxin type plant growth regulators including indole acetic acid (IAA), IBA, or NAA. In this study, the aim was to develop rooting protocols for Ne Plus Ultra and Nonpareil by examining the effect of different auxins, along with other factors including the composition of the tissue culture medium and the use of rooting co-factors on root production.



(C) Adventitious shoot arising from leaf callus

(D) Regenerated shoot from leaf callus after six weeks

For these experiments, elongating shoots were removed from micropropagated shoot cultures of Ne Plus Ultra and Nonpareil. Shoots were cultured in a tissue culture medium that contained either IBA or NAA at a range of concentrations for up to 14 days. Shoots were then transferred to a medium that was free of plant growth regulators. In addition a range of different media were tested to find the most suitable for the two almond cultivars, as was the addition of the chemical phloroglucinol to the medium. Phloroglucinol is a rooting co-factor that has been shown to improve rooting in other woody fruit species.

The first evidence of rooting was observable after four days, with the formation of small root structures on the stems of the shoots. Within seven days, these structures elongated and developed into roots (Figure 1E). After four weeks, rooted shoots could be removed from tissue culture pots and transferred to soil in a glasshouse where they were slowly acclimatised. For both Ne Plus Ultra and Nonpareil, the best method of inducing roots was to culture shoots in IBA at a high concentration (200 mg L-') for one day, and then transfer them to a medium without plant growth regulators for a further four weeks. The addition of the rooting co-factor phloroglucinol increased rooting for both cultivars. Under these conditions, at least 60% of the Ne Plus Ultra and Nonpareil shoots developed roots. On transfer to the glasshouse, at least 70% of the plantlets survived acclimatisation procedures and developed into normal plants (Figure 1F).

Genetic Modification Of Almond

For many years the only approach available for the introduction of new traits into plant species was via traditional breeding methods. These techniques which usually rely upon sexual hybridisation, followed by intensive selection procedures, are extremely lengthy processes. However, advances in the field of molecular biology have facilitated the introduction of foreign DNA into plant cells. This technique, known as genetic transformation, has been one of the major advances in plant biotechnology, and is predicted to provide an alternative method for cultivar development in many plant species.

A number of different procedures has been developed to facilitate the genetic transformation of plant cells. For this study, the technique known as the Agrobacterium-mediated approach was selected, as this procedure has been the most successful with other woody plant species. The Agrobacterium-mediated approach uses the naturally occurring soil pathogen *Agrobacterium tumefaciens* that causes the disease crown gall in plants. This approach takes advantage of a mechanism in the bacteria that allows the delivery of a section of DNA from the bacterium to the plant cell. Over the past decade, techniques have been developed that permit the exploitation of this system, allowing replacement of the naturally occurring genes responsible for plant disease, with alternative ones of agronomic interest. In this study, the disease genes were replaced with a reporter gene known as the GUS gene. When introduced into plants, tissues expressing the GUS gene turn blue when stained with a chemical that detects its presence.

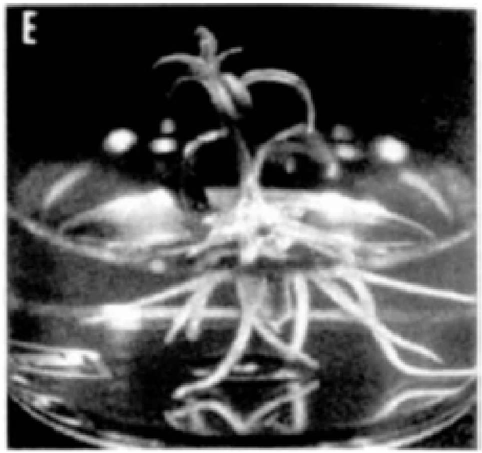
For these experiments, mature tissues were used to ensure that the genetic makeup of any recovered plants was known. Leaves were removed from micropropagated shoots cultures of Ne Plus Ultra and Nonpareil. They were dissected into small pieces, and submerged into an inoculum containing the bacterium carrying the GUS gene. After one hour the leaf sections were removed from the inoculum and transferred to filter paper moistened with tissue culture medium. The leaf sections were left like this for up to four days, during which time, the GUS gene was transferred from the bacterium to the plant cells.

After this, the leaf sections were washed in an antibiotic solution to remove any surviving bacteria, and transferred to a tissue culture medium containing a different antibiotic that allowed only the tissues that received the GUS gene to grow. Leaf tissues that did not receive the GUS gene cannot survive on this medium, and quickly die. Leaf sections that survived selection were then transferred to regeneration medium. The regeneration system used for recovering plants from the leaf sections was based on the findings from the previously described regeneration experiments.

To maximise the transfer of DNA from bacteria to the plant cells, a range of parameters was tested. Results showed that under optimised conditions, at least 70% of the leaf sections received the GUS gene from the bacteria. Of these, at least 15% for both Ne Plus Ultra and Nonpareil went on to develop callus that tested positive for the GUS gene.

Direction Of Future Research

The primary objectives of this study were to develop a range of tissue culture and genetic transformation techniques for almond cultivars grown in Australia and the USA. This research has resulted in the development of protocols for inducing adventitious shoots from mature leaf tissue and immature kernels, the induction of roots under tissue culture conditions, and the transfer of foreign DNA using *Agrobacterium tumefaciens* to the paper shell cultivars Ne Plus Ultra and Nonpareil.



(E) Root formation on Ne Plus Ultra shoot three weeks after treatment with IBA

(F) Rooted Ne Plus Ultra plant two months after transfer to glasshouse for acclimatisation

To date most transformation studies with perennial fruit crops have focused on the use of reporter genes, such as the GUS gene used in this study. The purpose of this has been to optimise the conditions for the transfer of foreign DNA into these species. The emphasis of this research is now moving towards the introduction of desirable traits such as those conferring resistance or tolerance to disease and environmental conditions, improved yield, and the regulation of growth or fruit ripening.

For almond, one of the most promising applications for genetic transformation is the regulation of self-incompatibility. Almond is self-incompatible, and commercial cultivation requires planting of at least two cross-compatible cultivars that flower at the same time, and the distribution of beehives throughout the orchard to ensure that there are enough pollinating agents. At harvest, it is necessary to collect different cultivars separately due to differences in nut quality. These factors have a large impact on the profitability of the crop, and hence, the production of self-compatible cultivars is a priority in almond improvement programs throughout the world.

For almond there are two ways in which a self-fertile cultivar may be generated using genetic transformation technology. The first would be to insert a gene for self-fertility into a selected cultivar, such as Nonpareil. The second approach would involve a technique known as antisense regulation. This technique involves the use of small pieces of genetic material that are based upon the genes that cause almond to be self-incompatible. Once inserted, they would result in the gene being turned off, and allow self-fertilisation to occur. Both of these approaches would use the Agrobacterium-mediated gene transfer procedure that has been described.

The inability to recover genetically modified plants from adult leaf tissue in this study highlights the need for improving the regeneration system used during the transformation process. Experiments will continue at Adelaide University, focusing on the use of different combinations and levels of plant growth regulators to try and improve the frequency of regeneration from leaf tissue.

Alternatively, immature kernels that have proven to be highly regenerative could be used in transformation experiments. Although plants regenerated from this tissue would not be true to type, they could be used as parental material in breeding programs, with their desirable traits incorporated by traditional hybridisation techniques.

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HAZELNUT TECHNOLOGY FOR WARMER CLIMATES

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Abstract

Hazelnuts are cultivated in very diverse situations due to the enormous agroecological, technological and socioeconomical differences of the producing areas. Hazelnut cultivars choice and cultural practices (planting systems, pruning, sucker control, soil maintenance, fertilizing, irrigation, pest control and harvesting) and their effect on orchard management efficiency are reviewed.

Introduction

The hazelnut is being cultivated in a big diversity of ecological situations, technological forms and socio-economic settings. In short, it concerns a considerable variety of "production models", with different response capacities with respect to unfavourable market situations (table 1).

Growing conditions of hazelnuts are best in mild climates without extremes of heat and cold. Temperatures of minus 10°C are critical, especially if accompanied by wind, which may kill both pistillate and staminate flowers. However, some winter chilling is necessary to break the dormancy period. This species is fairly sensitive to spring frosts since the buds of cultivated cultivars open relatively early in March.

Fruit set is another critical stage. At the end of May and June, maximum day temperatures should not be lower than 21°C over a period of three days or more. If this threshold is not reached, empty nuts are formed and fall before ripening, since embryo growth has been halted at a very early stage of development.

Another constraint on this crop is the frequent occurrence of strong winds which, in winter, disrupt pollination by blowing the fine pollen out of the orchard, and, in summer, cause high evapo-transpiration, drying the leaves and halting the growth of young shoots. In this latter case, the hazelnut root system, which is not very strong, cannot entirely compensate the tree's water losses.

For these reasons it may be clear why the hazelnut is cultivated mainly in regions sheltered from very cold winter, with soft winds to improve the pollination, without spring frosts and with relatively warm weather in the early summer, regular summer rain and high humidity

during the vegetative period. These conditions are most often found in zones with a maritime climate in the northern (between 40 0 and 45 0) and southern (31 0 and 41 0) hemispheres.

Although the hazelnut can be grown on very varied soils from the point of view of pH and fertility, it prefers deep, well drained fertile soils, either neutral or slightly acidic (about pH 6), and it is sensitive to root asphyxia.

Hazelnut cultivar choice and cultural practices and their effect on orchard management efficiency for the warmer climates are reviewed.

Hazelnut cultivars: characteristics

The hazelnut production is based entirely on cultivars selected from wild plants. Few varieties are utilised for commercial production (about 20). The characteristics of the main cultivars are as follows:

- **'Tombul'** (Turkey): round shape fruit, ripening at medium period, high kernel percent (49.2 %), good taste and aroma and good pellicle removal. Low vigour tree with high productivity. The husk is more than twice the nut length. High-chill requirements.
- **'Tonda Gentile delle Langhe'** (Italy): medium productivity, early ripening, medium nut weight, medium kernel percent (45.3 %), round shape, good pellicle removal, good taste and aroma and long storage life. High-chill requirements.
- **'Tonda Romana'** (Italy): medium-high productivity, late ripening, medium nut weight, medium kernel percent (48 %), round shape, bad pellicle removal, late leafing, and good taste and aroma. Medium-chill requirements.
- **'Tonda Giffoni'** (Italy): high productivity, spread out ripening, medium nut weight, medium kernel percent (48.4 %), round shape, good pellicle removal, early leafing, and good taste and aroma. Low-chill requirements.
- **'Negret'** (Spain): medium tree vigour, productive, late ripening, small-medium size, medium kernel percent (48 %) long shape, good pellicle removal, and good aroma and taste. Low-medium chill requirements.
- **'Pauetet'** (Spain): high vigorous tree and high yield, medium ripening, small-medium size, medium kernel percent (47 %), round-long shape, medium pellicle removal, medium leafing, and regular aroma and taste. Low-chill requirements.
- **'Barcelona'** (syn. 'Castanyera' in Spain, 'Fertile de Coutard' in France): it is the main cultivar in USA. High vigour and medium productivity, late ripening, high nut weight, low kernel percent (39 %), round shape, medium leafing and regular aroma and taste. Medium high chill requirements.

The Turkish cultivar 'Tombul', the Spanish cultivar 'Negret', and the Italian cultivars 'Tonda Giffoni' and 'Tonda Gentille delle Langhe' are considered the best currently available for the industry market. For in-shell market, 'Barcelona', 'Ennis', 'San Giovanni' and 'Corabel' are preferred.

In relation to self-incompatibility of hazelnut cultivars, it is important to have pollinizers with the same anthesis time of catkins as that of female flower receptivity of main cultivars. Recommendations for frequency of pollinizers in orchards vary widely (3 to 30 %), but the best would be an average of about 10 %.

Cultural practices

Training and tree spacing. The traditional training system in hazelnut orchards in the main production areas (Turkey, Italy and Spain) has been a multistem bush, according to its natural tendency of bushing growth. However, the training system used in the new orchards of the United States, France, Italy and Spain is in vase with only one stem. Production and agronomic aspects (suckers control, mechanized cultural and harvesting operations) have more advantages with this training system.

Tree spacing is highly variable in the different producing countries, as they depend on the fertility of the soil, rainfall, variety vigour and mechanisation requirements. This last characteristic is one of the most important to be considered in new orchards and, generally, the distance between rows should not be less than 5 m. In the orchards of Oregon (USA), trained in vase, tree density normally varies from 270 to 400 trees/ha (6 x 6 m or 5 x 5 m) while in the South-West of France they oscillate between 666 (5 x 3 m) and 800 trees/ha (5 x 2.5 m). In the Italian region of Viterbo, for 'Tonda Romana' (medium vigour), row spacing of 4.5 - 5 m and 3 m between trees, with densities of 740 - 666 plants/ha. In Spain, under irrigation, tree spacing from 6 x 3 m to 7 x 4 m (550 - 350 trees/ha) is recommended, depending of the soil fertility and vigour of the cultivar.

Pruning systems

Training young trees. Vase is the most used training system in modem hazelnut orchards. This pruning system normally varies in the producing areas, according, mainly, to the ecological conditions, vigour of the variety, quality of the plant, and the employed harvest system. In USA and France, with vigorous cultivars ('Barcelona' or 'Fertile Coutard'), selected stems and orchards designed for mechanical harvesting, pruning young trees is done during the first years, leaving 3 - 4 scaffold branches and trunk height superior to 80 cm, while in Spain and Italy, where generally less vigorous varieties are used ('Negret', 'Tonda gentile delle Langhe', 'Tonda Romana', 'Tonda Giffoni', etc.), lower crown heights are used (10 - 40 cm), in order to favour crop initiation and better adaptation to adverse crop conditions. After the formation of the tree crown, the primary branches are headed and then the secondary branches, to favour the general branching of the tree and to avoid also the first fruit bearing in the shoots extremity, as in non-vigorous varieties ('Negret') the presence of nuts in terminal shootings delays its vegetative development and causes a premature aging of the hazelnut.

Pruning of mature trees. Pruning of mature trees, in traditional orchards, is still a little extended practice and usually it is limited to the elimination of dry, damaged or excessively

Table 1. Summary of the most outstanding characteristics of the main hazelnut crop areas.

Production area	Rainfall (mm)	Soil	Growing	Cultivars	Production (kg/ha)
Giresum-Ordu (Turkey)	1 300	Mountain High fertility Acid pH	Dry farming Bush Not mechanizable	Tomboul	850-1 000
Piamonte (Italy)	800	Mountain High fertility Neutral or acid pH	Dry farming Bush	T.G.d.Langhe	1 000-1 500
Campania (Italy)	800	Slightly hilly Volcanic soils Fertile Neutral pH	Dry farming/ irrigation Bush and tree	S. Giovanni T. Giffoni Mortarella	2 000-2 800
Lazio (Italy)	600-700	Slightly hilly Fertiale soils Calcareous in several areas	Dry farming/ irrigation Tree	T. Romana Noccione	1 500-3 000
Sicily (Italy)	500	Mountain Varying soils	Dry farming Bush	S.M. Gesu	600-800
Camp de Tarragona (Spain)	500	Plain Low fertility Basic pH, calcareous	Irrigation Bush and Tree	Negret Pauetet Gironell	1 500-3 000
Priorat (Spain)	400	Mountain Low fertility Basic pH	Dry farming Bush	Negret Culpla Morell	600-800
Oregon (USA)	1 000	Plain Fertile, deep sandy, neutral or acid pH	Dry farming Tree	Barcelona Ennis Butler	1 700-2 000
Agen (France)	700-800	Plain Fertile, deep, sandy Basic pH	Dry farming Tree	F. Coutard Ennis Butler	2 000-2 500

inclined branches to the ground. In this situation, we have to point out that an insufficient pruning reduces shoot vigour of the mature hazelnut trees and therefore diminishes its crop potential and increases alternate bearing, as there exists a positive correlation between crop yield and annual shoot vigour. It has been observed that branches with a yearly growth below 5 cm hardly differentiate flower buds, as shoots of at least 15 - 20 cm are needed, according to vigour and tree age, to achieve good yields. The absence of pruning causes lack of illumination, and leads to a slight and sometimes null fruiting in the low and internal part of the tree. Few pruning strategies exist in hazelnut; European authors have done trials of different pruning intensities, getting more favourable crop yields with slight and yearly operations.

Sucker control. Sucker removal is a normal practice in hazelnut orchards. Traditionally it has been exercised in Turkey, Italy and Spain, by workers in winter. This system is not the most convenient, except for the first training years, as suckers after the whole vegetative period, weaken shoot growth of the tree. Now several herbicides are used, mainly Paraquat, 2,4-0 amine salt, MCPA, Glyphosate + MCPA and Ammonium gluphosinate, its efficiency depends on the sucker size and number of treatments done during spring and summer. Normally, treatment is advised when suckers have herbaceous consistency (15 - 20 cm height) and repetition at least three or four times between May and August.

Orchard soil management. During the first plantation years, periodical and shallow mechanical cultivation has to be given (lower than 10 cm) tending to eliminate weed competition and favouring ventilation and soil moisture. During youthful periods (until 3 - 4 years) it is dangerous to use some traditional herbicides with residual action. In substitution, others can be used like Paraquat, Oxifluorfen, Pendimentaline, etc., but avoiding young trees in the treatment.

In mature orchards soil management varies according to areas, climatic conditions and harvest type. Thus in Oregon (USA) and France, the soil is normally maintained with a permanent green cover in the centre of the row, with frequent flailing to avoid competition for water, and leaving the soil bare, with herbicides, in the tree row. In Spain and Italy, chemical weeding is normally practised below the tree canopies and mechanical labour between row helping the introduction of organic material to the soil and avoiding erosion in case of torrential raining. During the last years, in Italy (Piamonte, Campania and Lazio), a natural green cover is being recommended, with two or three yearly mowing, to correct the inconveniences of soil labour in mechanical harvesting, in order to avoid the excessive dust by vacuum machines and to improve the hazelnut harvesting machines efficiency with a more compact soil between tree rows.

Nontillage below tree canopy or between rows, favours ground preparation for mechanic harvesting and reduces damage to the superficial hazelnut root system. In the majority of productive areas, except for Turkey, the use of herbicides is very generalised, in both dry and irrigated orchards. The most used herbicides in mature orchards according their application time, are: Simazine, Diuron, Napromide, Oxifluorfen, Propyzamide, Trifluraline in preemergence and Paraquat, 2,4-0, Aminotriazol, Glyphosate, Ammonium gluphosinate, Terbutilazine + Terbumeton, Fluazyfop-butyl, etc. in postemergence.

Nutrition and fertilization. Fertilization practice presents a considerable criterion diversity and application prescriptions, although there seems to exist a major coincidence when the effects of different fertilizers on the hazelnut crop are described. Nitrogen is an important nutrient for plant development and consequently for crop yield. Phosphorus acts beneficially in hazelnut during fecundation and fruiting, although response to increased dose of this element are minimum. Potassium acts as a crop quality element, as it facilitates the assimilation of nitrogen in the leaf and the increase of kernel size.

The most recommendable quantities of fertilizer given by different authors, according to the existing data, with some discrepancy, is the equilibrium 1:0.4:0.9 (N:P:K). The most appropriate fertilizer contributions, with possible variances because of environmental conditions, are 120 to 150 kg/ha of nitrogen, 60 to 70 kg/ha phosphorus and 100 kg/ha potassium, with fragmented nitrogen applications in March-April (35%), end of May (50%) and

October-November (15 %) in case of shallow soils. Maybe potassium applications could be increased to assure healthier leaves in the period that follows harvesting, as it is intuited that there exists a lack of this element in the leaves at the moment that the kernel starts growing. Additional magnesium applications (mainly by foliar spray) and boron (through soil) complement the fertilizing programme.

According to the available data, it seems that standard leaf contents about 2.2% nitrogen, 0.18% phosphorus, 0.9% potassium and about 0.24% magnesium, are the most accepted values as indicators of the optimum level for sampled leaves at the end of August in Oregon and at the end of July in the Mediterranean area, which are the periods of maximum stability of mineral contents in hazelnut leaves.

Irrigation. The 'Camp de Tarragona' (Spain) hazelnut growing region, has been during many years a unique case where hazelnuts were irrigated, because in the other producing countries (Turkey, Italy, USA) the crop areas of this species were located in regions with higher rainfall and less extreme temperatures, where hazelnut presents a better adaptation to these climatic conditions. This situation has changed since hazelnuts have been introduced in new areas with less rainfall (in Italy basically), and because in other regions of France and Italy with important rainfall (700 mm per year) the necessity of irrigation has been detected in order to obtain good yields. In warmer climates (Tarragona, Spain), with average rainfall about 500 mm/year, mean year supply is about 2,500 m^3/ha in drip irrigation, distributed from May to September. To analyse the critical moments for irrigation in hazelnut crop training we divide its annual cycle in three characteristic stages for the producing region of 'Camp de Tarragona' (Spain): a) Vegetative growing: April-May-June ; b) Fruit filling (dry matter): July-August; c) Reserve accumulation: September-November

Pest management. Numerous pests and diseases can become a danger for hazelnut when their attacks exceed certain limits, most of them can be controlled by cultural or chemical means. Among pests, 'hazel weevil' (*Cucurlio nucum* L) is the worst enemy of hazelnuts in Europe and Minor Asia attacking the tender nut and producing a typical hole, destroying afterwards the kernel and causing severe damages. The bud mite, *Phytoptus avellanae* Nal, is present in all hazelnut producing countries. Aphids are insects in expansion in several countries (Spain, France and USA), standing out *Myzocallis coryli* and *Corylobium avellanae*. In Oregon (USA) the filbertworm (*Melissopus latiferreanus*) represents the main pest. Other pests are caused by *Zeuzera pyrina, Eulecanium coryli, Archips rosanus* and *Nezara viridula*.

Diseases that concern: 'anthracnose', caused by *Criptosporiosis coryli*, is a problem throughout Europe and Asia; the fungus attacks buds, stems and catkins of hazelnut trees, causing their desiccation. 'Eastern filbert blight', caused by the ascomycete *Anisogramma anomala* (Peck) E. Muller; originally observed on the American hazelnut in the eastern United States and currently it is a big problem in Oregon. 'Canker disease' caused by *Cytospora corylicola* Sacc., which produces the destruction of older branches, mainly in Spain and Italy. 'Sphaceloma', caused by *Sphaceloma coryli* can affect different parts of hazelnut, leaves, young shoots and nuts. Several other fungal diseases are known to affect hazelnuts: *Botrytis cineria* Pers., described in France; 'root rots' caused by *Armillaria mellea* (Vahl.) Pat. and *Rossillinia necatrix* (Hart.) Berl.; 'oidium' in the reverse of the leaves caused by *Phyllactinia guttata*.

'Bacterial blight', caused by *Xanthomonas campestris* pv. *corylina* is a serious disease in nurseries and young orchards in Oregon, eastern Europe, France and Italy. In layer beds bacterial blight affects stems and lateral herbaceous shoots, symptoms include necrosis and drying-out; this disease can girdle and fill young trees (up to 5 years of age).

The most significant virus affection is 'hazelnut mosaic', caused by the apple mosaic virus (ApMV). ApMV has been found in a large number of cultivars from Spain, southern Italy and Turkey. Symptoms, when present, include chlorotic ringspot, line patterns and flecking on older foliage. The virus can be readily detected in young foliage by ELISA Test.

Harvesting. Harvest, taking place from the end of August until half October, constitutes one of the most important crop costs. Hazelnuts are harvested on the ground, picking them up in one or two operations. At present, harvest is quite mechanized, except for Turkey where the fruit is collected by hand from the tree. In the remaining producing countries, there are three generalised harvest systems: harvesting by metallic broomer or blower followed by mechanical cleaning, used in mountain areas of Tarragona and Italy; harvesting by vacuum machine, is the mechanical system in plain areas of Spain and Italy, and harvesting by sweepers and pickup machines is the system diffused in big orchards of Oregon (USA) and France.

Generally, this last harvest system consists of two machines: a sweeper-windrower, self propelled or coupled to a farm tractor, and a hazelnut pickup machine of high yield. The optimum yearly labour surface for this machine is about 40 ha. These pickup machines are quite big, they require flat soils and wide tree spacing, and just one operator is needed. They have a good harvest yield, of about 800-900 kg/hour, that represents about 2-3.5 hours/ha; in French orchards they allow to harvest about 4 ha per day.

This harvest system is very fast and reduces very much the costs of this operation. The present tendency of new orchards in the Mediterranean and other countries (Australia) has to be oriented to the introduction of these mechanical pickup systems.

Conclusions

Cultivar choice. The Spanish cultivar 'Negret', and the Italian cultivars 'Tonda Giffoni' and 'Tonda Romana' are considered the best currently available for the industry market in the warmer climates. For in-shell market, 'Barcelona' and 'San Giovanni' are preferred in these areas.

Agronomic aspects. As follows some conclusions are described about the studied cultural techniques, and several trends are suggested to improve the orchard productivity.

• Training systems and tree spacing:

Tree training in vase with only one stem seems to be the most useful. What tree spacing concerns, distances between 6 x 3 and 6 x 4 m are recommended. In some, a setting of 5 x 3 m can be chosen (little vigorous varieties and poor soils) or 7 x 4 m, in case of vigorous varieties, fertile soils and in irrigation.

• Pruning systems:

Training young trees: use quality stems and, according to the cultivar vigour, cut the trunk not too high (50 - 80 cm) to form the vase of the tree. Then, the primary and secondary branches are headed for canopy branching. With respect to pruning of mature trees: light pruning of the canopy can be recommended, each two or three years. It could be interesting to make a profound study of mechanical pruning.

• Sucker control:

Chemical control of hazelnut suckers is recommended. The most convenient herbicide are several, pointing out 2,4-D amine salt, Paraquat, Glyphosate + MCPA and Ammonium gluphosinate. Varietal behaviour studies about hybrid rootstocks without sucker emission of *C. colurna* x *C. avellana* are done.

• Soil management:

In warmer climates, nontillage or a temporary green cover could be interplanted between rows to facilitate the integral mechanisation of harvesting in modern orchards. In spring, and later on, it should be eliminated with herbicides or flail movers in order to get a more compact soil during the passage of the harvest machines.

• Fertilization:

The most appropriate fertilizing contributions per ha, with possible differences because of environmental conditions, range from 120 to 150 UF nitrogen, 60 to 70 UF phosphorus and 100 to 120 UF potassium, with fractional applications of nitrogen. Additional contribution of magnesium and boron complement the fertilizing scheme.

• Irrigation:

It seems very important to supply enough water to hazelnuts during their vegetative cycle. It is interesting to point out the effect of water stress during the kernel filling. For the region of Tarragona (warmer climate), yearly contributions of 2.500 m^3/ha or more are recommended. Adapt them to punctual necessities is very important, specially in orchards with shallow soils. It is advisable to follow the indications of the climatic stations network, where available. A good irrigation installation and a convenient management are basic aspects for a better water irrigation utility.

• Harvesting:

Harvesting constitutes one of the most important production costs and its value depends of its mechanisation degree. The machine types used in the orchards in USA and France are the most convenient, because of their speed in picking up the fruit from the ground and because of their low labour costs.

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THE FEIJOA

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Introduction

The Feijoa or Pineapple Guava (*Acca* or *Feijoa sellowiana*) is a relative of the tropical guava, and is native to extreme southern Brazil, northern Argentina, western Paraguay and Uruguay, where it grows wild in the mountains.

It is cultivated in the highlands of Chile and other southern American countries, in southern and western Europe, in India in home gardens at temperate elevations, in New Zealand (producing some 400 tonnes per year) and California (where some 400 hectares are planted); also in Georgia (former USSR) where over 1000 ha are cultivated.

Description

The plant is a bushy evergreen shrub, 0.9-6 m or more in height, usually 2-4 m high, much branched, with pale grey bark. Spreading forms can spread as wide as they are high.

Leaves are opposite, short-stalked, bluntly elliptical, thick and leathery, 28-62 mm long by 16-28 mm wide. They are smooth and glossy dark green on the upper surface and silvery hairy beneath .

The flowers are conspicuous, 4 cm across, borne singly or in clusters from leaf axils of the previous years growth, with 4 fleshy oval petals which are white outside and purplish-red inside. Within are a cluster of erect purple stamens with golden-yellow anthers. Some selections are self-fertile, others require cross pollination.

The fruit is oblong or slightly pear shaped, 4-7 cm long and 2.55 cm wide, with a waxy skin about 7 mm thick. The fruits remain a dull green or yellowish-green until maturity, with a 'bloom' of fine whitish hairs and sometimes with a red or orange blush. The fruit emits a strong long-lasting perfume, even before it is fully ripe. When cut open the fruit has an edible creamy flesh and gelatinous pulp.

Within the fruits are 20-40, sometimes more, very small oblong seeds.

Uses

Fruits are aromatic and the better ones are delicious. The fruit flesh is thick, white, granular and juicy - translucent in the middle where it surrounds the seeds - and is sweet or subacid with a pineapple and strawberry flavour. The small seeds are hardly noticeable when the fruit is eaten. When cut, the flesh rapidly discolours from oxidations and turns brown - to prevent

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§ Member, WANATCA

this, fruits can be dipped in a weak salt or lemon juice solution.

The flesh and pulp (with seeds) are eaten raw as dessert or in salads, or are cooked in puddings, pastries, cakes, pies or tarts. They are also used as flavouring for ice cream and soft drinks. Surplus fruits can be peeled, halved and reserved in jars, or made into chutney, jam, jelly, sauces or sparkling wine.

Fresh fruits contain (per 100 g portion):

Protein	0.9%	Potassium	166 mg
Fat	0.2%	Sodium	5 mg
Carbohydrate	10%	Calcium	4 mg
Niacin	high	Phosphorus	10 mg
Vitamin C	28-35 mg (high)	Iron	0.05 mg

Fruits are high in pectin (up to 20%), and those grown near the sea are also rich in water soluble iodine compounds. The thick petals are spicy and are eaten fresh. They can be picked without interfering with fruit set.

The leaves, fruits (primarily the seeds) and stems all have antibacterial properties. The fruits also show antioxidant properties.

In New Zealand, growers sometimes use the plant as a windbreak around other wind sensitive crops. The wood is hard, dense and brittle.

Cultivation

The Feijoa likes a warm temperate or subtropical climate with a cool season. It can withstand winter temperatures of -10°C, some drought, and is humidity tolerant. A hardiness survey in Britain revealed that in zone 7 areas (winter min -12 to -17°C), some leaves and/or stem tips become scorched, while in zone 6 areas (-18 to -22°C), bushes are cut to the ground but regenerate well the following spring. Shelter is desirable as wind can cause fruit bruising and brittle wood to break. The flavour of the fruit is much better in cool than in warm regions. Sudden autumn frosts can damage ripening fruit. A flush of new growth occurs in the spring.

The shrub prefers a rich organic well-drained soil and prefers acid soils. It is drought resistant but needs adequate water for fruit production. The optimum annual rainfall is 760-1500 mm. It tolerates partial shade (though fruiting will be reduced) and some exposure to salt spray.

In England, the feijoa is often grown as a wall shrub. Here it only flowers profusely in sunny locations and ripens fruit in favoured locations.

Plants should be spaced at 4-5.5 m apart to allow for spread and good fruit production, unless erect selections are used when the spacing can be reduced; a typical commercial plantation may have 5-6 m between rows and plants 3-3.5 m in the row. Fruit is borne on the young wood, so pruning reduces the crop and is kept to a minimum. Light pruning after harvest can encourage new growth if necessary, and thinning of dense plants makes for easier harvesting. An open tree (central leader or goblet shaped) is desirable to allow birds access to pollinate and for easy harvest. Shoots within 30 cm of the ground should be removed; the best fruiting branches are those at 20-30° to the horizontal, and these should be 30 cm apart. The plants have a shallow fibrous root system and soil cultivation around them after establishment is inadvisable.

Barrier hedges have plants spaced at 1.5- 2 m apart, but fruiting capacity in these will be much reduced especially if/when hedges are trimmed (plants respond well to trimming).

There are few pests or diseases of note. Various scale insects can attack the plant, and fruit flies can attack ripe fruits.

Flowering occurs in July in England (June in France, May in California).

Bees are the main pollinators, although birds which are attracted to eat the petals can also aid pollination. Most flowers pollinated with compatible pollen show 60-90% fruit set; hand pollination is nearly 100% effective. Poor bearing is usually the result of inadequate pollination, and two cultivars should be grown together unless you are sure of self-fertility. Good pollination produces many seeds which in turn leads to larger and better-shaped fruit and a higher proportion of pulp.

Feijoa branch with flowers. All drawings from Geilfus

Branch with fruits

For fruit production, any fertiliser used on a fertile soil should be low in nitrogen so as not to stimulate too much vegetative growth. Potassium is likely to be the main nutrient required, with up to 10 g/m^2 required per year. Similar fertilisers should be used as for other heavy fruiting trees such as apples etc. Manure, compost and comfrey are all very suitable.

In hot dry spells, when the plants are carrying fruit, they should be watered and mulched.

With some varieties, ego Apollo, fruit thinning may be useful to achieve larger fruits. Thin in summer when the fruits approach the size of a blackbirds egg. 100-120 fruit from a tree 1.5 m high is sufficient. Take off damaged or misshapen fruit, then reduce to 2-3 fruit per cluster and remove any that will rub against a branch.

Fruits mature 15-26 weeks after flowering (depending on the cultivar), and ripen over several weeks. The fruits fall when mature and are usually collected daily from the ground and kept cool until slightly soft to the touch. A straw mulch, large cloths/tarpaulins, or suspended catching nets are often used beneath the plants to help avoid bruising, to which fruits are susceptible. Alternatively, mature fruits can be picked from the tree: a slight colour change (to a lighter green), softening, and easily detached fruits are ready to pick - although if picked from the tree before they are ready to fall, or if eaten before fully ripe, the fruits won't have their full richness of flavour. In Europe, fruits usually mature in November.

In New Zealand test plantings, yields have averaged:

Year 3	6 kg/plant	4 t/ha
Year 4	12 kg/plant	8 t/ha
Year 5	18 kg/plant	2 t/ha
Full crop (10 yrs)	30 kg/plant	25 t/ha

Trees remain productive for at least 30-40 years, and then can be rejuvenated by drastic pruning. In a warm atmosphere, the interior of fruits turns brown and decays in 3-4 days. In cold humid storage, undamaged fruits remain in good conditions for 4-5 weeks at 3-5°C and 2-3 weeks at 10°C.

Cultivars

Andre: Fruits medium-large, oblong to round, rough, light green; thick flesh with few seeds, rich flavour and very aromatic. Self-fertile, heavy cropper.

Apollo: Fruit medium-large, oval, light green, smooth thin skin, susceptible to bruising; flesh slightly gritty, very pleasant flavour, good quality. Ripens mid-late season. Plant upright. spreading, to 2.5 m tall, vigorous, productive, self-fertile. From New Zealand.

Beechwood: Fruits medium sized, elliptical, skin fairly smooth, dark green; good flavour. Tree self-fertile. Origin: California.

Besson: Fruits small-medium, oval, smooth, with red or maroon cheek, thin skinned; flesh medium-thick, fine-grained, very juicy, numerous seeds, rich aromatic flavour.

Bliss: Plant is partly self-fertile.

Choiceana: Fruits round-oval, fairly smooth, small-medium, of good flavour. Ripens mid season. Spreading plant of moderate vigour; partly self-fertile.

Coolidge: Fruits oblong or pyriform, medium size, crinkled skin; flesh of average flavour, poor keeper. Plant upright, strong growing, heavy bearer, highly self-fertile; widely grown in California.

David: Fruits medium-large, round or oval, skin has sweet and agreeable flavour; flesh of good flavour and fair texture. Ripens mid season. Grown in Europe.

Duffy: Fruits large, round, thin skinned; pulp sweet, low acid; ripens late. Bush medium sized, erect, vigorous. An Australian selection.

Edenvale Improved Coolidge: Fruits large, oblong, very good flavour and quality. Tree slow growing, self-fertile, precocious and productive; early ripening. From California.

Edenvale Late: Fruits medium sized, oblong, very good flavour and quality. Ripens late over a long period. Tree slow growing, self-fertile, very productive. From California.

Edenvale Supreme: Fruits medium sized, oblong, very good flavour and quality. Ripens mid season; fruit doesn't store for long. Tree slow growing, self-fertile, precocious, productive. From California.

Gemini: Fruits small-medium sized, egg shaped, skin very smooth, thin, dark green with a heavy bloom. Flavour and texture excellent. Ripens early. Tree moderately vigorous, to 2.5 m tall, part self-fertile, high yielding. From New Zealand.

Hehre: Fruits large, slender-pyriform, yellowish-green, thin skinned; flesh finely granular, very juicy, sweet, not aromatic, numerous large seeds. Seedlings erect, compact, vigorous, with lush foliage but only moderately productive.

Hirschvogel: Plant is highly self-fertile.

Jackson: Fruit medium sized, thick skinned; flesh dry, strong flavour, nearly seedless. Origin: California.

Lickver's Pride: Fruits large, round; very sweet, rich flavour. Tree rounded, self-fertile. Origin: California.

Magnifica: Fruits very large but of inferior quality.

Mammouth: Fruits large, round to oval, somewhat wrinkled, thick skin; flesh somewhat gritty, quality and flavour very good, poor keeper. Early-mid season. Plant of upright habit, vigorous, to 3 m tall; part self-fertile. A seedling of Choiceana widely grown in New Zealand.

Moore: Fruits large, of good flavour, ripens mid season. Plant very vigorous. Grown in California.

Nazemetz: Fruits large (80 g), pear shaped, side walls moderately thin. Flavour and quality excellent. Ripens mid to late season over a long period. Unusually, the pulp does not darken after being cut or as it ripens. Tree part self-fertile. From California.

Pineapple Gem: Fruits small, round, good quality; mid to late season. Tree part self fertile, dislikes coastal conditions.

Robert: Fruits medium sized, oval; flesh very juicy, somewhat gritty, mild flavour. Ripens very early. Leaves brownish. Needs cross pollination.

Roundjon: Fruit oval or rounded, somewhat rough-skinned and red blushed. Good flavour. Grown in Europe.

Smilax: Fruits small-medium, round; flesh sweet, fine flavour - clear pulp extends almost to skin. Tree short, bushy, self-fertile. Origin: California.

Superba: Fruits small-medium, round to oval, quite smooth, of good flavour. Plant spreading, straggly habit, medium vigour; partly self-fertile.

Trask: A bud sport of Coolidge. Fruits medium to large (80-140g), skin dark green and rough, flavour and quality very good. Ripens early. Tree part self-fertile, precocious. From California.

Triumph: Fruits medium-large, short, oval, plump, smooth; skin firm, uneven; flesh somewhat gritty with an excellent sharp flavour; good keeper. Plant upright, of medium vigour, mid season ripening, part self fertile. A seedling of Choiceana widely grown in New Zealand.

Unique: Fruits large, oval, smooth skinned, light green; pulp very smooth, good flavour. Early ripening. Tree to 2.5 m tall, vigorous, self-fertile, precocious; a regular, heavy bearer. Origin: New Zealand.

Propagation

The Feijoa is often grown from seed but does not reproduce absolutely true to type. Germination takes place in 3 weeks; the seed compost used must be sterile, otherwise many seedlings will die from damping off. Seed-grown plants fruit in 3-5 years from sowing.

Cultivars are propagated vegetatively by one of several means. Vegetatively propagated plant start to fruit in 2 years. In France and New Zealand, ground-layering is used, with rooting occurring in 6 months. Air-layering is usually successful too. Grafting (whip and tongue or veneer) onto seedling rootstocks is not very successful. Cuttings can be taken: young wood from branch tips or side shoots with a heel in summer will root in 1-2 months with bottom heat and a hormone rooting agent, given a moist humid atmosphere. Stooling can be practised: good success is achieved by treating stooled shoots by ringing them and using hormone rooting agent before earthing up.

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GROWING AND MARKETING PEPPERCORNS

DONNA CAMPAGNOLO
L & L Pepperfarms

Introduction

L & L Pepperfarms was established in 1984 after a down turn in the sugar industry forced the need to diversify into other horticultural crops. After working in Indonesia and the Philippines and seeing the diverse crops being cultivated, pepper stood out as a potential crop that could be grown in our tropical climate. Pepper originated in the southwestern coastal region of India from where it spread to many parts of Asia, Africa and South America. Today the southeast Asian countries of Malaysia, India, Indonesia, Thailand and Sri Lanka together with Brazil make up the IPC or International Pepper Community. World production has remained fairly constant at about 200,000 tonnes a year for export. Of this production the IPC countries produce 88%.

Table 1. World Pepper Production and export - countrywise (average, 1989- 1998)

Country	Production	Export
Brazil	25,400	23,300
India	58,600	31,800
Indonesia	47,700	41,600
Malaysia	21,500	2,160
Sri Lanka	4,400	3,700
Thailand	8,600	2,300
IPC Countries	166,200	124,300
Other Countries	30,600	19,200
World	196,800	143,500

(figures from IPC)

Non IPC countries growing pepper are Vietnam, China, Madagascar and Mexico, being minor contributors. Whole black and white peppercorns account for 95% of pepper traded in the world. The remaining 5% is traded in the forms of pepper oleoresin, pepper oil, green pepper and ground pepper.

L & L Pepperfarms has currently 1.2 hectares under production with another 0.4 hectare coming online in 2 years.

The Pepper Vine, Piper nigrum

The Pepper Plant

The pepper the world's most widely used spice is obtained from a tropical climbing vine *Piper nigrum* and is from the Piperaceae family. It is a native plant of southwestern India. They are normally grown from stem or terminal cuttings, rarely from seeds. The root system is developed from adventitious roots formed at the nodes, which are buried in the soil at planting. As the vegetative (orthotropic) shoot ascends, a simple leaf is produced at each node. A bunch of short adventitious roots is also formed to help the shoot adhere to the supports. At each node, there is an axillary bud, which develops into a lateral (plagiotropic) branch to bear the fruit spikes. Both the climbing and lateral shoots can branch upon cutting, but only the climbing shoots remain vegetative in growth. In the wild state the plant reaches lengths of 10 metres or more, but its growth under cultivation is controlled to ease harvesting.

The flower spike arises at the node opposite the leaf. Most cultivars have bisexual flowers, although male flowers are sometimes produced at the tips of the spikes. Flowers are mostly self-pollinated usually through wind although rain and ants may act as pollinating agents. The fruit is a berry, pale green and soft in the early stage, but turns dark green and hard as it develops. The outer skin (exocarp) becomes yellow and bright red and turns soft as it ripens. Each berry contains a single seed enclosed in a pulpy mesocarp. The commercial black peppercorn is the entire dried berry whereas the white peppercorn is the actual seed.

The peppercorn owes its pungency to the presence of alkaloids - piperine, chavicine and piperettine. The volatile essential oils impart the typical aroma of pepper. Together these compounds constitute the oleoresin, which can be recovered by solvent extraction. Varieties and also the growing locale influence the spiciness and pungency.

Soil and climatic requirements

The pepper is the fruit of perennial climbing vine that thrives in a warm and wet tropical climate. Moisture is required throughout the year as the plant is not able to withstand prolonged dryness. Low elevations give the best results and level ground is most suitable, provided there is no flooding. Soils should be well drained as waterlogging conditions result in poor growth and a high incidence of foot rot.

Cultivation

Terminal cuttings taken from 1 to 2-year-old plants usually propagate pepper. Traditionally cuttings with five sections are used, with the bottom 3 buried in soil either in a nursery bed or pots. About 12 weeks are required for rooting and development of buds. For field planting purposes we plant 3 cuttings directly beside the post with at least a 75% strike rate, eliminating the need for a nursery. Plants are planted at a density of 1900 per hectare.

Growing vines are trained up on support, hardwood posts are used, but we are looking for alternatives. We found that living posts of leguminous trees too difficult to maintain.

Vines must be pruned to encourage the formation of a desired canopy and encourage development of lateral branches. Initial pruning is done at 3 months and thereafter regularly until the vines reach the top of the support. After each harvest the terminal buds are trimmed to prevent further vertical growth. Occasional tying is needed to help train the vine up the post.

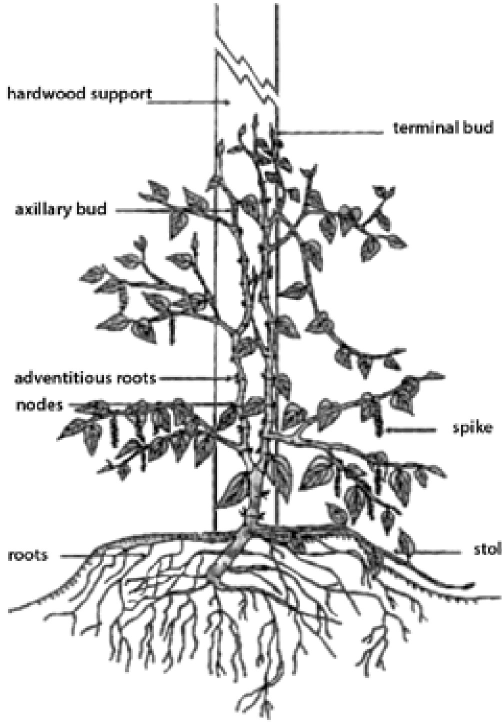

Figure 1. A pepper vine about 6 months after planting

Figure 2. Cutting used for direct planting

Pepper has high requirements for nutrients. Liming with dolomite is essential to improve Ca and Mg nutrition for the vines. Young vines must be fed frequently with N, P and K. N and K are in strong demand for mature vines. The vines should not be allowed to flower freely until they are 2 years old. Since it takes 8-9 months for the fruit to mature, the first harvest is around 3 years after planting.

Harvesting and processing

Spikes are usually thrown in December/January and are harvested around October/November. Pepper produces a minor and major crop in a year. Spikes are picked by hand when mature but still green. Unlike major producing countries where harvest is continuous over a 2-3 month period, for ease of management the crop is picked over a 2-week period. Once picked the berries are removed mechanically from the spike and then dried in the sun for 34 days. At present we are getting a 29% recovery rate from harvest to drying.

A small percentage of the crop is left to turn red and is then picked for processing into white pepper. The ripe berries are separated from the spike and then soaked in water to remove their pericarp and then sun dried.

Marketing

Pepper by virtue of its versatile use in the modem world has earned the reputation as the King of spices. In developed countries, the usage of pepper in food industry has increased substantially because of its taste, flavour and seasoning characteristics. More than 60% of pepper is consumed in food industrial and food service sectors due to shift in the eating habits all over the world and the balance quantity is consumed in household, medicine, perfume, health and beauty segments. Ethnic foods particularly Indian, Chinese and Thai are having a growing impact in many countries and expanding to cover a wide range of tastes in food. In developing countries 90% of the pepper is consumed in the household segment.

Pepper both black and white is a principal spice being traded in the international spice market. Majority is traded in whole/unground state, though in recent years however, there has been a significant increase in the trade of value added pepper products from producing countries.

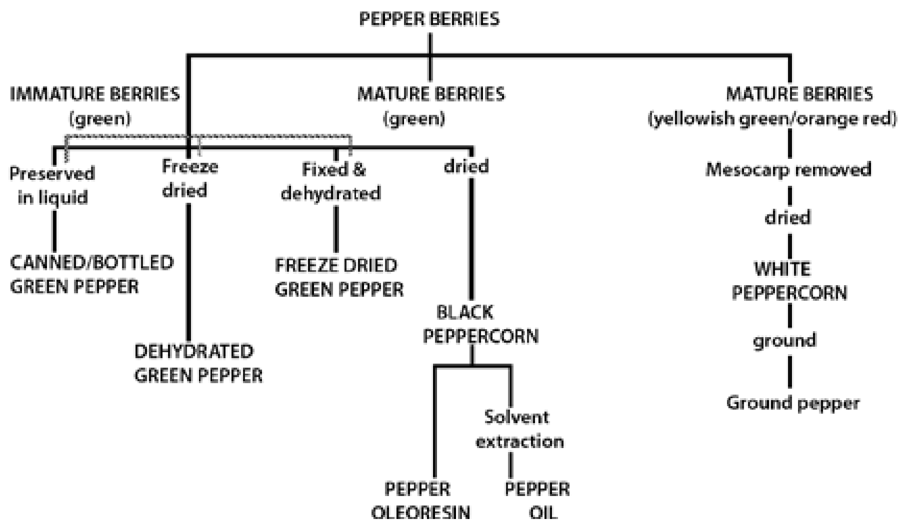

Figure 3. Uses of pepper berries

Pepper products, which are popularly traded internationally are pepper powder, green pepper, pepper oil and pepper oleoresin.

The demand/consumption of pepper is growing on average of 2.5% annually.

Pepper price tends to move in a cyclical way and price fluctuation can be very different from one year to the next. In general, price varies substantially, largely because of fluctuations in supply in major producing countries. The price swings were accentuated by speculative trading in the past, but this has been less evident in recent years.

There are different standards specification for pepper such as ESA (European Spice Association), ASTA (American Spice Trade Association) and ISO (Intl. Standardisation Organisation) standards, in addition to different standards set by the major producing countries. The parameters, test methods, methods of drawing samples & definitions are different in many of the existing standards. We use the ASTA standard in regulating our quality.

Australia imports 2000 tonnes of various forms of pepper. Production from our 1.4 hectares varies according to pest and disease pressure and climatic conditions. We have established a niche market through a lot of hard footslogging and persistence. Higher world prices and our quality have seen our product hold its own with our buyers. At present we have concentrated on the dried market where we sell to wholesalers and also value add and sell direct to the supermarket chains in the north. A small percentage of our crop is sold as fresh green peppercorns into the markets. These are picked at the immature stage, as the berry needs to be soft inside to be edible. The next area for development is the pepper oil and oleoresin market.

The viability of pepper in the wet tropics will depend on world markets and prices and the ability to mechanise some of the processes involved in harvesting and processing. Traditionally pepper growing in undeveloped countries is on small holdings where fluctuations in prices determine the inputs the vines receive, low world prices-low inputs-lower production hence the cyclical nature of this commodity.

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IDENTIFICATION OF SUPERIOR CASHEW TREES FOR NORTHERN AUSTRALIAN CONDITIONS

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Abstract

One hundred and thirty-five well-buffered cashew trees originally derived from seedlings were evaluated for nut yield characteristics during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah, Far North Queensland. Wide variation in total nut yield per tree/year, nut number per tree/year and mean individual nut weight was observed. The frequency distribution of the population was positively skewed towards higher values of the different nut yield components. Total nut weight/tree was positively correlated with nut number/tree (r = 0.803**) but it was not significantly correlated with mean nut weight/tree. Nut number/tree was negatively correlated with mean nut weight (r = - 0.563**). Four trees (TN 10203, TN 12310, TN 20216 and TN 21406) were selected as superior trees, each producing average nut yields of more than 6.0 kg/tree/year and mean individual nut weights of more than 6.0 g.

Introduction

The cashew (*Anacardium occidentale* L.) is an important tropical tree crop grown primarily for its nuts, the kernel of which can be roasted and sold as confectionery products. It is also cultivated for its edible apple, which can processed into jam, jelly, syrup, juice, beverage and candied fruit. The cashew nut shell liquid (CNSL), which can be extracted from the mesocarp of the shell, is a high grade industrial oil used in the manufacture of paints, varnishes, lacquers and brake linings of motor vehicles (Ohler 1979).

The cashew is a relatively new crop in Australian agriculture. Trial plantings in the 1960s and 1970s in the Northern Territory, Northern Queensland and Western Australia were not followed by significant further expansion because there was a general lack of familiarity with the growing of the crop in those areas and the genetic materials introduced from Africa and Asia were poorly adapted (Chacko et al. 1990). Recently. however, renewed interest has been shown with the introduction of new genetic materials which give rise to the opportunity for selection and development of high yielding cultivars with good quality kernels.

One of the major problem facing the cashew industry is the lack of superior varieties combining high yield with good quality nuts (Salleh et al. 1989). The first step in improving this highly heterogeneous crop is by direct selection of superior trees from the existing population under local growing conditions. To do this, some knowledge of the existing variability amongst the trees is necessary. This study was therefore conducted to determine the variability present in the cashew population and to identify high yielding trees amongst the oldest trees originally derived from seedlings at Cashews Australia, Dimbulah.

Materials and Methods

One hundred and thirty-five well-buffered cashew trees were selected from the two blocks of trees originally derived from seedlings at Cashews Australia, Dimbulah. The trees were derived from two seed lines: a natural cashew grove from Port Douglas and K 160, from the Kamerunga Research Station, Queensland Department of Primary Industries, Cairns. All trees investigated at Dimbulah had received the same cultural management such as fertilisation, irrigation and pest management.

Yield data were collected during the 1993 and 1994 fruiting seasons when the trees were five and six years old, respectively. Nuts were harvested as the fruits ripened and were separated from the apples. All nuts harvested from each tree were weighed, counted and the mean individual nut weight derived.

Cashew branch with flowers, fruits, nuts. From 'Indische Vruchten' by J J Ochse

The ranges, means, standard deviations and coefficients of variability for the different yield components were determined and the frequency distribution examined. The correlation coefficients for the relationships between the observed values for different yield components were derived and tested for significance. Highly productive trees were identified.

Results and Discussion

Evaluation of Nut Yield Components: Nut yield per tree/year

Nut yield per tree/year ranged from 1.16 kg to 7.66 kg, with a mean of 3.91 kg (Table 1). Such a wide range of variability in nut yield suggests that this character may provide some scope for selection of superior trees in cashew. The coefficient of variation was 34.7%.

Table 1. Range, mean, standard deviation and coefficient of variability in nut yield components during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings

Character	Range	Mean	Standard deviation	Coefficient of variation %
Nut yield per tree/year (kg)	1.16 - 7.66	3.91	1.36	34.7
Nut number per tree/year	151 - 1555	755	310	41.1
Mean individual nut weight	3.15 - 9.21	5.46	1.25	23.0

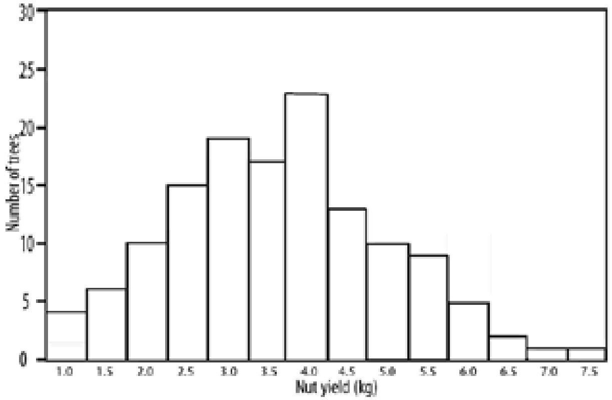

***Figure 1**. Frequency distribution in nut yield per tree/year (in kg) during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings*

The frequency distribution was positively skewed towards higher nut yield per tree/year (Figure 1). Of 135 trees evaluated, 16.3% of the trees (22 trees) were further than one standard deviation from the mean on the higher yielding side of the distribution.

Nut number per tree/year

The total number of nuts harvested per tree/year ranged from 151 to 1555, with a mean of 755 (Table 1). The coefficient of variation was 41.1%, the highest amongst the nut yield components.

The frequency distribution was positively skewed towards higher numbers of nuts per tree/ year (Figure 2). Of 135 trees evaluated, 10.4% of the trees (14 trees) were more than one standard deviation above the mean.

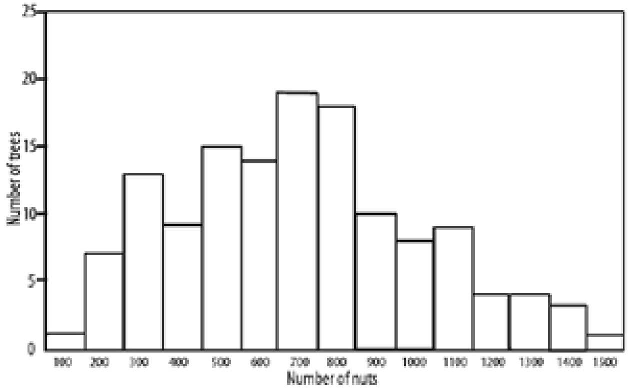

***Figure 2**. Frequency distribution in nut number per tree/year during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings*

Mean individual nut weight

Mean individual nut weight ranged from 3.15 g to 9.21 g, with a mean of 5.46 g (Table 1). The coefficient of variation was 23%.

The frequency distribution was positively skewed towards higher mean individual nut weight (Figure 3). Of 135 trees evaluated, 17.8% of the trees (24 trees) had nuts more than one standard deviation heavier than the mean.

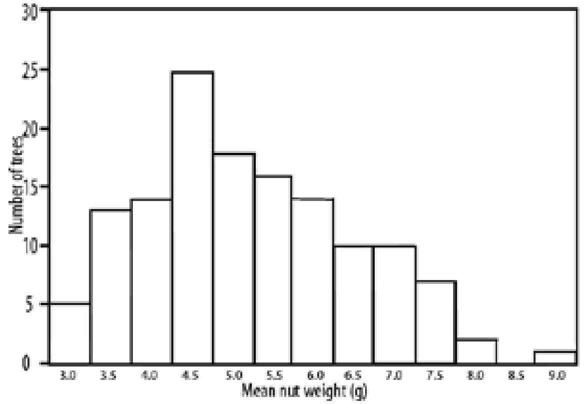

***Figure 3**. Frequency distribution in mean nut weight per tree (in g) during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings*

Correlation analyses between nut yield, nut number and mean nut weight

Nut yield per tree was highly correlated with nut number per tree (r = 0.803**, p<0.01, Table 2). The tree, TN 11603, which gave the lowest nut yield (1.16 kg) also had the lowest number of nuts (151 nuts) while TN 20516, with the highest nut yield (7.66 kg), had the highest nut number (1555 nuts). A similar correlation between nut yield and nut number was observed by Northwood (1966, r = 0.947**), and Faluyi (1987, r = 0.894**). These authors suggested that selection for increased nut count per tree would probably lead to increased total nut weight per tree.

Table 2. Correlation coefficient between nut yield, nut number and mean nut weight per tree during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings

Character	*Correlation coefficient*
Nut yield vs nut number	0.803**
Nut yield vs mean nut weight	-0.009ns
Nut number vs mean nut weight	-0.563**

ns - Not significant

** - Significant at 1% level

The association between nut yield and nut number is presented in Figure 4. For high levels of nut yield, the range in nut number was high.

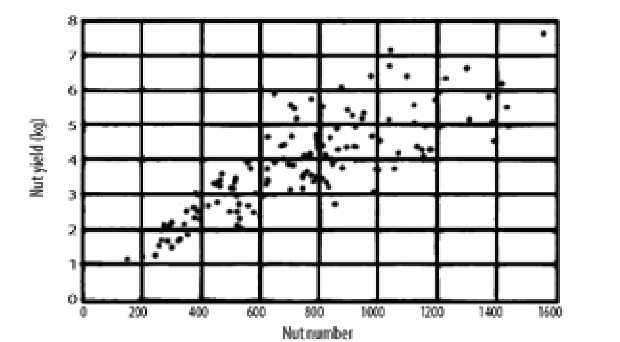

Figure 4*. Relationship between nut yield per tree and nut number per tree during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings*

No significant correlation was observed between nut yield per tree and mean individual nut weight (r = -0.009ns, Table 2). Figure 5 shows the association between these two characters.

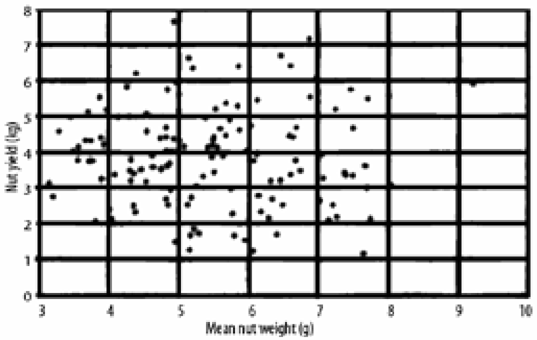

Figure 5*. Relationship between nut yield per tree and mean individual nut weight during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings*

Ramadas and Thatham (1982) also reported a lack of association between nut yield per tree and mean nut weight per tree (r= -0.034ns). They recommended the possibility selecting trees with high nut yield and large nut size.

Nut number per tree showed a significant negative correlation with mean individual nut weight (r = 0.563**, p<0.01, Table 2, Figure 6).

These results implied that trees which produced higher number of nuts produced smaller nuts. Sanwo (1980) explained that in trees which produced few nuts, the amount of photosynthate allotted by the tree for nut formation would have increased the size of the individual nuts that reached maturity. Therefore, selection for high numbers of nuts per tree will probably result in decreased mean nut size (Faluyi 1987).

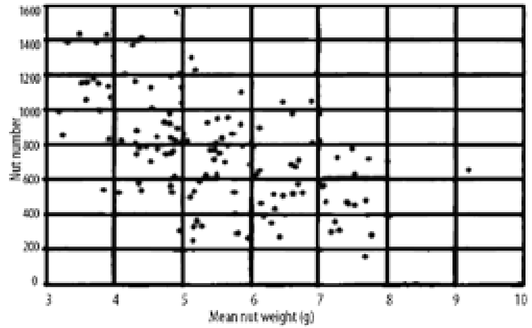

Figure 6*. Relationship between nut number per tree and mean nut weight per tree during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah for 135 well-buffered cashew trees originally derived from seedlings.*

Selection of Superior Trees

In selecting higher-producing cashew trees, high nut yield must be considered, but the nuts need to be of satisfactory quality, in this case, meaning sufficient size. Large-sized nuts command premium prices in the market. However, Ohrel (1979) and Mohan et al. (1987) observed that high yielding trees produced medium-sized nuts and they suggested that trees bearing medium-sized nuts should be preferred in selection. For the practical purposes of processing and marketing, a nut weight of below 5 g, has been considered uneconomical (Salleh et al. 1989).

In order to identify highly productive trees amongst the population of 135 well-buffered trees, nut yield per tree/year was plotted against mean nut weight per tree/year for those cashew trees with more than the average (754) nuts per tree/year (Figure 7). Lines were drawn to identify the mean nut weight per tree/year (5.46 g) and nut yield per tree/year 3.91 kg) . Promising trees were those represented within the top right hand section of Figure 7.

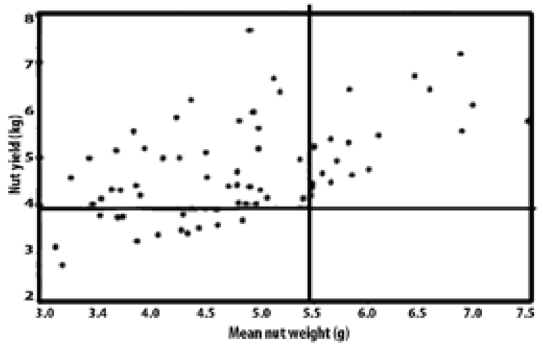

Figure 7*. Distribution of trees bearing more than 754 nuts per tree/year during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah from amongst the 135 well-buffered cashew trees originally derived from seedlings.*

Of the 135 well-buffered trees evaluated, only 19 trees combined levels of nut yield per tree/year, nut number per tree/year and mean individual nut weight which were numerically greater than the population mean (Table 3). Of these 19 trees, only four were considered highly productive (TN 10203, 12310, 20216 and 21406) because they gave nut yields of more than 6.0 kg per tree/year and mean individual nut weights of more than 6.0 g (Table 3).

Table 3. Promising trees selected based on the nut yield, nut number and mean nut weight during the 1993-94 fruiting seasons at Cashews Australia, Dimbulah from amongst the 135 well-buffered trees originally derived from seedlings

Tree Number (TN)	*Nut yield per tree (kg)*	*Nut number per tree*	*Mean nut weight per tree (g)*
10203*	7.16	1042	6.87
10210	4.65	834	5.58
10221	5.21	945	5.51
10328	5.54	807	6.88
10417	4.43	807	5.49
10427	5.38	950	5.66
10508	4.19	766	5.47
11206	4.73	786	6.02
11506	4.34	793	5.48
11903	5.76	770	7.48
11905	4.46	789	5.66
11908	4.91	858	5.72
12310*	6.10	873	6.98
20216*	6.42	974	6.59
20415	6.41	1098	5.84
21006	5.30	911	5.83
21115	4.62	788	5.86
21303	5.45	892	6.11
21406*	6.70	1039	6.45

* Trees amongst the population of 135 well-buffered cashew trees which were considered highly productive.

Conclusion

One hundred and thirty-five well-buffered cashew trees, originally derived from seedlings, have demonstrated a wide range of variation in nut yield per tree/year, nut number per tree/ year and mean individual nut weight. The number of nuts per tree/year was the most variable character. The frequency distribution of the seedling population was skewed towards higher values of the different nut yield components, indicating that high yielding and good quality nuts may be able to be selected from the population.

Nut yield was significantly correlated with nut number, indicating that an increase in nut number per tree contributed to increased nut yield per tree. The absence of a significant association between nut yield and mean individual nut weight implied the possibility of selecting high yielding trees with heavy nuts. The number of nuts per tree was negatively correlated with mean individual nutweight, indicating that trees producing more nuts had smaller individual nuts. Four highly productive trees (TN 10203, 12310, 20216 and 21406) were identified, on the basis that they produced nut yields of more than 6.0 kg per tree, nut numbers of more than 754 nuts per tree and mean nut weights of more than 6.0 g. These trees are recommended as mother trees for clonal propagation.

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Gatton College: A 1211 .

INTRODUCING THE MOLUCCA NUT

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In the 16th century, the bounty of the "Spice Islands" inspired sea explorers to make their first perilous voyages around the globe. Their annals are filled with sea dragons, walking leaves, head hunting heathens, and giants with misplaced heads. Half the explorers starved, festered and died. None of them knew where they going and most of them lived off piracy and bloodshed. But all this was worth the natural riches of Molucca.

After a hellish journey, Molucca was painted as an earthly Eden: refined kings and humble servants, fruits as big as your head, trees with edible trunks, and spices, yes, glorious spices! Cloves cinnamon, nutmeg and mace. A kitchen arsenal fit to flatten the stench of the most fetid, worm-infested carrion.

In the accounting of exploitables, most ships' chroniclers also made mention of a certain "sweet almond". They saw it gathered from the forest, eaten raw, roasted, in biscuits and gruels, all on its own or mixed with that odd sago palm trunk. The Moluccans knew their beloved "almond" as kenari. Most Europeans never knew it at all, the merchant voyagers were too busy packing ship bellies with cloves, scraping onto "desperate shoals", casting off cannon, meal, pulse, finally a few tons of those precious cloves and limping back to London, Lisbon, Amsterdam or Seville, if they were lucky.

Over the last four centuries, the western world has largely forgotten kenari and its islands. Despite its natural riches, modern-day Molucca, now more properly known as Maluku, faces an economic, civil and environmental crisis. Merely by munching Molucca Nuts you offer rays of hope for each of these problems. Kenari trees (*Canarium indicum* and *Canarium vulgare*, family Burseraceae) are the backbones of Maluku forests. Early research on *Canarium* showed Maluku to be one of the most likely centres of evolutionary radiation for the genus. If so, Maluku is a key storehouse of genetic diversity for trees that are now important to humans and ecosystems from Africa and Polynesia.

Oddly however, Maluku *Canarium*s remain poorly studied. As logging companies meet diminishing returns in Borneo, Java and Sumatra and turn their sights east, we may lose *Canarium* diversity before we even know what it is. Thankfully, kenari individuals are quite abundant. A lowland forest census near Seram Island's Manusela National Park found *Canarium indicum* to be the second most common tree, with more than 90 trees per hectare. This astonishing density may in fact reflect a long tradition of loose cultivation.

Kenari nut anvils dating back 800 years have been found on Seram. And not only are kenari plentiful--they're huge! The clean, white trunks of kenari trees tower straight through

the forest understorey and their branches sprawl far and wide above the canopy. Some reach as high as 50 metres tall.

Such stately emergent trees are favoured roost and nest sites for birds, including Maluku's rainbow of parrots and the spectacular Salmon-crested Cockatoo. Many of these birds are found nowhere else on earth and are endangered by forest destruction and trapping for the pet trade. Kenari trees are also an important food source for birds and other wildlife. Locals claim that most of the nuts they collect on the forest floor have passed through the guts of doves, who digest the thin fleshy fruit. Thankfully, a rock-hard shell protects the inner Molucca Nut meat from all but the sharpest blows with a rock or machete. For lack of imagination, the Molucca Nut is sometimes called a Java almond. An unfortunate name, as kenari isn't from Java (though it's been introduced as far as India), and its resemblance to an almond stops at its shape. Once the Molucca Nut is out of sight and into the mouth it melts into a sweet, delicate, creamy delight. It's more like a Maluku macadamia. Or is it? Let's try another ...

Yes, right out of the shell, the Molucca Nut is hard to resist. It's the kind of food that moms hide from kids. Then, in the off-season, Ibu sneaks into the pantry, blanches and grinds her quarry, and--Surprise!--kenari cake. Or cookies or candies. Or a rich, wholesome porridge, as described in the annals of Magellan's first round-the world voyage. My own favourite Molucca Nut recipe, courtesy of Ibu Lin, yields crispy wafers, a bit like butter cookies, but thinner and richer and accented with a touch of locally harvested cinnamon. Where is that Ibu?

In a giant Moluccanut tree

But if Molucca Nuts are so great, why aren't they in your supermarket? According to Richard Hamilton, macadamia breeder from the University of Hawaii, the commercial status of *Canarium* is equivalent to that of the macadamia some 30 years ago. From a nut that was hardly known some decades ago, the macadamia has since become one of the most prized and expensive nuts on the global market. The major hurdle to commercial development for *Canarium*, claims Hamilton, is the difficulty of propagation. To which we reply, "Why bother?" *Canarium* grows rampant in Maluku. Why not... We have a useful model for wild nut harvest and export in the Brazil nut. It's safe to say that every cocktail-mix Brazil nut you've ever eaten was collected from a wild tree growing somewhere in Amazonia. (And don't you always eat them first?)

As of 1986, Brazil nuts exports from Manaus, alone, totalled US$5.6 million and employed many thousands of people. Though Brazil nut trees make excellent timber, they're illegal to cut down--and jealously guarded--as their nut crop promises much greater cash income over the long term. (One study shows nut income exceeding timber income within ten years.) Certain developments of the Brazil nut industry can be readily applied to Molucca Nut export. These include collection and centralised processing strategies, and the stockpiling of nuts to regulate prices and meet year-round demand. (We're fortunate, however, that the diverse microclimates and double monsoons of Maluku allow Molucca Nuts to be harvested somewhere in the region throughout much of the year.) Molucca Nuts show other similarities to Brazil nuts. Both are collected from giant trees that are considered some of the most elegant within their forests. And both trees, though slow to come into production, fruit prodigiously for well over a hundred years. The most productive mature trees generate upwards of 100 kg of nuts annually! This makes wild harvest from primary forests, and from ancient stands where these trees have been loosely cultivated for generations, very attractive.

Saturday Night Live, circa 1975. Dan Akroyd wasn't kidding. He was selling *Canarium*. Yes, it really is "a dessert topping AND a furniture polish!" But wait--there's more! By dry weight, Molucca Nuts TM! are 65 -73% oil, including ester stearic, palmitine and oleine fatty acids. With a nearly identical fatty acid content, oil from *Canarium ovatum* (the Philippines' "pili nut") has been qualified as equal or superior to olive oil for cooking purposes.

Canarium oil also has strong emollient properties, making it an ideal base for moisturising lotions, soaps and shampoos. Various *Canarium* nut oils and resins have been reported to relieve joint pains. While running a pharmacy in the Solomon Islands, Australian chemist Peter Hull studied these properties in *Canarium indicum* (known locally as the ngali nut). The result is "Arthrileaf'.

Tired of those stubborn, messy immiscible fluids? Fret no more when mixing oil and water. Your Molucca Nuts include emulsifying agents. Don't be caught without them next time you're whipping up cosmetics (like those lotions) or food products (sauces, salad dressings--even dessert toppings). But, you ask, what about protein? Yes, your Molucca Nuts come complete with protein--and complete protein at that. Recent analysis of pili nuts yielded 11.5% to 14% protein content. And most of that was 11S globulin protein. The stuff of soybeans. This well-balanced vegetable protein would make a worthwhile protein isolate. What to do with the Molucca Nut meal left over from oil extraction? Sell it!

Aveda, for instance, now uses Brazil nut protein as an alternative to keratin in several of their haircare products. But what about those piles of Molucca Nut shells? Well, they are rather pretty, aren't they? The inner surface could pass for fragments of glazed tile. These might find use as mosaic tiles for local crafts. Similar products using coconut shells as laminates for boxes, picture frames and furniture are now very popular Bali exports. In the Philippines, pili nut shells make excellent fuel for cooking and small industry. They also make an ideal horticultural medium for orchids. Or how about Molucca Nut shells ground into a body scrub? Perhaps one based on Molucca Nut oil and fresh-scented, antibacterial *Canarium* elemi ...

Yes, *Canarium* is more than just nuts! When invaded by pathogens, *Canarium* trees launch a counter-attack. They exude a thick, honey-like oleoresin known as elemi. You, too, can use elemi to fight infection. Traditionally, elemi is applied as a poultice for ulcerated wounds, and for this it was popular in the western pharmacopeia by the early nineteenth century. With the development of synthetic antibiotics, elemi has fallen out of favour, but a growing interest in natural medicine paves the way for an elemi comeback.

Elemi has a pungent, piney, lemony scent. In parts of Indonesia and India it's a popular incense for religious ceremonies. In the western world, it's begun to see use in aromatherapy and offers further potential in perfumery. In the Philippines, export of "Manila elemi" (*Canarium luzonicum*) is big business. Around 2,306 tons valued at US$4.76 million were exported between 1990 and 1997, making this product one of the Philippines' most important non-timber forestry products. About three-quarters of these exports were to France. Elemi also serves as a turpentine substitute. It's used in products such as paints, varnishes and plasters, to which it adds toughness, elasticity, water-repellency and pest-resistance. A study from the Philippines' Forest Products Research and Development Institute found oil of elemi to have fungicidal properties and, in sufficient concentrations, to be toxic to dry wood termites.

All-in-all, the odour and chemical properties of elemi would make it an eco-friendly floor wax or even a "Lemon-fresh Lysol" alternative. Yes, dessert topping, furniture polish and so much more! How did you ever live without Molucca Nuts? Molucca Nuts offer sustainable income alternatives to Maluku communities. As Indonesia recovers from what the World Bank identifies as the worst economic crisis in recent history, and as Maluku struggles to heal itself following two years of civil unrest, local income generation is vital to assuring peace and environmental conservation.

Specifically, Molucca Nuts offer on-the-ground alternatives to liquidation of forest at (US$1.50 per cubic metre of wood) and poaching of wild birds at (US$0.50 to $10 each). At these prices, Molucca Nuts really can make a difference!

Project Bird Watch, a US non-profit organization, and Yayasan Wallacea, an Indonesian NGO, help Maluku communities by forging cooperatives that allow collection of Molucca Nuts over broad areas of forest and by establishing export markets. We pay a handsome price for quality and reliability and for the assurance that communities will do all in their power to continue sustainable use of natural resources. Modest mark-ups support our conservation aims, such as community education and ecotourism development, while offering competitive prices to our buyers. A guided tour of projects, analyses and pontifications. There's also lots more information on elemi, including our recommendation to extract higher value from exports by localising production of essential oil.

Australian Quarantine Regulations for Ngali Nut

In a nutshell, the easiest way to satisfy Oz quarantine (one of the toughest in the world) is to import nuts that are commercially packaged and labelled and basically DOA: roasted, boiled, blanched and/or very well vacuum-packed. If not, start reading the remaining 40 kilobytes on quarantine treatment, reexport or--gulp!--seizure for destruction. And yes, *Canarium indicum* is rated as a food product.

[Based on material from the website: http://www.tpp.org/pbw/moluccanuts/index.html]

CHIP BUDDING SPROUTED CHESTNUT SEED

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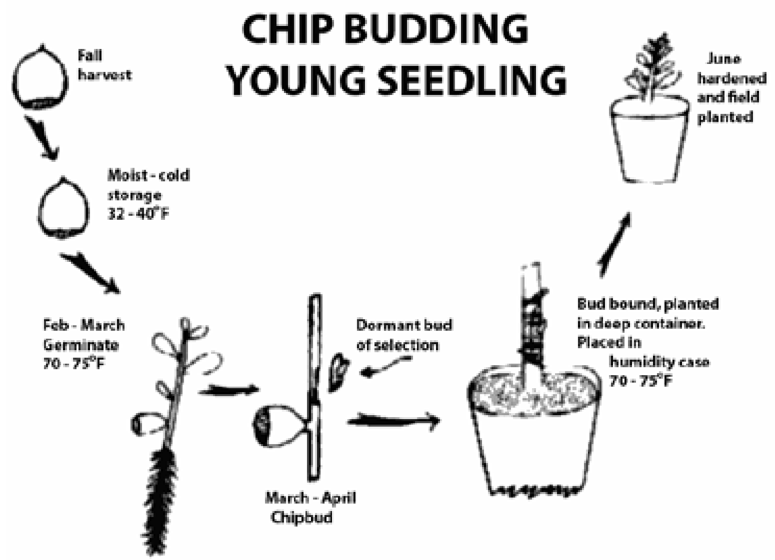
Numerous methods have been used with varying degrees of success to vegetatively propagate chestnut. None has been successful enough to be widely adapted by commercial or amateur nut growers in North America. Recently, Ackerman and Jayne (1980) published on a method they developed. I learned of the method one year earlier through personal communication and report here on two years results with the technique.

The method is illustrated in Figure 1. Cold stratified seed was removed from storage approximately one month prior to budding. Seeds were sown in flats in a mixture of 2 peatmoss: 1 perlite: 1 soil, and maintained at 18-27°F. in a greenhouse. Seedlings were removed from the flat and budded when the shoot (epicotyl) was 8-15 cm long and usually before any of the leaves were fully expanded. The terminal part of the shoot was cut off leaving about 5 cm. A chip bud from a dormant scion was placed in the shoot within 2.5 cm of the tip of the nut. Buds were taken from fresh collected and stored scions.



Because of the small diameter of the stock it is best to choose scion wood of narrow diameter. However, success can be obtained even if the scion diameter is twice that of the stock. Even if the diameters are different, the cambium layers of the stock and bud chip can be matched on the top, bottom and one side. As pointed out by Ackerman and Jayne, shoot diameter of seed sources varies greatly and is not always correlated with seed size. American chestnuts, for instance, often have a thick epicotyl despite the small seed size.

The stock shoot was cut approximately halfway through the stem to receive the bud. The grafted bud was bound with a rubber band or small rubber budding strip. Grafts were planted in individual deep pots and placed inside a polyethylene covered humidity case at 21-24°F. The potting medium was the same as the germination medium.

After about 3 weeks the case was partially opened so that in 4 to 5 weeks the grafts were conditioned to the greenhouse environment. After danger of frost the plants were further conditioned outside in a lath house where they received half normal sunlight for 2 or more weeks prior to field planting. Plants were fertilised, mulched, and watered as necessary in the field. A second flush of growth was apparent on most plants by August 1 (Figure 2). Average survival of the grafts at time of field planting was 55%, with success being much greater early in the season (Table 1). Most failures occurred within 4-5 weeks of grafting. Older and more differentiated stock apparently lessened the chances for success.

Table 1. Two-year results of chip budding sprouted chestnut seed.

Date	Number grafted	Number field planted	%
March 22-April 1, 1979	62	40	65
May 1979	128	2	2
March 1980	133	126	95
April 3-11, 1980	123	88	72
April 21-29. 1980	33	8	24
Totals.-	479	264	55 avg.

(Seed sown 4 - 7 weeks before grafting)

More than 20 scion sources were used including *C. sativa, C. dentata, C. mollissima*, and hybrids. Graft incompatibility was rare in contrast to our previous experience with normal spring (cleft) grafted chestnut on 1-3 year old root stock. Further testing is needed to verify this.

Experience with chestnut and other plants suggests that if good growth is obtained the first summer then losses the following winter will be minimal. Over wintering of the grafts made in spring 1979 was good the first winter (76% survival), and could possibly have been improved if more growth had been obtained the first summer with better cultural techniques and by doing all grafting in early spring.

Ackerman and Jayne (personal communication) have used this chip budding method successfully on a few other plants including oak and walnut. The technique lends itself to use by the amateur. Seed could be germinated indoors, grafted, the grafted plants potted individually, and each covered with a clear plastic bag and kept in a bright window until they could be moved outside. Care should be taken that enclosed plants do not overheat in full sun. The biggest obstacle for the new grafter will be the dexterity required to cut, place, and wrap the bud, but with a little practice the method can be mastered by most people.

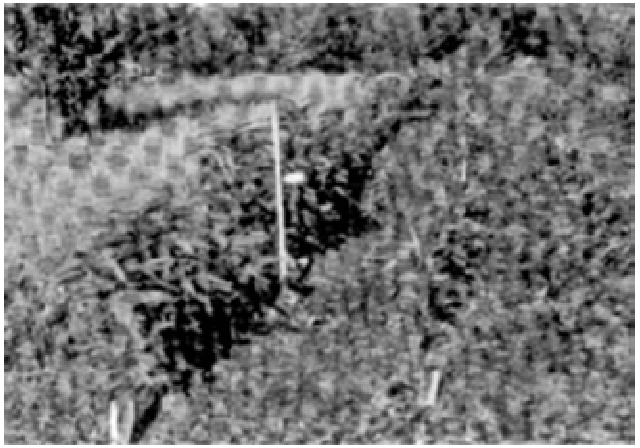


Figure 2. Field planted grafted chestnuts. Photo taken about 5 months after sprouted seed was budded. (60 cm indicated on metre stick)

Summary

Recently germinated chestnut seeds can be successfully chip budded with dormant buds. Grafts made in early spring were more successful (80% average) than those done in late April and May. The method appears to be a practical bench method of value to amateurs and horticulturists with possible commercial application.

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THE PITAYA OR DRAGON FRUIT

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Introduction

Plants in the cactus family, Cactaceae, originated in North, Central, and South America. They are widely distributed, from coastal areas, to high mountains, and in tropical rainforests. Their appearance is just as variable, from thimble-size species, to enormous column species, and the epiphytic (climbing) species.

The cactus family are highly adaptable to a new environment. The plants are able to tolerate drought, heat, poor soil, and cold. The modification of the stem for water storage, the reduction or absence of leaves, the waxy surfaces, and night-time opening of the tissues for carbon dioxide uptake (the CAM process), enable the plants to tolerate harsh conditions. Terms used to describe plants with such adaptations include xerophyte and succulent. These adaptations to survive dry, hot conditions, apply to the above-ground plant. The roots are non-succulent and require small amounts of water and cooler temperatures. Cacti will not tolerate saline or water-logged conditions, nor will they grow where there is an absence of plant life.

In their native lands, the plants were used for many purposes, but one of major importance is the fruit as a food source. Fruit was collected from naturally established stands. Later, cuttings were taken from highly productive plants and grown around houses. A similar process is now in place in several countries around the world to establish plantations of cacti with edible fruit, from column, shrubby and climbing types. Epiphytic or climbing cacti use their adventitious roots from the stems to cling to rocks and trees for support. These roots do not feed from the host plant. The aerial roots collect water and nutrients from their surroundings, enabling the plant to survive if the base is severed. This feature also allows the plants to be successfully grown from cuttings.

Hylocereus undatus (Haworth) Britt & Rose, a climbing cactus thought to be from the tropical rainforests of Central and northern South America, is one species that has been used as a food source. It has already received world-wide recognition as an ornamental plant for the large, scented, night-blooming flowers. Its fame is now spreading throughout the world for its fruit, especially in Israel, Vietnam, and Australia.

Other climbing cactus species grown for the edible fruit include *Hylocereus polyrhizus* and *Selenicereus megalanthus*. *H. polyrhizus* has red skin and red flesh dotted with edible black seeds, while *S. megalanthus*, the pitaya amarillo or yellow pitaya, has yellow skin and clear to white flesh containing edible black seeds. Columnar cacti, such as *Cereus peruvianus* - the apple cactus, and the shrubby Opuntia species - the cactus (prickly) pears, are also grown for their edible fruit. The Opuntia species are also well known due to their noxious weed status. Plants spread and establish rapidly from seeds and vegetative pieces. The potential for *Hylocereus* to become a weed is unknown at this stage.

Growing areas

In Mexico, Guatemala, and northern South America, the cactus fruits are known as pitaya, pitahaya, pitajaya, pitaya roja, and pitahaya de Cardón. In Israel, the name pitaya has been adopted. In Vietnam, the fruit is called Dragon Fruit or Thanh Long. The plants grow naturally in Mexico, Central and South America and are also planted in backyards. Orchards are now established to provide fruit for the local and export markets in North America and Europe.

Hylocereus undatus is not able to tolerate the intense sunlight in Israel. Plantations are established in shadehouses on metal trellis systems to provide fruit to the local and export markets in Europe.

About one hundred years ago, the French brought *H. undatus* into Vietnam, where it was grown exclusively for the King. Later, it became popular with the wealthy families throughout the country. More recently, it has been established as a backyard and orchard plant, providing fruit to the local and export markets in South East Asia and Europe.

Pitaya fruit

Fruit appeal

So successful is the fruit in Vietnam, that at times it is the major export item, and can fetch higher prices than durian - the' King of Fruits' in South East Asia. Formerly uncultivated, marginal lands are used to establish *H. undatus* orchards. The plants are grown on concrete or wooden posts, trees and fences, for support. The branches are encouraged to hang down to promote flowering and fruitset. Water and fertiliser requirements may be lower when compared to other tropical fruit species grown in these areas.

The attractive colours in the fruit encourage people to buy. The bright red or pink skin glows, the green scales enhance the red skin colour, and the brilliant white flesh looks even more enticing dotted with the tiny, edible, black seeds. The fruit is considered a gourmets' delight, creating a spectacular centrepiece on any table.

Uses for the fruit

H. undatus fruit is highly appreciated when served chilled and cut in half to reveal the attractive colours. The flesh and seeds are scooped out with a spoon, much like a kiwi fruit. The flesh is firm and crisp, with a delicately sweet and lingering flavour. The juicy flesh can also be mixed with milk or sugar, used in marmalades, jellies, ices and soft drinks.

Flowering and fruiting

In warm climates, the dry season is when active growth slows or stops. *H. undatus* flowers are self compatible, producing fruit with one species, but cross-pollination with other *Hylocereus* species can produce larger fruit. H. undotus is a long-day plant, requiring longer day lengths to induce flowering. In the Northern Hemisphere, the main fruiting season occurs between May to October. Recent observations suggest the season in Darwin may extend from October to April.

Buds are contained in aureoles along the three-ribbed stem and emerge in the summer months. Once emerged, the buds then form into branches or flowers. The scented, white, night-blooming flowers attract bats and moths. Bees and other insects visit the flowers before dusk as the petals open, and after dawn as the flowers begin to close. Ten days after opening, fruitset is visible. Fruit development is rapid. After a further 25 days, the fruit is ready to be harvested. Fruit can be left on the stem up to 15 days at this stage.

The average fruit weight is 350 grams and this increases with the number of seeds present. The flowers and fruit can be thinned to 1-2 fruit per branch, to produce fruit of an even size and quality for the export market. An unripe fruit contains mucilage, a sticky substance, which makes the fruit unappealing. Fruit is cut from the stem at the full-colour stage and packed for the markets. At the full colour stage, the skin becomes pink-red and the scales remain green. The fruit is non-climacteric, having the best flavour, soluble sugar level and acidity when harvested at the full colour stage.

From the information gathered on pitaya, the stored fruit have thinner skin as water moves from the skin to the flesh, higher sugar levels but less flavour than freshly harvested fruit, and may develop rots. The yellow pitaya (*S. megalanthus*) can be stored for four weeks at 10°C, and a week or more at 20°C. The relative humidity for both temperatures is 60 - 70%. Caution is needed when using these suggestions until data is available for *H. undatus*. In Vietnam, a second fruiting season is possible using lights to extend the daylength or potassium nitrate to induce flowering. Induction commences 70 days before the expected harvest although less fruit is produced from flower induction.

Orchard management

Seedlings are slow growing, making them unfavourable for propagation. Healthy, green cuttings are preferred for rapid propagation. The cutting should be half a metre in length for successful establishment. The cutting is cured by storing in a dry place for a week before potting into a free-draining mix. Cuttings need to be shaded and require minimal water and fertiliser before the roots develop. Once the roots have developed, the plants can be sun-hardened and planted into a mounded area. Plants should be established on well-drained beds, up to 300 millimetres high, three metres apart within a row and four metres between rows, depending on the size of orchard equipment. Concrete or wooden posts can be used as support, with a frame on top to train the branches. One to four plants can be used for each post depending on post size. A single leader stem is grown up the post, with side branches removed, until the top of the post is reached. Branches then need to hang down to flower and fruit, and training is easier at midday when the branches are soft. The majority of roots are found in the top 15-30 centimetres of soil and irrigation is required to ensure the soil does not dry out completely. Wet and dry periods during fruit development may lead to splits in the fruit. Irrigation is used to maintain water levels in the soil during fruit development to prevent splits. Thick mulch placed on the mound, but away from the stem, will also slow water loss.

Many of the fruiting cacti grow naturally in areas with high minerals, lime and decaying organic matter. A balanced NPK fertiliser, organic fertiliser, lime, and foliar fertiliser during fruit growth, are required by *H. undatus*. Fertiliser is included in the planting hole and then applied after the first month. A three month fertiliser program continues after this, with a once a year organic application and liming. Fertiliser can be applied as granules or through the irrigation. Nitrogen is required during vegetative growth, but is normally reduced during the resting and pre-flowering stages. Urea sprays, at 3-5%, can be used to encourage vegetative growth, with micro elements added if required. Pruning the tips allows easy access through the orchard and is used for flower and fruit thinning. An open, manageable, and productive canopy is maintained by thinning the branches. A plant in the first year should have 30 branches, increasing to 130 branches in the fourth year. After harvest, the plant is pruned to a maximum number of 50 main branches, with 1-2 secondary branches on a main branch. Tertiary and quaternary branches should be removed.

Cacti may be attacked by a range of pests that should be monitored and controlled with the recommended sprays and baits. Pests can include mites, thrips, ants, scale insects, mealy bugs, beetles, slugs, borers, nematodes, fruit flies, and mice. Some, or all of these, may be present on *H. undatus*. Diseases from fungi and bacteria can occur if injury or wet conditions are present. Contact Departmental officers from the Resource Protection Division for suitable control methods.

The future

H. undatus has a niche market in Australia at present. Prices are dependent on the demand for the fruit. The ease of establishment and rapid growth may quickly lead to an over supply in the market. The export potential for *H. undatus* from Australia is unknown at this stage.

[Based on Agnote No. 778, May 1999. Available at http://www.nt.gov.au/dpif/pubcat/agnotes/778.htm]

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**, and the **WANATCA Yearbook**.

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.

The **WANATCA Yearbook** is our major research publication, with original articles of permanent interest. It is indexed as part of the global coverage of the U.S.-based Biological Abstracts Service.

The **Australasian Tree Crops Sourcebook (ATCROS)** is our major reference work, containing regularly-updated tables of all sorts of useful material about tree crops (common and botanical names, growing conditions, recommended areas etc.), membership lists, lists of useful tree crop organizations world-wide, and a commercial-sources list, acting as a Directory of Tree Crop Services for the whole of Australia, New Zealand, and adjacent areas. Relevant services (e.g. seed suppliers) are listed world-wide. This information has now been updated and converted into a major World Wide Web site on the Internet - address is **<http://www.AOI.com.au/atcros>**.

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