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Theobroma cirmolinae, Mountain Cocoa

West Australian Nut and Tree Crop Association (Inc.)

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WANATCA Yearbook

Volume 12

1987

West Australian Nut and Tree Crops Association (Inc.)

The Association publishes a quarterly magazine 'Quandong' and the Yearbook. The West Australian Nut Growing Society was incorporated into the Association from 1981.

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

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Our Cover Illustration

Mountain Cocoa or Cacao, *Theobroma cirmolinae* -- a colder-climate variety of cocoa frotm the mountains of South and Central America. A possibility for the chocolate supply industry near Perth?

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Editorial

In the School of Agriculture at the University of Western Australia, I am involved in teaching and research in Horticulture, with special emphasis on fruit, vegetable and vine crops. This work is exciting and there is a good deal of interest in it shown by students at the postgraduate and undergraduate level. At present there are thirteen people doing research projects, which cover diverse crops such as rockmelons, beans, carambola, plums, mangoes, grapes and bananas.

A range of subject areas are also being studied. Salinity, water relations, flowering, irrigation management, nutrition and post-harvest are among them. This work is taking much of my time and so less has been devoted to other activities such as editing the Yearbook. Indeed it has only appeared because of the encouragement and efforts of David Noel.

So, perhaps the Yearbook is like a fruit or nut tree - sometimes it takes a little time to produce something! I have enjoyed gathering the articles in the 1987 edition, and I think the authors have done a good job. I hope you enjoy reading it.

David W. Turner
Editor

Orchard Establishment and Economics of the Pistachio

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Introduction

The edible pistachio (*Pistacia vera*) is a native of western Asia and Asia Minor. The main producers are Iran, Turkey, Syria, Italy (Sicily) and Greece, with significant production in Afghanistan, the USSR, North Africa and the USA. In California, a strong export industry has developed, which in 1981 produced 7045 tonnes of unshelled nuts, valued at $18.7 million, from 10 800 hectares of bearing trees. In 1986 the projected figures are 25 000 tonnes, valued at more than $100 million, from 13 000 hectares.

Pistachio trees were first imported into Australia in 1935 and planted at the Yanco Agricultural Research Centre, NSW. Further experimental plantings have been made at Wagga Wagga Agricultural College, NSW, the CSIRO research station at Merbein, Victoria, and at the Department of Agriculture research station at Loxton, South Australia. In New South Wales, commercial plantings have been made at Mudgee, Dubbo, Narromine, Griffith, Hay and Kyalite. Further plantings are expected in other south and south-western areas of New South Wales. It is likely, however, that the capital required for irrigation, harvesting and processing, and the long lead time before the first commercial crop, will limit interest.

Description

The pistachio is a member of the Anacardiaceae family and is related to the mango. There are 11 species of *Pistacia*, but only *P. vera* has edible fruits. Individual trees can live for up to 200 years with a bearing life of 80 years. It is a small deciduous tree, 3 to 9 m high and 5 to 10 m across. The tree is deep rooting with a vigorous root system that is generally dense with the taproot reaching 1.5 to 2 m, and spreading feeder roots travelling 3 m or more.

Budbreak is usually in late August to early September. Flowering is usually in mid-October. The trees are dioecious, that is, there are separate male and female trees. Harvest is usually in March to April. The fruit is a large kernel protected by a thin, hard bivalve shell encased in a fleshy resinous husk.

Fruit is fully sized 6 to 8 weeks after flowering and pollination. At this stage it has a firm but nearly empty shell. The embryo soon enlarges and is fully developed within 16 weeks. Water loss then follows and the nut is ripe 4 to 6 weeks later. 'Blanks' (empty fruits) can develop if the embryo aborts. When the fruit ripens and enlarges, splitting of the shell occurs. A commercial variety ideally averages 70% and up to 90% split nuts. The pistachio is the only nut to split this way.

Climate and Soil

The pistachio is extremely drought tolerant but requires irrigation for economic yields. Cool winters (July mean minimum 5°C or below) are needed to break bud dormancy. Flowering occurs during October, and the site should ideally be frost-free then. Summers should be hot and dry with a mean monthly rainfall of less than 25 mm and a January mean maximum temperature greater than 30°C. This helps to mature the nuts and prevent possible build-up of an aflatoxin-producing fungus. It also reduces the staining of shells during harvest.

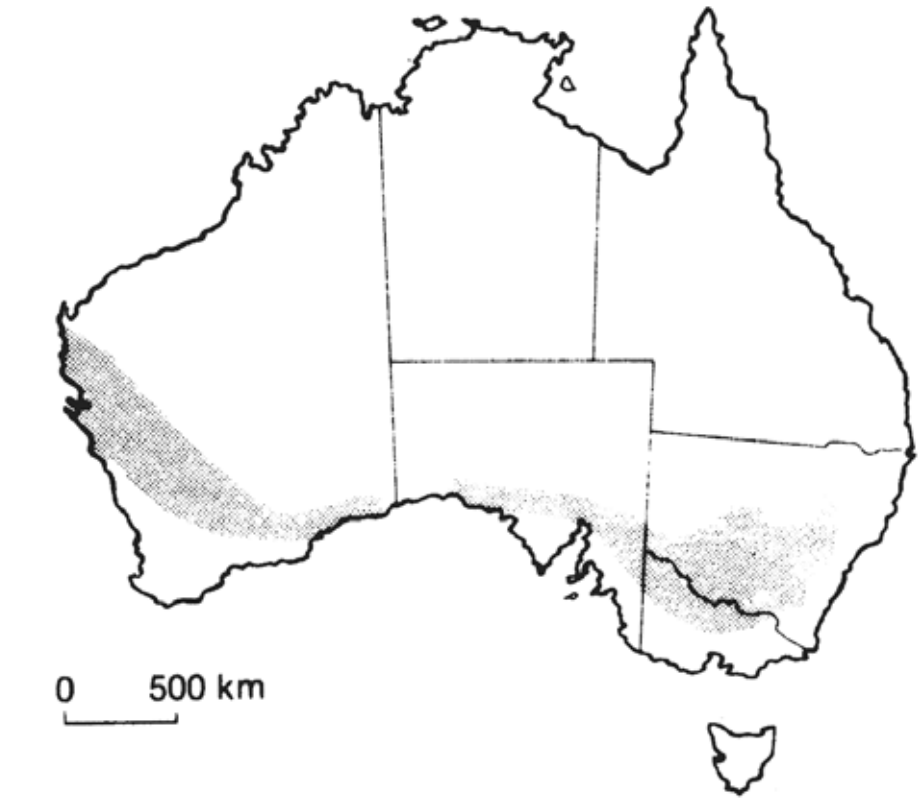

Fig. 1. Likely cropping range for pistachios in Australia

Figure 1 shows the likely cropping range for the tree in Australia. Pistachios can be grown on a wide range of soil types with pH ranging from 5.0 to 8.0, and prefer deep, lighter-textured, well-drained soils. Alluvial river flats are suitable. Good drainage is important as the tree will not tolerate long periods of waterlogging or high water tables.

Planting and Establishment

Source of trees

Budded trees can be purchased from a nursery at a cost of $13 to $20 each, but must be ordered two years in advance. The high cost of purchasing these trees is likely to prove uneconomic to growers. A second option is to buy seedling trees that can be planted and budded in the field. Alternatively, trees can be budded in the nursery prior to planting out. Seedling trees cost between $0.70 and $4.00.

A third option, the propagation of your own trees, is likely to be the most popular, especially for growers looking at a larger scale operation. If you intend propagating your own trees, remember to give priority to establishing male trees. Production has been delayed in many orchards because there were not enough males flowering and ready to pollinate female trees in the first, flowering year.

There are established procedures for growing your own trees, right through from rootstock seed collection and germination to the ultimate budding of a scion into the stock. If you wish to order rootstock seed, contact your local district horticulturist by December. Seed is then distributed the following April. Details for doing your own propagation can be obtained from your local district horticulturist and are listed in our Farm Business Note No. 24 (see references at end), and CSIRO Paper No. 609, Pistachio - a technique for chip budding by B.A. Needs and D. McE Alexander. The potting mix used in propagation of the trees has been costed at $1.50 a bag including freight, plus $0.30 for the cost of each bag (1984).

Budding

Budwood can be ordered from CSIRO, Merbein, during June and July. Each budstick costs 20 cents (1985) and contains five or so buds. Budwood may be stored for 5 to 6 months at 3° to 5°C until needed for chip budding.

Both chip budding and T-budding can be done with the tree in the pot or in the open field after planting, when temperatures and moisture are suitable for sap flow. Beware of cold snaps as sap flow stops and there is less chance of the stock and scion knitting together. Applying nitrogenous fertiliser at least 4 weeks prior to budding improves success by encouraging stock growth and sap flow. Experienced budding staff will have little problem chip budding using a budding knife. For the inexperienced, the Lilliput® budding machine, costing about $300, provides a professional operation with very good results. Chip budding has proved to be one of the best methods for working pistachio rootstock. However, success does not come easily. The budding operation may have to be done a few times over 2 to 3 years before all the trees are fully budded.

Depending on locality the ideal time for chip budding is late September to mid November, and for T-budding is late November to February. Budwood for T-budding may be selected from previously budded trees in summer once the new season's growth has matured.

Everything must be in favour of the budding operation for success. All going well, a success rate of a least 70 per cent should be expected, but sometimes disappointing results can occur. The pistachio is not as easy to bud as other trees, and warm temperatures and a glistening sap flow are important clues to the best time to bud.

Rootstock

The two varieties used in Australia for rootstocks are *P. atlantica* and *P. terebinthus*, the latter being slower growing but preferred in cooler areas. *P. atlantica* is more susceptible to cold injury when trees are less than 2 years old. Both species are susceptible to *verticillium* wilt, a major disease problem overseas. Avoid planting in soils that have been used to grow cotton, strawberries, tomatoes and potatoes.

P. chinensis is not suited as a rootstock. Recently *P. integerrima* selections have proved to be the most resistant to wilt.

Scions

The two varieties of female trees that have performed best in Australian trials are Sirora (formerly 15-11) and Kerman. They flower at different times and should be planted apart with suitable pollinators so they can be harvested separately. Kerman produces a clean white nut with a larger shell than Sirora. Sirora is less white with more staining on the shell. Sirora matures about 10 days later than Kerman. Until a preference is determined, growers should plant 50% of each.

Peters Male is the standard Californian recommendation for male trees and CSIRO recommends that each tree carry three Peters selections of early, mid-season and late. This provides the best chance of pollination as the total flowering period of a female may last up to 10 days.

Breeding and variety evaluation are part of a continuing research program. More varieties are likely to become available in future years. Budwood supplies could become scarcer in future as demand grows, so priority should be given to establishing source trees.

Windbreaks

Pistachios are hardy and rely on wind for pollination, so windbreaks are not critical. However, proper planning and layout of windbreaks can lead to better production and improved crop growth, especially in young trees. As much of the region now planted in NSW receives hot dry winds from the west during mid-summer, a windbreak can be beneficial.

Orchard layout

There are a number of possible combinations of tree spacing in a pistachio orchard using either single or double planting. The location of the male pollinator trees is critical as pollen is wind-spread. Growth rate must also be considered as pistachios are very slow growing and double planted rows of trees must be retained for some time. A pollination arrangement with trees planted on a 5 m x 8 m grid could be one male to eight females as in Fig. 2.

This results in 250 trees per hectare (220 female and 30 male). This layout is used in the cash flow budget later. A minimum distance of 9 m must be left at headlands for machinery access.

M F F **M** F F **M**

F F F F F F F

F F F F F F F

M F F **M** F F **M**

F F F F F F F

F F F F F F F

M F F **M** F F **M**

*Fig. 2 Pollination arrangement of Male (**M**) and female (F) trees planted 5 m x 8 m*

Maintenance

Irrigation

Irrigation is very important for pistachios to obtain commercial yields. This is especially so from September to April for the period from winter dormancy to bud burst in spring, and later flowering, fruit sizing and just before harvest. Pistachio fruit development (or filling of the shell) occurs just before harvest, and water supply in the month prior to harvest is especially important. The effect of water supply on shell splitting is not yet known.

Table 1. Annual water requirements for pistachio (Ml/ha)

	under-tree sprinkler		trickle irrigation (heavier soils)	
	hot dry inland	cooler areas	hot dry inland	cooler areas
young trees	4-6	2-3	3-4	1-2
mature trees	8-10	4-5	6-8	3-4

As a guide, pistachios use about 75 per cent of citrus water requirements. The actual amount, though, will vary with factors such as district and soil type (see Table 1).

Tensiometers are important aids for scheduling irrigation. On many soils, under-tree sprinklers are an ideal system, even though they have more than enough capacity in earlier years. This system would cost about $10 a tree, which is more than a dripper system at about $7 a tree. Trickle irrigation has been used successfully in overseas orchards. Soil type is an important determinant in the success of trickle irrigation.

Fertiliser
In general, young trees should receive a complete fertiliser containing N, P and K with the option of additional nitrogen side-dressings. Mature trees will benefit from mainly nitrogen fertiliser. A zinc spray will probably be necessary each year, especially on sandier soils. Other minor nutrient deficiencies may show up from time to time. A soil test prior to planting is necessary and soil and leaf tests at regular intervals are good management.

The application of fertiliser in irrigation water allows split applications to be made with minimum effort. Young trees respond well. Apply 50 to 100 g of 11:15:9 (N:P:K) or equivalent to each young tree for each year of tree age up to 5 years, then increasing to 2 to 3 kg per tree depending upon vigour. Split applications, applying half the fertiliser in spring and the rest in summer, are recommended. Additional nitrogenous fertiliser applied in summer will boost growth. Growers have a choice of a complete or nitrogenous fertiliser for mature trees, applying 300 to 400 g per tree of actual nitrogen. Use leaf analysis to monitor requirements for other nutrients.

Zinc sprays are available in powder and liquid formulations, including chelated forms. Apply zinc to foliage. The semi-concentrate orchard sprayer is a good, all-round machine for this job. Alternatively, use ultra-low volume (ULV) or ground rigs. Extra nitrogen applied during late spring to summer will considerably boost tree growth.

Weed control
Most chemicals used for weed control in pistachio orchards overseas are not registered for that use in NSW. Contact your district horticulturist for advice.

Mechanical cultivation and hand chipping are needed with young trees. To avoid damaging valuable feeding roots do not cultivate deeply. Sarlon Weed Mats have been used for weed control in young trees during establishment years. The mat also allows rain to pass through the plastic weave, and the black colour warms the soil. It is necessary to have a weed-free strip 1 m wide along young tree rows, increasing to 3 m for older trees, with a permanent mown sward between rows. Grasses and legumes grown in pasture mixtures in your area can be selected for the sward. Annual ryegrass is well suited for a permanent sward.

Pests
Few major pests have been encountered to date. Leaf-eating beetles can be a problem on young trees. It is possible that problems might develop with rootknot nematode causing damage to roots, and birds may attack the fruit.

Diseases
No major diseases have appeared in Australia so far. Damping-off can cause loss of seedlings during propagation. Epicarp lesion is a potentially serious disease. However, there appears to be varietal resistance, with Sirora being least affected.

Disorders
Blank or seedless fruit is an important problem and is usually due to seed abortion or fruit failing to pollinate properly. The problem is largely reduced by selecting the rootstock and scion combination least affected.

A potential problem is aflatoxin contamination caused by the fungus *Aspergillus flavus*. This has not yet been recorded on pistachios in Australia though it occurs overseas. It is brought on by rain and high humidity. Areas with less rain in the harvesting period will have reduced risk.

Shell staining is often a varietal feature, which may reduce marketability of nuts.

Tree training and pruning
Palmette, central leader and vase shapes are being assessed, but none has emerged as being the best.

The aim in pruning is to have a high crown on female trees (1 m off the ground) to assist mechanical shaking, and a similar crown (minimum 50 cm) on male trees for cultural operations. Skirts of mature trees are kept at least 1 m off the ground.

Unlike the peach, the pistachio does not require formal pruning. Rather, it can be detrimental, so leave the mature tree alone as much as possible and prune only to keep fruit production low down on the tree, to remove branches that cross over and to open the centre slightly in vase trees.

Yields

Little local information is available on yields or on methods of harvesting and processing the crop. Most of the information comes from California, but this may not be directly applicable to the Australian situation. Pistachios tend to crop in a biennial fashion, with a year of heavy cropping followed by a year of light cropping. Nuts have to be dehusked and dried and blanks, non splits and culls separated. The ratio of marketable nuts in shell to fresh nuts in husk is very important. Fresh nuts in husk will yield only one-third this quantity of dry nuts in shell after dehusking but then a further 20 per cent is deducted to take account of non-splits, blanks and culls. While Sirora is presently outyielding Kerman, Sirora appears to be of lesser quality and more grading may be necessary.

Table 2 shows estimated yields for Australian orchards from three sources. We emphasise that these figures are estimates only, as no data are yet available.

Table 2. Estimated yields for pistachios in Australia
(dry nuts in shell in kg)

Female trees/ha	200		220*		223	
Annual yield	/tree	/ha	/tree	/ha	/tree	/ha
Age of trees (years)						
6	0.22	44	0.80	176	0.67	150
10	1.02	204	2.40	528	3.40	758
15	2.33	466	8.00	1760	6.70	1500
20	..	..	8.50	1877	9.00	2000

* Figures used for the cash flow budget (see Table 4 a & b).

Table 3 shows data from California for the percentage of rejected nuts (non-splits, blanks) in the harvest. The tendency for biennial bearing is shown in the figures for total harvest. In each year, the proportion of acceptable nuts is very low in comparison with other crops.

Table 3. Percentage of accepted and rejected nuts, California harvest

Year	Total harvest (kg)	Splits	Non-splits	Blanks
1979	11 446 559	68.3	15.3	16.4
1980	23 558 766	51.9	29.6	18.5
1981	10 822 660	60.9	23.1	16.0
Average		60.37	22.67	16.77

Source: California Pistachio Commission.

Harvesting and Processing

Harvesting and processing must be done properly to ensure atop quality product. It is possible to harvest the nuts by knocking them onto groundsheets, dehusking them with commercial potato peelers and drying by placing them in onion bags on racks. After this stage many growers would probably sell their dried nuts and leave the brining, roasting, grading and sorting to a specialised processor. The separation of nuts for non-splits and blanks could be done off the farm and payment adjusted, as it is with many other products.

In the medium term, however, at least some of these tasks on the farm (harvesting, windrowing and collecting nuts, dehusking and processing) are going to be mechanised because it is cheaper that way. Contracting, if a local industry develops, may be an alternative method. The stages involved in harvesting and processing, and some of the machines available, as described below.

Removing nuts from trees
Nuts can be knocked down by hand onto groundsheets or a butt shaker can be used. This can be a scissor attachment fitted to a tractor p.t.o. or a fully integrated shaker, umbrella, elevator, trailer and prime mover. The shock wave shaker is approximately $12,000 and the fully integrated harvester is about $80,000. These are available in Australia. Separating nuts from leaves, twigs and clusters can be done with an air blower.

Dehusking
Commercial (wet) potato peelers such as the 'Crypto®' (available for $1,200-$3,000) do a slow, but good job. They can handle 7-14 kg of fresh nuts in 4 to 8 minutes. Small dry dehullers coupled to a tractor p.t.o. will dehull up to 900 kg/hour. It is a priority to get nuts from the tree to the processing plant and husks removed as soon as possible, preferably within 12 hours. Alternatively, nuts might be held in husk in a cool store for up to 3 days before dehusking. It is important to remove husks at harvest time and dry as soon as possible to 2.2 to 8.2% moisture at 21°C to inhibit fungus growth. The best level is 4 to 6% moisture. At 0% the nuts lack flavour.

Further processing
Separating non-splits and blanks is achieved by using a flotation tank, as blanks will float while non-splits will sink. Drying the nuts is most simply done on racks, under cover and protected from rain. The nuts are spread no thicker than 4 cm on the racks for about 10 days, depending on the weather.

For brining, roasting, grading and sorting the crop is bagged and usually despatched to a processor.

Cash Flow Budget

A cash flow budget for 20 years is presented in Table 4. Because of the many assumptions built into such a budget, its main use, apart from a broad indicator of profitability, is a guide for people to work out their own costs. The cash flow is for 4 ha of pistachio planted at an 8 m x 5m permanent spacing, giving 220 female and 30 male trees per hectare. We think that within a 20 year time span none would have to be removed.

Many of the costs are specific to individual situations. Land purchase has not been included as many growers will simply be developing their own properties. The same applies to much of the basic farm machinery needed. Labour has been costed. The orchard is established by propagating your own trees. If seedling trees are available at the right price this could be a worthwhile option, but it must be remembered that there are many unknowns, and a least-cost approach is adopted here.

Table 4. Cash flow — establishing and growing a 4 ha pistachio orchard, 250 trees per hectare, 220 female, 30 male, over a period of 20 years.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
INCOME						704	1643	1173	2816	2112	4224	3285	5632	4224	7040	5397	8448	6336	9856	7509
Yield kg 4 ha						2816	6571	4693	11264	8448	16896	13141	22528	16896	28160	21589	33792	25344	39424	30037
Value @ $4.00 kg ($)																				
COSTS ($)																				
Capital																				
Fencing, windbreaks	1072																			
Machinery	5550	200	200			13000		17000												
Tree Propagation	3443																			
Land Preparation, planting	548																			
Irrigation	10000																			
Labour	2016	2464																		
Annual																				
Fertilizer, chemicals	4	55	75	95	82	147	207	250	314	347	502	502	502	502	502	502	502	502	502	502
Budding	50	15	5																	
Irrigation		504	504	504	504	596	596	596	596	596	688	688	688	688	688	780	780	780	780	780
Labour, growing, harvesting		5152	4816	4368	4032	5152	5152	5152	5152	5152	5264	5264	5264	5264	5376	5600	5600	5824	5824	5824
Marketing					197	461	328	788	591	1182	920	1577	1182	1971	1511	2365	1774	2759	2102	
Total capital and annual costs	12683	18390	5600	4967	4618	19092	6416	23326	6850	6686	7736	7374	8031	7636	8537	13393	9247	8880	9865	9208
Income less costs ($'000)	-12.7	-18.4	-5.6	-5.0	-4.6	-16.3	0.2	-18.6	4.4	1.8	9.3	5.8	14.5	9.3	19.6	8.2	24.5	16.5	29.6	20.8
Cumulative income ($'000)	-12.7	-31.1	-36.7	-41.6	-46.3	-62.5	-62.4	-81.0	-76.6	-74.8	-65.6	-59.8	-45.3	-36.1	-16.4	-8.2	16.3	32.8	62.3	83.2

Labour

If we assume that land is already owned, labour represents a large proportion of the total cost of the program. In the first ten years it represents 40 per cent of total capital and management costs. Labour is costed at $7 an hour and assumed to be employed on a casual basis.

Break-even point

The first commercial harvest is in year 6, the first substantial positive net income is in year 9 and the cumulative income breaks even in year 17. The peak debt is $81,000 in year 8. With all labour costed, the return on capital (internal rate of return) is 8 per cent. With labour excluded, the return is 17 per cent.

Given that there are significant taxation concessions for the capital costs of irrigation (the cost is fully deductible in the year expenditure is incurred), and the delay until full commercial production, the opportunity for reducing tax on income earned elsewhere could make an investment in pistachios an attractive proposition for well established irrigation farms which are on a high marginal tax rate. Changes to tax laws could change this situation considerably.

Conclusion

Pistachios, like most tree crops, have a long delay until first commercial harvest and positive cash flow. The internal rate of return at 8 per cent is not high and for this reason the crop will be most attractive to those who already have much of the infrastructure on hand, such as land, irrigation, machinery and surplus labour. It is quite likely that the capital value of a property where pistachio development has occurred would be increased.

Another strong factor influencing profitability will be the marginal rate of taxation applicable to the property, as the tax liability could be significantly reduced by investment of this type. Because pistachios require little pruning, and pest control so far is nonexistent, the labour demand could mean they are also attractive to part-time farmers.

Further Information

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This article first appeared as Agfact H3.1.45 of the Department of Agriculture, NSW, and was first published in 1985.

The Sapindaceous Fruits and Nuts

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I. INTRODUCTION

The Sapindaceae are basically a tropical to warm-temperate group of plants and are relatively non-specialised in their habit of growth. Most are small to moderate size trees, large shrubs, or woody climbers. The most specialised growth forms are the rather strange unbranched palm-like trees like *Talisia*, woody climbers like *Paullinia*, and subshrubs or perennial herbs with woody bases. The largest trees include *Schleichera oleasa* (60 m) and *Pometia pinnata* (40-50 m).

Many species are important timber trees, *Pometia pinnata* being one of the most important timber trees in New Guinea. *Blighia sapida* wood is used in West Africa for making furniture, being hard, close grained, durable and resistant to termites.

Saponins, which are chemical substances that produce soapy lather, are present in the fruits, seeds and other tissues of many members of the family, and genera like *Sapindus*, *Aphania*, *Paullinia* and *Serjana* are used in the tropics as soap substitutes.

Crushed material from some species of *Paullinia* and *Serjana* are used in the tropics to stupefy fish in pools or small streams. However, it is the fruits of the many species in the family that interest us here. The family comprises some of the most interesting and fascinating fruits to be found anywhere. The name *Sapindacae* is derived from that of the soapberry, *Sapindus*, whose fruit is used as a soap substitute, as mentioned earlier.

Other fruits in the family include the lychee, longan, rambutan, and pulasan, which are famed throughout the Orient. The family includes fruits that are extremely sweet through to those that are extremely sour; fruits that are prepared as savoury dishes; fruits that taste like chestnuts; and even one with seeds that are made into a stimulating beverage with-three times the caffeine content of coffee: all these fruits shall be considered in greater detail.

II. THE WELL-KNOWN SAPINDACEOUS FRUITS

"The rambutan is the long-haired gentleman of the group, the pulasan having a modern cut, the lychee is closely cropped and the longan as bald as the venerable Buddhist monk". This quotation is very apt as it describes very well the four well known Sapindaceous fruits. It has long been recognised, even by the locals, that the four fruits are closely related. Indeed, they all belong to the sub-family *Nepheleae*, and have all been included in the genus *Nephelium* at one time or other.

1) *Litchi chinensis*, the Lychee

The lychee is indigenous to China and is no longer found in the wild. It is an attractive small to medium size tree, 10-12 m in height, with a low-branched, straight trunk, dark brown bark and a dense crown. The leaves are alternate, petioled, and even-pinnate, with 2-4 pairs of leaflets. The rachis is up to 28 cm long. Leaflets are 5-12 cm long and 2.5-6 cm wide, coriaceous, oblong-elliptic to lanceolate, sharply acute, glabrous, shiny dark green above and glaucescent beneath. The young foliage is a beautiful reddish bronze. The tree is showy when in full bloom with masses of tiny apetalous, polygamous flowers borne on ancillary or terminal many-branched panicles 30 cm or more long. The flowers are greenish white or yellowish, with small valvate sepals, fleshy disc, 6 to 10 stamens with hairy filaments, and a 2 to 3-lobed, 2 to 3-celled, pubescent ovary mounted on a short stalk, with one ovule in each cell, and a 2-lobed stigma.

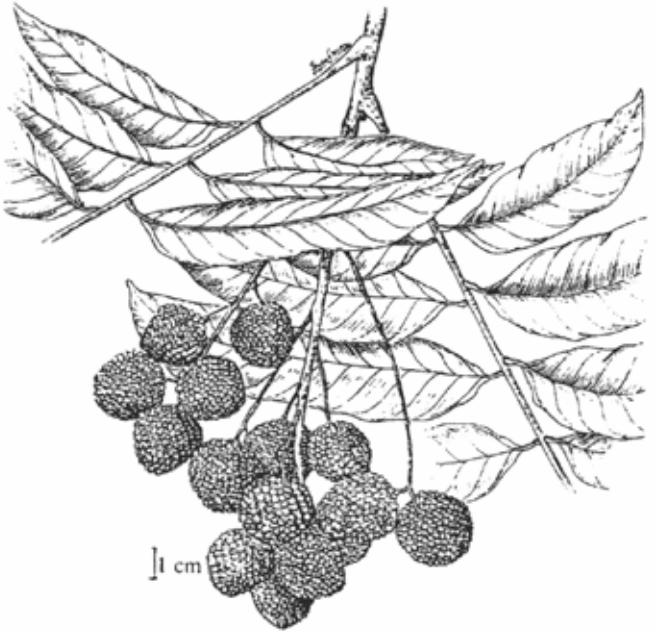

Fig. 1. The Lychee

Five different types of flowers have been described, the classification being based on the length and functionability of the stamens and on the development and functionability of the pistil. Flowers are unisexual in function and are classified broadly as either male or female. Both classes are borne on the same panicle, but tend to alternate in their periods of opening. The typical male flower has a vestigial or abortive pistil at its centre and this is surrounded by the 6 to 10 stamens with filaments up to 10 mm long. A single flower remains functional for several days, during which the pollen sacs ripen and shed pollen in succession rather than all at once. The typical female flower has a small but fully developed pistil which rests on a short stalk. The ovary is usually 2-lobed, each lobe containing an ovule. It is surmounted by a short style which is cleft at the apex into 2 rays that expose white sticky stigmatic surfaces when expanded. The pistil is surrounded by the stamens which have very short filaments. The pollen sacs do not open and shed no pollen. Generally only one lobe develops into a fruit, the other aborting. Occasionally both lobes develop and a twin fruit results.

The fruit is a nutlet (drupe). The drupes are 2.5-4 cm in diameter, ovoid, hanging in large or small pendulous clusters. The pericarp is thin, hard, brittle, dark red, bright red, light red or sometimes yellow, and is covered with faintly protruding, angular tubercles. The flesh or aril is white, translucent, very sweet with a faint pleasant aroma, and separating readily from the large, shiny, dark brown, oblong-elliptic seed. Better varieties have large fruits, and small, frequently abortive seeds and bear heavily. The taste has been likened by some to be suggestive of the Bigarreau cherry or the Muscat grape.

The main lychee belt of China lies between 15 to 30 degrees north of the equator, and has an annual rainfall averaging 1600 mm. The wettest month is June with 263 mm, and the driest January with 94 min. Relative humidity is 70% in January and 83% in June. Mean maximum and minimum temperatures are 19°C and 9°C in January and 33°C and 25°C in July. The best trees in China are located on ridges or spoil banks along canals, rice paddies, fish ponds, lakes, and streams, where their roots can obtain a regular supply of moisture and still have perfect drainage.

However, they will thrive in a diversity of conditions. They are fairly hardy, withstanding light frosts unharmed, but will not fruit in a hot humid climate. A humid atmosphere is not necessary for good growth provided there is an ample supply of water for irrigation. Acid soil and the presence of mycorrhiza on the roots in such surroundings is highly beneficial.

'Lychee nuts' are prepared by drying the fruits just as they come from the tree. The pulp shrinks away from the shell into a thin layer surrounding the seed and has a nutty sweet raisin-like taste.

The Chinese classify the lychee into 2 types:
1) 'Hill Lychee' from South Guangdong and Hainan which flowers and fruits early, and requires a dry autumn, and a winter temperature as low as 12°C, e.g. Tai So, Kwai May Pink, and Haak Ip.
2) 'Water lychee' from further north (around Guangzhou), which flowers and fruits later and requires a dry autumn and a winter temperature as low as 6°C, e.g. Wai Chee, No Mai Chee, and Kwai May Red.

There is also a 'tropical' lychee from the Amboina islands near Java which fruits regularly in warm areas - the 'Amboina' Lychee.

Chinese varieties available in Australia are:
Tai So - This is the most common variety in Australia. A consistent bearer.
Haak Ip - Fruit quality good. Skin smooth with even pattern.
Seong Sue Wai -Small fruit, skin slightly rough, quality medium to good. Seeds mostly small.
Wai Chee - Regular bearer, slow growing. Quality medium to good. Last to be harvested.
Souey Tung - Fruit similar to Haak Ip, but lopsided heart-shaped.
Kwai May Red, Kwai May Pink - Quality very good, seeds mostly small. Irregular bearer.

No Mai Chee - Quality excellent, seeds nearly all small. Fruit heart-shaped, blotchy red yellow skin colour.

Other Chinese varieties include:
Sum Yee Hong - Earliest cultivar, very large fruit, lopsided heart-shaped. Quality fair.
Bah Lup - Fruit moderately large. Quality medium.
Fay Zee Siu - Historically famous, large fruit. Quality good, seeds small.
Kwa Lok - Quality good, skin smooth, alternate bearer.
Chong Yun Hong -Round fruit, thick purplish redskin, flavour fragrant sweet. Quality good, low yields.
Tim Naan - Fruit small, seed very small. Quality fair.
Sai Kok Zee - As late as Wai Chee but larger fruit.

Other varieties available in Australia:
Bengal - Reasonable bearer but fruit ordinary.
Brewster - Vigorous tree.
Groft - Bears well in Hawaii where others fail.
Muzaffarpur - Fruit large, oblong, seed large.

Other Litchi species:

There is only one other species, *Litchi philippensis*, the Kumingi. This is a wild plant grown largely in the Philippines and is of little importance.

2) *Euphoria longana*, the Longan:

The longan is native to India, Burma and China. It is a small to medium size evergreen tree, 10-12 m in height, with a low branched trunk and a densely foliaged crown. The leaves are alternate, even-pinnate, and 20-30 cm long with 2 to 5 pairs of leaflets. The leaflets are alternate or nearly opposite, elliptic to lanceolate, obtuse, glabrous, shiny dark green, light green, or greyish green, coriaceous, 7-15 cm long and 3-6 cm wide, with prominent veins. The flowers are small, yellowish white and borne in large upright much branched axillary or terminal panicles up to 30 cm long. The sepals are small and imbricate. Petals are present but small. The filaments are pubescent and the anthers glabrous. The ovary is divided into 2, sometimes 3, parts. Longan flowering in each panicle progresses with the opening of the staminate, then the pistillate, followed by the hermophrodite, and then finally, again by the pistillate flowers. There is overlap of flowering types.

The fruit is a nutlet, globose, about 2.5 cm in diameter, yellow or reddish brown, with a nearly smooth, thin pericarp, covered by flattened tubercules. The large shiny, dark brown seed is surrounded by a white, juicy, sweety, gelatinous aril. The panicle may carry up to 80 fruits. The longan is more cold resistant than the lychee and is less exacting in its soil and cultural requirements. Trees have the tendency to overbear. The practice in China is to thin

the panicles severely to increase fruit size. The prime environment for longan production lies between the latitudes 15 to 28° north and south of the equator. It is most successful in areas with short and cool winters, followed by high temperatures in spring and summer.

Dried longans are prepared in the same way as dried lychees and have a similar taste. The dried arils are used in Chinese medicine.

In Thailand, the hard-fleshed, crispy varieties are favoured, the following being the most popular varieties:
Daw - An early variety
Dang - Heavy bearer, quality fair, not particularly crisp.
Chompoo - Flesh has a pinkish tinge. Quality good.
Haew - Crisp flesh, popular in the market, alternative bearing.
Biew Kiew - Crisp, cream coloured flesh, heavy cropper.
Bai Dum - Very late variety. Bears regularly, poor shell colour.

Other varieties include:
China: Fu Yan, Wu Yuan, Xi Xia.
Taiwan: Yang Tao Ye, Chau On Diao, Duan Yu.
U.S.A.: Kohala, Homestead, Sweeney.

Fig. 2. The Alpay

Other Euphoria species of promise:
Euphoria didyma, the Alpay:
A native of the Philippines, the alpay is a small to medium size tree, reaching a height of 8 - 12 m. The leaves are pinnate with pointed, rather narrow, prominently veined leaflets. The flowers are in compact clusters, borne like those of a mango.

The fruits are round, green, warty, attaining a diameter of about 2 cm, with a shell-like rind. The aril, which envelopes a big seed, is thin and translucent, but juicy, sweet, with an agreeable flavour. The tree is found wild and is hardly cultivated, but is widely distributed both in dry and humid areas.

Euphoria malaiense, the Mata Kuching:
This is a Malaysian tree growing to 18 m high. The leaves are divided into 3 to 5 pairs of drooping leaflets, the size and shape of which vary enormously. The flowers are small, white and scented.

The fruits are round, up to 2 cm in diameter, with a tough skin which is pale, dull yellow-brown with dark raised flecks. The aril, which envelops a big seed, is whitish, translucent, and sweet and in good forms nearly 0.5 cm thick, though usually much thinner. The seed is very large in proportion, and is shiny brown with a pale patch at the base.

The tree grows wild in Malaya, Borneo, Sumatra, and the Celebes. In Malaysia, it is commonly cultivated in the States of Penang and Negri Sembilan.

The better varieties of the alpay and the mata kuching could be developed to replace the longan in the hot humid tropics where the longan does not do well.

3) *Nephelium lappaceum*, the Rambutan:
The rambutan is highly regarded and common throughout the Malay Archipelago where it is indigenous. It is a medium size tree reaching 15-25 m in height, with a straight high branched trunk, dark brownish-grey bark and a rather copiously branched, broad, rounded or lax crown. The leaves are alternate, petioled, even pinnate or spuriously odd pinnate by abortion of one of the apical leaflets, and with 2 to 4 pairs of leaflets. The rachis is 7-30 cm long. The leaflets are alternate or sub-opposite, elliptic, oblong or elliptic-obovate, thinly coriaceous, yellowish green, dark green or glaucous and dull beneath, glabrescent, 5-20 cm long and 2.5-11 cm wide.

Fig.3. The Rambutan

The inflorescences are axillary and terminal, erect, widely branched, shorter than the leaves, yellow green, farinose, rusty pubescent, many flowered and 15-20 cm long. The flowers are unisexual-dioecious, short-pediceled, apetalous, faintly odourous and 0.25-0.4 cm in diameter. The pedicles are thin, terete, greenish yellow, and densely rusty pubescent. The calyx is cup shaped, 4 to 6 lobed, yellowish green, rusty tomentose on the outside, beset with short

white hairs within. The disc is small shiny light yellow. There are 5 to 8 stamens in the male flowers. The filaments are white, clothed with white woolly hairs, the anthers are small ovoid or ovoid-oblong, 2-celled and a dull light yellow.

The rudimentary ovary is small and rusty pubescent. There are 5 to 7 staminodes in the female flowers. The filaments are clothed with white hairs and the anthers small and sterile. The ovary is short stalked, 2-lobed, rarely 3-lobed, yellowish green, densely clothed with long dark brown hairs. The cells are as many as the lobes, each with an ovule. The style is deeply bifid, rarely trifid, yellowish green and densely covered with brown pubescence.

The trees may be classified into 3 groups:
1) Trees with only staminate flowers. These are male trees, comprising 40-60% of seedlings.
2) Trees with flowers which are functionally female.
3) Trees with hermaphrodite flowers, some of which are functionally female and some functionally male. This is the most common form in the selected cultivars with the percentage of male flowers between 0.05 to 0.9%.

The fruit usually consists of a single nutlet with a second one represented by a small tubercle at its base, and is globose or ovoid, red or yellow, beset with tubercles which terminate in a soft spine, 15-8 em long and 2-5 cm in diameter. The spines are short or long, red or yellow, always uncinate at the tip, laterally compressed, 0.54.8 cm long, the tips withering and falling off in some varieties. The pericarp is glabrous, 0.2-0.4 cm thick. The seeds are 2.5-3.5 cm long, 1- 1.5cm in diameter and arillate. The aril is white, translucent, sweet and juicy, 0.4-0.8 cm thick and adnate to the testa.

The rambutan is strictly tropical in its climatic requirements, being restricted to areas below an elevation of 300 m in the Malay Archipelago. These trees need a minimum of 2500-3000 mm of rainfall evenly distributed throughout the year. It is usually grown in areas within 12 to 15° north and south of the equator.

The seeds are sometimes eaten roasted. They contain an edible fat. The rambutan is a highly variable species. The colour of the pericarp is usually in various shades of red, but some varieties (e.g. R156 and R l63) are yellow in colour. The taste and texture of the aril also vary tremendously and falls between two extremes:

1) Fruits with arils that are soft, very juicy, and which cling tenaciously to the seed. These are usually very sour, though some can be quite sweet. When they are eaten, the juice is usually sucked off the aril and the seed with the remaining aril spat out or sometimes swallowed. These fruits are from seedling trees and are not popular, being considered of poor quality. They are seldom seen in the markets.

2) Fruits with arils that are very sweet, comparatively dry and crispy, and which come off the seed easily with the seed testa adhering to it. A good example of this type of fruit is Cik Embong (R 168) which is very popular amongst the Malays, and commands high prices in the

market. However, a lot of people find the seed testa adhering to the aril quite objectionable.

Between these two extremes and with various combinations of sweetness, juiciness, crispiness, and degree of adherence of the aril to the seed are the numerous horticultural varieties. Varieties with arils that are relatively testa-free (arils that come off the seed with only a few fragments of the seed coat adhering to it) include R3, R156, R160, Rapiah, and Silengkeng.

Other varieties include:
Malaysia: R4, R7, %99, R134, R161, R162, R170.
Singapore: Jit Lee, R37.
Thailand: Chompoo, Rongrien, Bang Yi Khan, See Tong, Nam Tan Kruad.
Indonesian varieties include:
Lebakbooloos - Dark red fruits. Aril greyish white, tough, sour-sweet, and firmly fixed to the seed, parts of seed coat coming away with the flesh.
Seematjan - Most common variety. Fruits dark red, 2 strains 'Besar' and 'Ketjil'.
Seenjonja - Fruit dark wine red. Aril adheres firmly to seed.
Seetangkooweh - Fruit ellipsoid, strongly compressed. Aril yellowish white, sweet, adhering firmly to the seed coat which comes off easily.
Seelenkeng - Much in demand and relished. Aril closely resembles that of the lychee, is tough, sweet, shines faintly and always has few fragments of seed coat adhering to it.
Seekonto - Fruits ellipsoid, slightly compressed. Aril dull greyish white, dry and coarse. Seed coat always adheres to aril and comes off seed easily.
Atjeh kooning is a collective name for yellow varieties.

4) *Nephelium mutabile*, the Pulasan:

The pulasan, closely related and very similar to the rambutan, is also indigenous to the Malay Archipelago. It is a small to medium size tree reaching 10-15 m in height, with a round, smooth, low-branched trunk, brown bark and an irregular crown. The leaves are alternate, petioled, even pinnate or spuriously odd pinnate by abortion of one of the terminal leaflets. The rachis is 7.5-23 cm long. The leaflets are opposite or nearly so, oblong -lanceolate or elliptic-lanceolate, coriaceous, dark green, dullish glabrous above, pale glaucous or bluish grey and covered with short appressed hairs beneath, 5-15 cm long and 2-6 cm wide.

The inflorescences are axillary and terminal, erect, clothed with short yellowish or brown pubescence, and 10-20 cm long. The flowers are polygamous or unisexual dioecious, apetalous. The pedicels are thin and pubescent. The calyx is cup-shaped, shallowly 4 to 5 lobed, membranous, and clothed with brown hairs. The filaments are filiform and short pubescent. The anthers are small, sub-globose and 2-celled. The rudimentary ovary is turbinate arid clothed with brown hairs. The stamens in the bisexual flowers, or the staminodes in the female ones, are longer than the calyx. The ovary is sub-ordate, 2 to 3 lobed, coarsely
hairy. The style is erect, pubescent, almost single or deeply bifid, the limbs becoming recurved.

The fruit consists of one well developed nutlet, with one or two abortive ones at its base. It is ovoid, dark red or sometimes yellow, beset with many obtusely conical tubercles which are often connate at the base and form toothed crests, 5-6 cm long and 3-3.5 cm in diameter. The tubercles are robust, erect and 0.5-0.8 cm long with straight brown apex. The pericarp is thick and shiny yellowish-white inside. The aril is clear, yellowish white, juicy, sweet, adnate to the testa, and 0.6-0.9 cm thick. The seeds are ovoid-oblong or ellipsoid, compressed laterally, 2 - 3.5 cm long and 1.5-2 cm broad. The testa is thin and greyish-brown.

The pulasan is widely grown in the western part of Java, and small plantings exist in other parts of Indonesia, Malaysia, and Thailand. The fruit is of comparable quality to the rambutan and many consider it superior. There are numerous varieties of pulasan in Java and these are divided into two main groups.
1) Dark red fruits with crowded tubercles and an aril which separates from the seed.
2) Lighter-coloured fruits with widely set tubercles and an aril which adheres firmly to the seed.

Best forms of the first group have fruits 7-8 cm long and 4-5 cm in diameter with yellowish or light greyish-white aril about 1 cm thick. Those of the second group are smaller.

The pulasan is more exacting in its climatic and soil requirements than the rambutan, and thrives only in a warm, humid atmosphere, on rich, well-drained, continuously moist soils.

Available varieties include P1, P4, P5, P6, P8, P22, P22, P28, P54, P63, Lee, Merah, Poetih, Sibabad, Koening.

Fig. 4. The Pulasan

Other *Nephelium* species with edible fruits
These include:
Nephelium eriopetalum, the Lotong.

Nephelium glabrum the Redan
Nephelium philippense, the Bulala
Nephelium excrospermoides, the Aluao
Nephelium maingayi, the Liat
Nephelium chryseum
Nephelium robustum
These are all wild forest trees bearing small rarnbutan-like fruits, with thin arils, and which are eaten by the jungle people.

III The Lesser-Known Sapindaceous Fruits:

These fruits are relatively little-known except in areas where they are cultivated for local consumption.

1) *Pometia pinnata*, the Taun or Dawa:

Also known as the Fijian longan, Pometia has been previously classified into 10 species. It is now generally accepted that there is only a single species, *Pometia pinnata*, with several forms of which the best known are: var. *pinnata*; var. *acuminata*; var. *alnifolia*; and var. *glabra*.

It is commonly found in Papua New Guinea, Solomon Islands, Western Samoa, and Fiji, but is used most significantly in Papua New Guinea where it is known as taun, and in Fiji where it is known as dawa. It is a large tree, 25-40 m (sometimes 50 m), with a trunk diameter of up to 90 cm. Trees are erect even when planted in the open. Leaves are large, up to 90 cm long and pinnate with leaflets 30 cm long and 7.5 cm wide. The leaflets are tomentose, light green, and new flushes are deep wine red. The flower type is variable and flowers are effectively unisexual. They may be entirely functional male, or predominantly female but with some functional male flowers on the same panicle.

The panicles are up to 50 cm long with small cream white flowers. Newly set fruits may be vivid red, changing to green and then to pale red when ripe. Other forms are light purple or dull yellow when ripe. Borne in clusters, the individual fruit have a smooth pericarp and are round to oblong, and up to 7 cm in diameter. The aril is semi-transparent, white and quite juicy. The seed is round, up to 2.5 cm in diameter. The pericarp is hard and approximately 0.4 cm thick.

The natural habitat lies within 20° north and south of the equator, and has a minimum rainfall of 2500 mm annually, evenly distributed throughout the year.

No clonal varieties have yet been named. Five different types of seedlings are now growing in the Cairns area in Northern Queensland:
1) Trees with hard-shelled green and red fruits from Wewak, Papua New Guinea.
2) Trees with round green fruits from Fiji.
3) Trees with large soft-skinned fruits from New Ireland.
4) Trees with purple and green hard-shelled fruits from New Britain.
5) Trees with smaller brown-skinned fruits from Irian Jaya.

The Papua New Guinean and Fijian trees have fruited. Both types of fruit are sweet and of good flavour. Some testa (seed coat) adheres to the flesh as with the rambutan.

2) *Blighia sapida*, the Akee:
The akee is a polygamous tree 7-25 m high, occurring wild in the forests of West Africa. It is also cultivated in Jamaica where it has become naturalised. It has bold pinnate leaves 15-25 cm long, each of which most commonly has 3-6 pairs of elliptic, ovate or obovate almost stalkless leaflets that diminish in size from the apex to the base of the leaf. The largest leaflets are 10-18 cm long and 5-9 cm wide. The flowers, small, greenish-white, and exceedingly fragrant, are in axillary racemes, and male, female and unisexual blooms are on the same tree. The racemes are pubescent and are 4-15 cm long. The flowers have 5 petals and 8 to 10 stamens that in male flowers are long-protruding.

The somewhat bell-shaped, leathery rinded fruits, or capsules, 7-10 cm long arid 4-5 cm wide, are slightly 3-lobed and depressed at their ends. They become yellow and red as they ripen and at maturity split lengthwise in 3 places to reveal 3 shiny black oblong seeds, each surrounded by a fleshy, cream-coloured, brain-like, nutty-flavoured aril. The aril is relished by many people in the tropics, especially in West Africa and the West Indies. Arils may be eaten raw, but usually after cooking, when they resembles scrambled eggs. They may be simmered in water with salted fish or fried in butter.

Great care is required in its preparation as the pink raphe attaching the aril to the seed is highly poisonous. The peptide, hypoglycin A, also occurs in unripe arils and only those from naturally opened fruit should be eaten. Having a high oil content, the aril soon becomes rancid after ripening, and becomes unfit to eat. Therefore, arils from unripe, damaged, or fallen fruits should not be eaten, otherwise harm may result. Akee poisoning which causes vomiting has resulted in casualties in Jamaica. The seeds and pods are also reported to be poisonous.

There are no named varieties.

3) *Melicoccus bijugatus*, the Mamoncillo:
The mamoncillo is cultivated mainly in the Caribbean region where it is indigenous. It is a slow-growing, medium size, upright, grey-trunked tree, 10-18 m in height. It has shiny pinnate leaves with 2 pairs of pointed elliptic to elliptic-lanceolate hairless leaflets 5-10 cm long, light green to blue green in colour. Small, fragrant, greenish-white flowers are borne on terminal panicles about 10 cm long. Individual flowers have 4-5 sepals, same number of petals, 8 stamens, and a 2 or 3-lobed stigma.

Fig. 5. The Mamoncillo

There are two types of trees:
1) Male or staminate trees.
2) Bisexual trees, most of which are functionally female, although there may be some functional male flowers.

Cross pollination is generally necessary for fruit set. The fertilized flowers develop into a dense cluster of small green, round or oblong fruits, 2-4 cm in diameter. When mature, the fruit has a thin tough, leathery pericarp surrounding a juicy, white, cream or light orange translucent pulp (or aril). The flavour ranges from sweet to sour and the juiciness is variable. The thin layer of pulp clings tenaciously to a large seed. Fruits of normal size have a single oval seed, while occasional larger fruits have two. The starchy white kernels of these seeds are sometimes eaten as nuts, preferably after roasting.

There are no named varieties.

4) *Paullinia cupana*, the Guarana:
The guarana is a large woody climber of the Amazon basin up to 10 m high. It has a smooth erect stem with a very dark bark. The leaves are pinnate with 5 leaflets on a common petiole, 7-15cm long, glabrous same as the rachis, which, however, is channelled above and concave below and somewhat striated. The flowers are small, aromatic, whitish or pale, with 5 sepals, the 2 upper larger and connate. There are 4 petals with the fifth abortive. Two of the petals are smaller and bearing a scale below the apex. There are 8 stamens. The ovary is 3-celled, bearing a 3-pointed style. The inflorescences are in pendulous circinate cyrnes, 10 cm long.

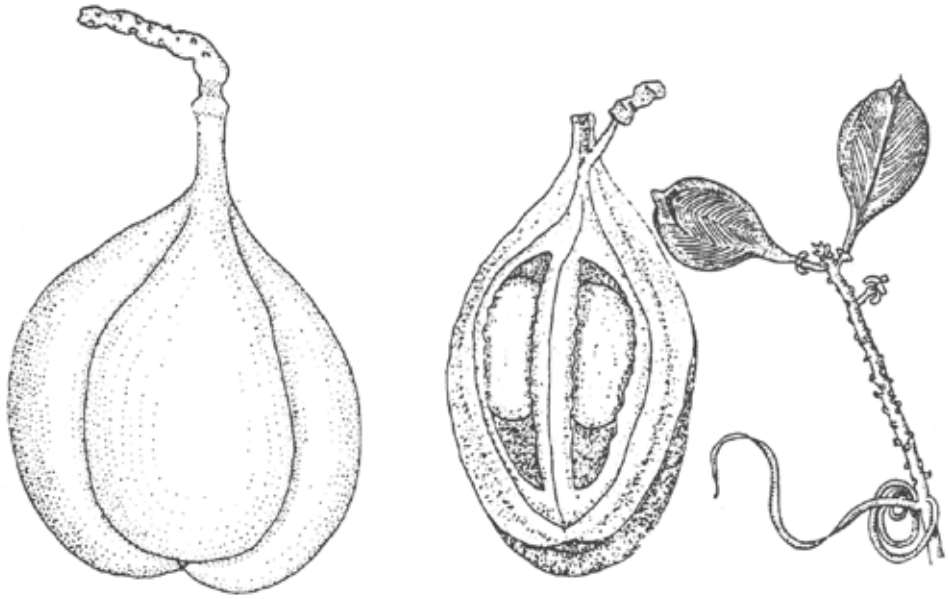

*Fig. 6. Development of the **Paullinia** fruit*

The fruit is a pear shaped capsule divided into 3 splitting locules, 1 cm in diameter, of red or yellow colour, containing 1 or 2 globular or ovoid seeds, 1.2 cm in length, black with an arillus that changes colour from white to yellow and red.

The guarana has been cultivated for centuries. It is sometimes cultivated as a small bush. The seeds are harvested and the pulp and arillus removed by washing in water. The seeds are then dried, roasted and shelled. After this, the clean kernels are crushed and then further dried to form a fine dry powder. This is left to absorb moisture, and then formed into cakes, which are then baked until they are as hard as bricks, and are reddish-black or purplish black in colour. This is the Guarana of commerce which contains about 5% caffeine. This is used to make a stimulant drink, popular in South America, which has a bitter astringent taste and a faint coffee-like odour. Its caffeine content is about three times greater than an equivalent amount of coffee. The astringent action is cause by tannin.

The bark of another species, *Paullinia yoco*, the Yoco, also contains caffeine and is also used as a beverage.

IV The Little-Known Sapindaceous Fruits

These are often wild or semi-wild trees. Some of them have fruits with the potential for further development.

1) *Cubilia bancoi*, the Kubili:
The kubili is native to the Philippines and is distributed from Luzon to Mindanao in primary forests at low to medium altitudes. It is not cultivated, and although found growing wild in many regions, it is not abundant. It is small to medium size tree, 10-15 m in height, with compound leaves. The leaflets are large, smooth, and pointed at both ends. The flowers are small and are borne on rather large terminal inflorescences.

The fruit is oval, bright green, 5-6 cm long and covered with numerous soft spines. The aril is white, fleshy, juicy, and covers one half of the seed or nut. The nut is roundish-oblong, 3 - 4 cm long and 2.6-3.8 cm in diameter, dark red, depressed at point of attachment and is covered with a very thin seed coat. It is of excellent quality and flavour when boiled or roasted like chestnuts, and has been claimed by some to be one of the best flavoured nuts. Others, however, consider it quite bland. Unlike the chestnut, it does not keep for long under ordinary room conditions.

It grows well at low to medium elevation in areas with evenly distributed rainfall, and the better varieties should be brought into cultivation.

2) *Diploglottis cunninghamii*, the Native Tamarind:
A native of Australia, it is widespread over southeastern Queensland to southern New South Wales. It is a small to medium size tree, 10-20 m in height, with a spreading crown. The leaves are 30-80 cm long, pinnate, with 8 to 12 leaflets, 10-30 cm long and 2-6 cm wide, elliptic to lanceolate, dark green and somewhat hairy above, densely clothed with velvety brown hairs beneath. The flowers are small, yellow to brown, hairy and 2 to 3-lobed. The fruit is a capsule 2 - 3 cm across, yellow in colour, 3-lobed, with 3 large seeds enclosed by

an orange-yellow fleshy aril. The jelly-like aril is very sour but refreshing when chewed, and can be used in drinks or to make jams.

Other *Diploglottis* species with edible fruits include:
Diploglottis campbellii, the Small-leaved Tamarind:
This is a small to medium size tree, 10 - 18 m in height, with a spreading crown. The leaves are 10 - 30 cm long, pinnate, with 4 to 8 spreading leaflets, 7 - 15 cm long and 2-6 cm wide, broadly lanceolate, glabrous and dull green in colour. Panicles are 5 - 16 cm long and much branched. The flowers are small, creamy brown, hairy and fragrant. The capsule is 4 - 6 cm across, 3-lobed, small, hard and yellowish brown in colour. There are 3 seeds, 2 cm across, enclosed by a red juicy aril. The juicy aril is refreshingly sour but considered by many to be superior to that of *Diploglottis cunninghamii*. It can be eaten raw or made into drinks and jellies.

Diploglottis diphyllostegia:
A relatively rare, small to medium size tree resembling *Diploglottis cunninghamii* and distinguished by its smaller, less hairy, thinner textured leaves. Capsules are 1 - 1.7 cm across, yellowish or orange, hairy, 2-3-lobed. There are 2 to 3 large seeds enclosed by a yellow aril which is edible and makes an attractive jelly or drink.

3) *Talisia olivaeformis*, the Talisia:
The Talisia is restricted in the wild to tropical Central and South America. It is a tall tree growing to 20 m in height. The leaves are pinnate with 1 - 2 pairs of broad elliptic leaflets, 5 - 10 cm long. The flowers are small, in branched panicles, with 4 to 5 sepals, 4 to 5 greenish or yellowish petals, and 5 to 8 stamens. The fruits are similar to those of the mamoncillo, to which it is related. It is olive-like and is edible, each containing a large stone and lacking much flesh.

Two trees raised from seed at the Fairchild Tropical Garden have fruited at 10 years old. Since both trees bore fruit, it is not necessary to have trees of different sexes in proximity as is necessary with the mamoncillo.

4) *Alectryon macrococcus*, the Mahoe:
This is a rare, small, and ungainly tree to 8 m in height. The fruits are large, with the colour of a potato, and are perfectly smooth. They hang in clusters from the branches and become ruptured when mature, exposing a bright scarlet aril and a glossy chestnut-brown orbicular seed.

The name mahoe refers to the double fruits. Mature fruits are 3-7 cm in diameter, subglobose, pendent, glabrous, with one or two lobes, the second lobe being normal or commonly abortive. The aril is firm, fleshy, but hardly juicy, scarlet throughout and said to resemble the peach in flavour and odour. The Hawaiians eat both the arils and the kernels of the fruits.

Other species of Alectryon with edible fruits include:
Alectryon tomentosus:
Native to Australia, this is a small to medium size tree 10-18 m in height. Fruits are capsules about 1 cm long, 1 to 3-lobed, covered with rusty hairs, with black seeds and a scarlet fleshy

aril which is edible.

5) *Chytranthus macrobotrys*, the Ndugulu:

This tree is native to Zaire, Nigeria, Cameroon and the Republic of Central Africa. It is a small slow-growing tree, in the understorey of the forest, reaching no more than 10 m in height and resembling the rambutan in shape, but usually much more open. Leaves are pinnately compound, the stem of each leaf being of a dark purplish colour.

Fruits are produced directly on the trunk much in the manner of the cacao tree, and the fruits even look somewhat like cacao pods. Inside the fruit are 5 to 20 round and flattened seeds about an inch across. These seeds are boiled and eaten as nuts and are quite good eating. The flesh around the seeds is edible but sour and is used to make a drink to protect against colds.

Another species of *Chytranthus* with edible fruit is *Chytranthus mannii*, also a native of tropical Africa.

Also known as Ndugulu, and from the same area in Africa, is the related *Radlkofera calodendron*. This is not as common as *Chytranthus macrobotrys*, and is a much taller and straighter tree. Fruits are produced in the same manner and are similar to those of *Chytranthus macrobotrys*. They are used in much the same way.

Other little-known wild or semi-wild Sapindaceous fruits:
The following is a list of other Sapindaceous trees with edible fruits:
Aphania senegalensis, the Senegal Cherry: The Senegal cherry is a red, astringent, somewhat sour fruit consumed by natives of West Africa. The fruits are sold in native markets. The seeds are considered poisonous.

Crossonephelis pengangensis:
A Malayan tree. The seeds are edible, usually boiled.
Cupania americana:
The seeds of this tree are used in the West Indies as food and have the flavour of chestnuts or sweet acorns.
Dienbollia grandifolia:
An African tree. The fruits contain a single seed in a pulp said to be edible. The seeds are slightly oily and also edible.
Erioglossum rubiginosum, the Mertajam or Kalayo:
The edible fruit is 2 cm across and roundish-oblong. Native to the Malay Archipelago.
Hedyachras philippensis, the Aglano:
A native of the Philippines, this tree has small edible fruits.
Heterodendron oleifolium:
An Australian native. Red fruits are eaten by Aborigines of South Australia.
Otophora fructicosa, the Lunau:
The dark red fruits are used in the Philippines, where the roasted seeds taste like chestnuts.
Oxythece fabrilis:
A large tree found in Guadeloupe and Dominica. The fruits are sometimes used to make a drink.
Pancovia harmsiana:

A tree from Congo and Gabon. The fruits are edible and are consumed during times of want.
Pappea capensis:
This fruit is the 'wild preum' (wild plum) of South Africa, and is edible. Oil is obtained from the seeds.
Pappea ugandensis:
A small tree of Uganda, Congo, and Rhodesia. The seeds containing oil are consumed by the natives.
Sapindus indicum, the Soapberry:
The seeds contain 50% of a thick, greenish drying oil. They can be eaten when quite ripe, but great care should be taken as the latex contained in the fruit wall is caustic.
Soapberries are also used as soap substitutes. Other species include: *Sapindus saponaria*; *Sapindus mukorosii*, and *Sapindus oahuensis*.
Schleichera oleasa, the Lac Tree:
This tree is used in India as a host for the Lac insect. The seeds yield an edible fat, and it is the source of Macassar oil.
Schleichera trijuga:
The seeds of this tree are also a source of Macassar oil or Kussum oil.
Staphylea pinnata, the Bladder nut:
The kernels from the seeds taste like pistachios.
Staphylea trifolia, American Bladdernut:
The seeds contain a sweet oil and are sometimes eaten like pistachios.

V. Conclusion

I am certain that the list of edible Sapindaceous fruits given here is far from complete. Many of these little-known fruits like the kubili, the alpay or the mata kuching deserve more attention and there are probably many more that have not come to our notice.

During 1985, two Queenslanders travelled round Indonesia collecting seeds of rare jungle fruits, and reported their experience in the January 1986 issue of the Newsletter of the Rare Fruit Council of Australia. This is a highly commendable effort as many of these jungle species should be brought into cultivation before they disappear under the onslaught of logging and land clearing. A list of their "Borneo Collection" is reproduced in the February 1986 issue of ***Quandong*** and includes the following very interesting descriptions of a few Sapindaceous fruits:

Dimocarpus longana var. *malesiana*, the Isau:
A small round mid-green fruit about 25 mm in diameter. The thin brittle shell is covered with small bumps, and is easily opened. The translucent flesh is 4-6 mm thick around a single black seed. The isau is similar to the longan, very sweet and juicy with a musky or melon-like flavour reminiscent of a very sweet water melon.

Dimocarpus longana var. unknown, the Kakus:
Kakus is another delicious longan-like fruit similar to the isau, but with a yellow or yellow-brown pebbly shell. Sometimes larger than the isau. The sweet musky flesh is a degree less juicy than isau but has a more distinctive smoky flavour - somewhat rockmelon-like.

Nephelium maingavi, the Liat:
A small (35x25 mm) sweet and juicy rambutan-like fruit, slightly acid with a hint of mint.

Nephelium sp., the Pangkal:
Often sour, but this variety was sweet when fully ripe. Round, bright red fruit, 5 cm in diameter, covered with short dense hairs.

Nephelium sp., the Sibau:
Like a small rambutan, good flavour, sweet.

As far as I know, *Dimocarpus longana* is a synonym of *Euphoria longana*. The isau and the kakus could, therefore, simply be local tropical varieties of the longan. Or, more likely perhaps, they are local varieties of *Euphoria malaiense*, the mata kuching, which is also indigenous to Borneo, and which looks and tastes very much like the longan (which is not indigenous to Borneo). In peninsular Malaysia, imported longans are often referred to as mata kuching. The species is quite variable, those from Penang having small blunt leaflets, whilst further south are forms with larger pointed leaflets. Most *Nephelium* fruits look and taste rather like the rambutan, and it is interesting to find out what species the pangkal and the sibau belong to.

It is hoped that many more such trips will be undertaken in future, perhaps to other tropical regions of the world.

VI. References

Most of the information given in this article is gleaned from the following sources:

A: *Periodicals*

The following Societies and Associations publish regular Newsletters and Yearbooks which contain articles on rare, exotic and tropical fruits and nuts:

1) West Australian Nut and Tree Crop Association, P.O. Box 565, Subiaco, Western Australia 6008. If you are reading this article, and are not yet a member, you should join without further delay and support Western Australia's own Association. Regular meetings are held and the Association publishes a quarterly newsletter, 'Quandong', and an annual Yearbook loaded with articles on tropical fruits and nuts.

2) Rare Fruit Council of Australia, P.O. Box 707, Cairns, Queensland 4870. The R.F.C. of A. has been in the forefront on the introduction of tropical fruits into Australia. It publishes a bi-monthly Newsletter. I have been a member for two years now, and have found the Newsletter a storehouse of information on tropical fruits. It is also an organisation that deserves our support.

3) California Rare Fruit Growers, Inc., The Fullerton Arboretum, California State University, Fullerton, California 92634, U.S.A. The CRFG is now in its 18th year and has become a world leader in the area of rare fruits. Southern California has a climate very similar to that of southwestern Australia, and growing conditions 'The Fruit Gardener' and an annual Yearbook to be renamed 'Journal'. Both are crammed with information on tropical and subtropical fruits.

4) Rare Fruit Council International, 13609 Old Cutler Road, Miami, Florida 33158, U.S.A. Founded in 1955, this is the parent organisation of the R.F.C. of A. It publishes a monthly Newsletter, and an annual Yearbook.

B: *Books*

1) **Allen, B. M**., *Common Malaysian Fruits*, Longman, 1975. This is a very good introduction to Malaysian fruits.

2) **Bailey, L. H**., *The Standard Cyclopedia of Horticulture*, The Macmillan Company, 1928. This is a very good source of information for many tropical fruits. There are very good drawings of tropical fruits. Some of the nomenclature is out of date, e.g. the Mamey Sapote is listed under *Lucuma* and not *Pouteria*. However, most information on tropical fruits is never out of date! There is usually a set in the local library

3) **Bose, T. C**., *Fruits of India, Tropical and Sub-tropical*, Naya Prokash, 1985. This is an excellent new book on tropical fruits.

4) **Coronel, R.E**., *Promising Fruits of the Philippines*, College of Agriculture, University of the Philippines, 1983. This is another excellent new book on tropical fruits.

5) **Elliot, W.R. and Jones, D.J**., *Encyclopaedia of Australian Plants*, Lothian Publishing Company, Vol. 2, 1982; Vol. 3, 1984. A very good source of information on Australian species.

6) **Everett, T.H.**, *The New York Botanical Garden's Illustrated Encylopedia of Horticulture*, Garland Publishing, Inc., 1981. Information on some of the better known tropical fruits is given.

7) **Hedrick, U.P.**, *Sturtevant' s Edible Plants of the World*, Dover Publications, Inc. 1972 (originally published in 1919). This book lists plants of all types with edible parts. Some of the nomenclature is also out of date.

8) **Menninger, E. A.,** *Edible Nuts of the World*, Horticultural Books, Inc., 1977. This is a very interesting book that covers all types of nuts, both the common as well as the rare and unusual types.

9) **Ochse, J. J.** et al, *Tropical and Subtropical Agriculture*, Macmillan Company, 1961. This book is seldom included in the recommended lists of books on tropical and subtropical fruits that I have come across. However, I find it one of the most informative books of all. Volume 1 covers most of the important tropical and subtropical fruits, and Volume 2 covers the other crops. The illustrations are excellent. It is out of print but can be borrowed through the Library Services.

10) **Page, P.E**., *Tropical Tree Fruits forAustralia*, Queensland Department of Primary Industries, 1984. This is another one of the excellent new books on tropical fruits brought out in the last three years.

11) **Popenoe, W.**, *Manual of Tropical and Subtropical Fruits,* Hafner Press, 1920. 66 years old and still most useful! For many years it was the only comprehensive book on the subject.

12) **Purseglove, J. W.**, *Tropical Crops*, Longman, '*Dicotyledons*', 1968; '*Monocotyledons*', 1972. This is a highly informative book.

13) **Sturrock, D**., *Fruits of Southern Florida,* Southeastern Printing Company, 1959. A good introductory book.

14) **Uphof, J.C.Th**., *Dictionary of Economic Plants,* 2nd Edition, Verlag von J. Cramer, 1968. This book lists all plants with economic use.

Note: Information on the Ndugulu is supplied by Paul Noren of Bangui, Republic of Central Africa.

* The following sources of line drawings are gratefully acknowledged: (Fig. 1,4) **S.Sastrapadja**, *Buah-Buahan*; (Fig.2) **W.H. Brown**, *Wild Food Plants of the Philippines*; (Fig.3) **R.E. Coronel**, ref. 4 above;
(Fig.5) **P.B. Cavalcante**, *Frutas Comistíveis da Amazônia*; (Fig.6) **M.G.M. van Roosmalen**, *Fruits of the Guianan Flora*.

Western Australian *Terminalia* Species

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AUSTRALIA

Terminalia is a pan tropical genus of c. 250 species, represented in Australia by 29 species. All members of the genus are deciduous trees or shrubs, varying in height from 2 to 40 m. In Western Australia (WA) 15 species are native to the tropics. These and two other species, *T. arostrata* and *T. catappa*, are discussed in more detail below. Unfortunately few of our Western Australian species are in cultivation, therefore specific information on their cultivation is limited.

***Terminalia arostrata* Ewart Et Davis** (Fig. 1)
An erect tree to 12 m.The mature fruit is globular smooth, 2- 2.5 cm diameter, succulent, dark purple or black. Grows on river or creek levee banks, black soil or basalts. (Note: recorded for Northern Territory, but very near WA border, probably will be found here).

This is a beautiful weeping tree with a rounded crown, and is often described as the weeping willow of the tropics. Unwatered in the dry season, trees may become partly or fully deciduous, but with adequate water and a deep mulch will retain full leaf cover. Used as an indoor foliage plant the young seedlings are likely to make random zig-zag shoots that follow no conventional pattern. The fruit, which is sour, is reputed to be edible, however we have no reference to the kernel being eaten.

***Terminalia bursarina* F. Muell.** (Fig. 2)
Shrub or rarely a tree to 8 m. The mature fruit has two narrow wings, a short beak is irregularly ridged, 1-1.5 cm long and 0.5-1 cm wide, dry, green, yellow or brown. Grows on edges of permanent seasonal creeks. Flowering and fruiting periods are irregular.

***Terminalia canescens* (D.C.) Radlk.** (Fig. 3)
Shrub or rarely a tree to 10 m. The mature fruit is a two winged nut, 2-3 cm long, 1-1.8 cm wide, dry, brown. Grows on skeletal or desert sandy soils, or well drained soils of any nature. Fruiting irregular: February to November.

***Terminalia carpentariae* C.T. White** (Fig. 5)
Shrubs or tree to 15 m. The mature fruit densely velutinous, ovoid, 1.5-3.5 cm long 1.2-1.7 cm wide, succulent, yellow-green. Sandstone or sandy alluvium plains. Fruiting occurs between September and November. Fruits acid. Eaten by aborigines.

***Terminalia catappa* L. (Indian Almond)** (Fig. 4)
A large tree to 15 m. The mature fruit is large, succulent, yellow, 5-8 em long, 2-5 cm wide. This species does not occur naturally in Western Australia. This stately tree is striking to the eye as its horizontal branches grow in widely spaced whorls to create a pagoda like appearance. It is a rapid grower with a trunk diameter of 35 cm or more.
The leaves are large and leathery and change from green to yellow or bright red before fall-

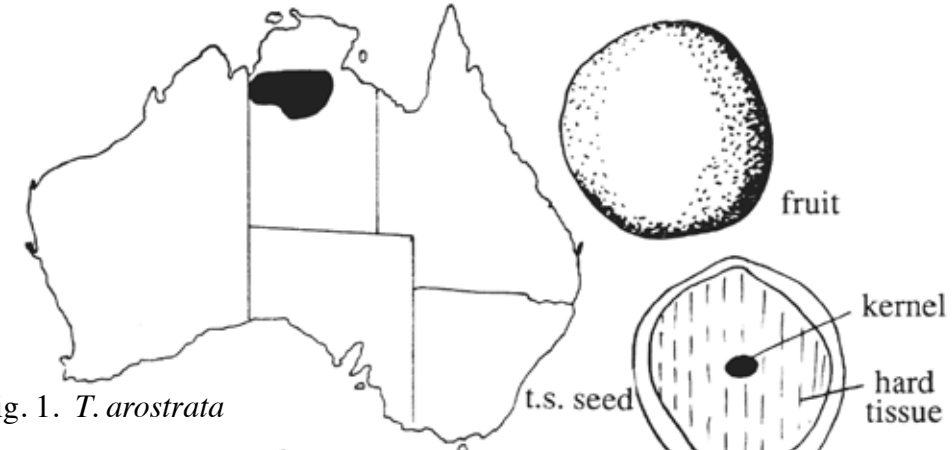

Fig. 1. *T. arostrata*

Fig. 2 *T. bursarina*

Fig. 3. *T. canescens*

Fig. 5. *T. catappa*

Fig. 6. *T. carpentariae*

Fig. 7. *T. cunninghamii*

ing. Greenish white flowers are fairly insignificant, produce a faint perfume and can be produced when the plant is only three years old. Although the fruit can be eaten it is sour and not generally sought after. The kernel, which is much prized by many people, tastes similar to an almond, however, it is fairly small and difficult to extract. This species is extensively planted along seashores in many tropical countries and has been used to control erosion in sand dunes in Puerto Rico. Fresh seed is very easy to germinate, and seedling growth is rapid.

***Terminalia cunninghamii* C.A. Gardn**. (Fig. 6)
Tree to 8 m. The mature fruit is glabrous, globular-ovoid, 3-4 cm long, 3.5 cm diameter, succulent, colour? Sandy soils on sandstone. Mature fruits January - March. Fruits eaten by aborigines, known locally as 'Pindan Quandong'.

***Terminalia ferdinandiana* Excell** (Fig. 7)
Shrub or rarely a tree to 8 m. The mature fruit is glabrous, ovoid, 1.5-2.5 cm long, 1-1.8 cm wide, succulent, yellow-green. Wide variety of soils. Fruit recorded April to July. Eaten locally, but acid, known as 'Billy Goat Plum'.

This species is widely planted in Darwin, responds well to regular watering and the application of fertiliser, but becomes almost evergreen. When grown under natural conditions it is fully to semi-deciduous and develops new leaves and flowers in the early wet season. The flowers, in keeping with other members of the genus, are in short terminal sprays, greenish-white in colour and have a strong perfume. In Darwin the tree is recommended for home gardens and for use as a street tree where fallen leaves will not create a nuisance. Fresh seed if filed or chipped is easy to germinate.

***Terminalia fitzgeraldii* C.A. Gardn**. (Fig. 8)
Shrub or tree to 8 m. The mature fruit is glabrous, ovoid, 2-3.5 cm long, 2-2.3 cm wide, succulent, dark purple. Clay soils, fruits recorded from January to May. The kernel was eaten by aborigines, the flesh is edible but acid.

***Terminalia grandiflora* Benth.** (Fig. 9)
Tree to 15 m. The mature fruit is globular or ovoid, 3-4 cm long, 2-2.5 cm wide, succulent, purple. Basaltic soils, laterite or levee soils, fruits recorded from December to April. Eaten by aborigines, known as 'Plumwood' 'Nutwood' or 'Yalu'. This species took 35 days to germinate in our nursery, however, we were not able to grow it on.

***Terminalia hadleyana* W.V. Fitz**. (Fig. 10)
Tree to 7 m. The mature fruit is glabrous, ovoid, 1.5-2 cm, 0.8-1.5 cm wide, succulent, yellow-green. Stony soils, fruits recorded from January to May-June. Eaten at Kalumburu.

***Terminalia latipes* Benth**. (Fig. 11)
Shrub or tree to 10 m. The mature fruit is pubescent, ovoid, 1.8-3.5 cm long, 1-2 cm wide, succulent, yellow-green. Sandstone soils, fruit recorded from October to November.

***Terminalia petiolaris* A. Cunn. Ex Benth**. (Fig. 12)
Shrub or tree to 10 m. The mature fruit is glabrous, ellipsoid, 2-2.5 cm long, 1-1.5 cm wide, succulent. Dark red to black, on coastal stabilised dunes, fruits recorded from May to September.

***Terminalia platyphylla* F. Muell**. (Fig. 13)
Tree to 20 m. The mature fruit is glabrescent, oblong to spindle shaped, 2-4 cm long, 0.7-1.5 cm wide, succulent, purple. Banks, levees or shores of creeks, river, swamps, lagoons or sinkholes in limestone areas. Fruit recorded January to October.

***Terminalia platyptera* F. Muell**. (Fig. 14)
Tree to 15 m. The mature fruit is a pubescent two winged nut, 1.5-3 cm long, 4-12 cm wide, dry yellow-green. Basaltic or riverine soils. Mature fruits recorded from April to July.This species took 17 days to germinate in our nursery, however we were not able to grow it on.

***Terminalia seriocarpa* F. Muell**. (Fig. 15)
Tree to 30 m. The mature fruit is glabrescent, ovoid, 1-1.8 cm long, 0.8-1 cm wide, angled, succulent, red or purple. River or creek bank, rain forest. Fruit recorded from January to May.

This large ornamental tree is suited to planting in parkland areas, shelter belts or possibly as an avenue tree. Young trees are highly decorative with a neat symmetrical crown and little space between the layers of branches. The tree is much smaller in exposed positions, in good growing conditions it can reach a height of 30 m. Leaves are light green, glossy on the surface and dull below. Drought induces leaf fall, but regular watering creates an evergreen effect. This species produces edible succulent fruit which is said to be delicious, however we can find no reference to the small kernels being eaten. Trees have been harvested for their timber which is useful for interior construction. Seed germinates easily and seedling growth is rapid.

***Terminalia supranitifolia* N. Byrnes** (Fig. 16)
Spreading shrub to 3m. The mature fruit is glabrous, ovoid-globular, 1-1.5 cm long, 1-2 cm wide, succulent, yellow-green. Coastal rocky ridges, fruits recorded January to May.

***Terminalia volucris* R. Ex Benth.** (Fig. 17)
Tree to 8 m. Fruit a two winged nut, 1-2 cm long, 3-7 cm wide, dry, yellow. Blacksoil plains or seasonal swamps, fruits recorded from December to April. Foliage used as cattle fodder.

Propagation and Cultivation
Propagation is by seed sown in the spring or early summer. Fresh seed of *T. catappa* germinates very easily with no pretreatment, however the fresh seed of many species often takes months to germinate. The woody shell of the seed hardens with age making embryo expansion more difficult until the shell is broken down. It is therefore suggested you use the following pretreatment to aid germination.


Fig. 7. *T. fernandiana*

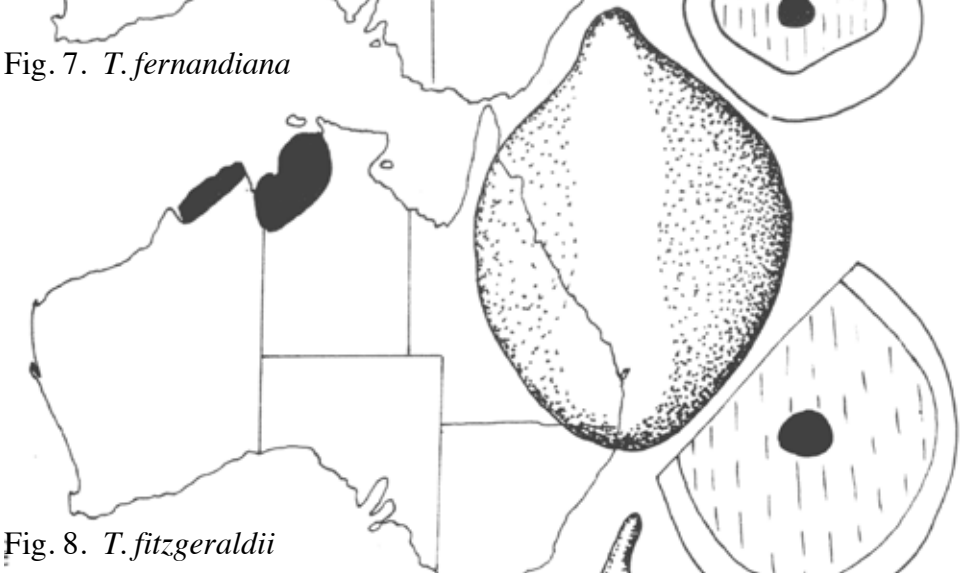
Fig. 8. *T. fitzgeraldii*


Fig. 9. *T. grandiflora*

Fig. 10. *T. hadleyana*

Fig. 11. *T. latipes*

Fig. 12. T. petiolaris

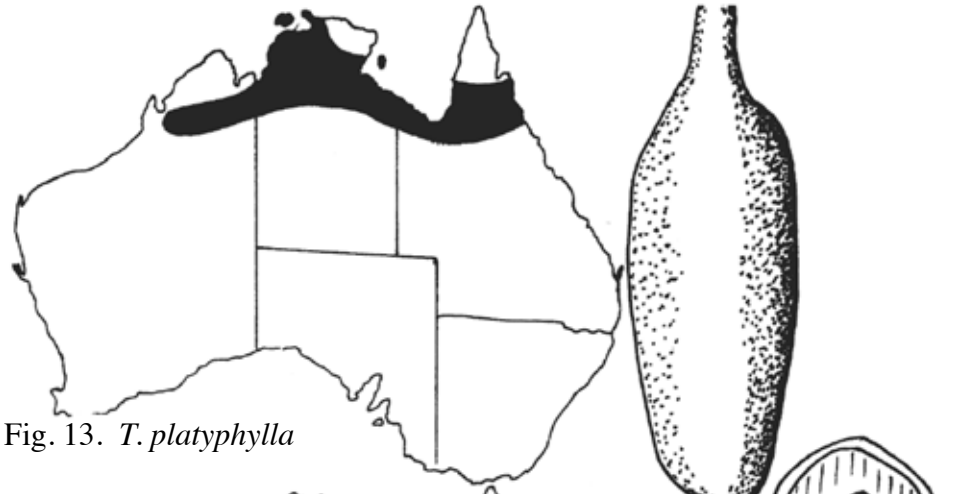

Fig. 13. *T. platyphylla*

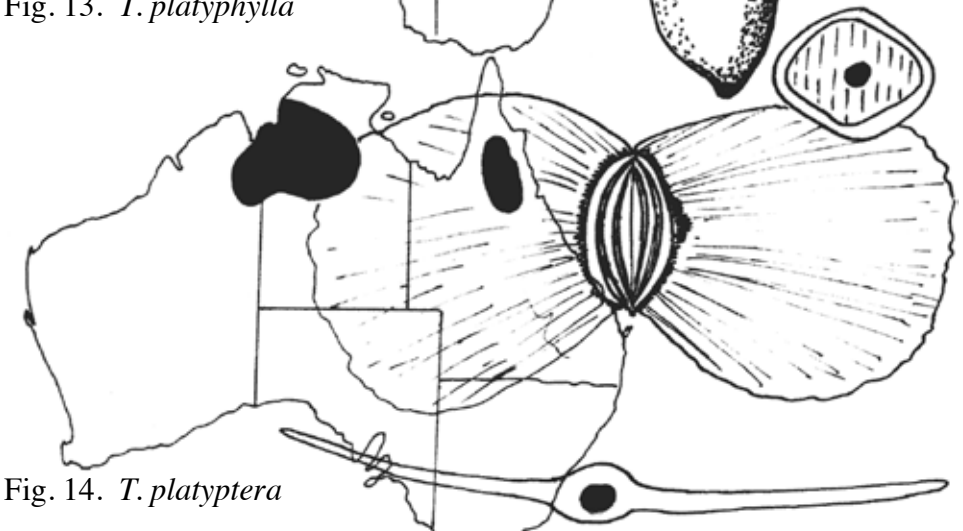

Fig. 14. *T. platyptera*

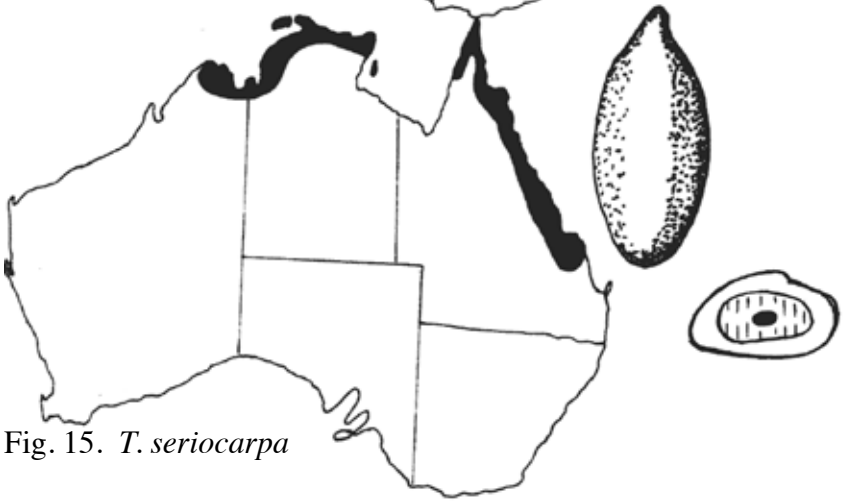

Fig. 15. *T. seriocarpa*

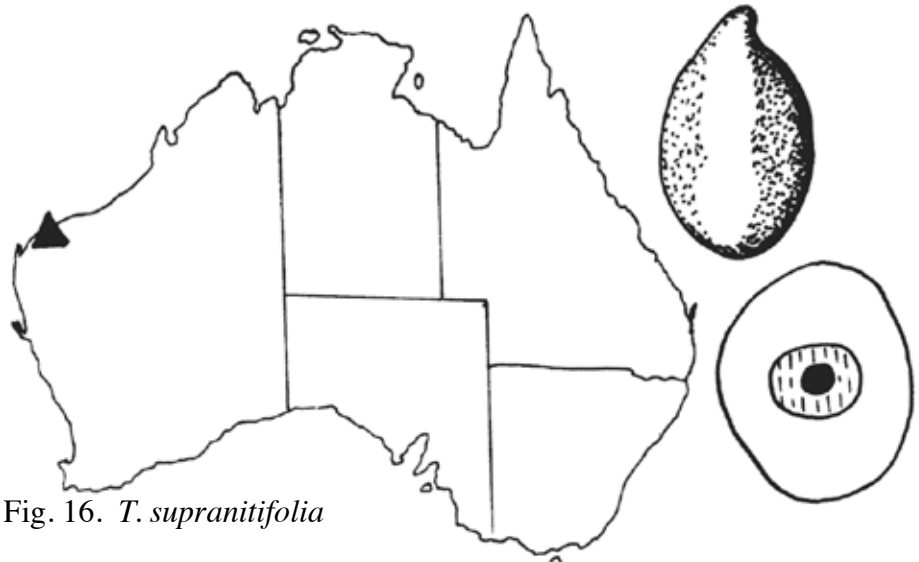

Fig. 16. *T. supranitifolia*

Fig. 17. *T. volucris*

Notes on Distribution Maps and Fruits of *Terminalia* species mentioned in the text.

Mature fruits shown are the largest known, generally wild fruits are less than half this size (average size equals half the size shown).

A section through each fruit, at the middle is also shown to illustrate different sizes of succulent coating.

Remove any outer flesh (fruit) and scarify the seed, e.g. file down a small piece of the shell, do not file too deeply or you may damage the seed. This process will allow water and air to penetrate the seed coat and so hasten germination. The seed should be sown in a free draining preferably sandy mix. Sow several seed per pot and prick out (transplant) the seedlings as soon as they germinate, that is when they are only 1 or 2 days old, into a sandy free draining mix. A general potting mix should be ideal.

Few of our West Australian species, to our knowledge, are in cultivation. Therefore, it would be wise to use only a small amount of slow release fertiliser in these mixes, a weak solution of liquid fertiliser can be added later if required. Seedlings of species in cultivation are fast growing.

We do not recommend growing *Terminalia* in the south of the state, as the climatic conditions are not suitable for their-growth. Although we have germinated a few species in our nursery we have not been able to grow them on in our botanic garden. *Terminalia catappa* is being grown by the Forests Department nursery in Broome. Several species of *Terminalia* are being grown in cultivation in the Northern Territory and Queensland, they have enormous horticultural potential in those districts and in the north of our state. The trees in many instances are extremely durable, that is they are used for windbreaks, erosion control and as ornamental trees.

As ornamental trees they offer variable shapes, leaf colouring (if allowed a dry season) or evergreen if watered. They are fairly resistant to white ants and most pests. Although the large flowers are fairly insignificant because of their colour, the fruit of many species is attractive when ripe. The typical sympodial branching is also another feature of this genus. When a branch forms a terminal cluster of twigs one continues growing while the rest are suppressed, in this way the branch is extended.

General Information

Although a few species are cultivated in developing countries for their kernels, they are not considered to be of commercial value for nut production. However, the kernel of *T. kaernbachii* from Papua New Guinea is reputed to be as large as a small hen's egg and should be worthy of cultivation on a small scale. *Terminalia catappa* may also be worth cultivating if a method can be devised to economically extract the kernels.

The timber of many species is durable and used for planks or beams inside houses. Leaves and bark are used for tanning. Bark of several species is used for dyeing and the bark of *T. alata*, which contains an unusually large amount of lime when burnt, is often used in India instead of shell lime.

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Hearne, D.A. *Trees for Darwin and Northern Australia,* 110-113.
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Nut Trees in the Suburban Block

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INTRODUCTION

This article examines the use of nut trees in a typical Perth suburban quarter acre block. It will be appreciated that every such block will have its own particular features, and that a general article such as this must be based on a 'hypothetical average block', so that recommendations and comments given may need modification for any area which differs appreciably from the hypothetical average.

SOILS

Most Perth suburban blocks are based on sand. This type of soil is both a blessing and a curse. Its good points are its excellent drainage, ease of working and friability, and general lack of disadvantageous minerals. Its bad points are its very low organic content, and hence mineral-buffering capacity, its tendency to be 'sour', and its ability to form a water-repellent (hydrophobic) surface layer which can make irrigation procedures more difficult. In addition, most 'older' Perth sands are riddled with nematodes (eelworms) and many have significant populations of harmful soil fungi such as the *Phytophthera cinnamomi* fungus responsible for Jarrah Dieback and Avocado Rootrot.

To make best use of most suburban blocks, it is therefore most desirable to build up the organic content of their soils through application of manure, compost, or other organic matter, or by growing and turning in various greenleaf plants. Sawdust, bark, and shredded paper are all of value provided that they can be fairly evenly mixed with the sand. Once tree crops are established, care should be taken that as much as possible of the organic byproducts from leaf-fall, prunings, etc., are re-incorporated in the soil. A dramatic improvement in soil quality can be obtained within only two or three years through careful attention here.

From personal experience I can vouch for the fact that organically-improved soils really do behave much better for tree crops than unimproved ones. Not all the reasons for this are known. However, it seems that soils with high organic contents support enormously higher levels of soil microorganisms, most of which act against pests such as nematodes and harmful fungi. The useful effects of soil aeration through earthworm activity are well known, and earthworms are most active where soil organic content is high. Organic matter improves soil structure, giving better and more even water-holding capacity, and can actually improve the use of chemical fertilizers since it can act as a sort of 'nutrient bank', holding excess chemical and releasing as required.

Soil structure can also be improved without any effort, in the long term, by adopting a suitable micro-ecology approach as mentioned below.

SPECIES

At the present time there are two types of nut tree which can be regarded as well proven and very suitable for suburban planting. These are the pecan and the macadamia. Other species also have a place, both older favourites such as the almond, and newer fruits and nuts such as mango, cherimoyer, and chestnut. However, there are good grounds for basing any metropolitan smallscale planting on pecan and macadamia, which form a good complementary pair, and varying the other species to suit the particular needs and desires of the particular planting involved.

Pecan. The pecan is a large, spreading, deciduous tree which typically sends down a deep taproot. Many good producing trees already exist in the metropolitan area. The nuts produced are of good flavour and are readily saleable. With reasonable initial care the trees grow well and are not subject to any particularly marked drawbacks.

The pecan is a native of the southern part of North America, where it has evolved to grow in areas such as creek bottoms. Botanically *Carya illinoensis*, it is a member of the hickory family, and a relative of the walnut. In contrast to the normal walnut, it will succeed in areas with hot dry summers, and so is much better suited to Perth conditions. Once established, it is a relatively hardy tree, although benefitting from good supplies of deeply penetrating water.

Like most other members of its family, the pecan produces first-class timber which is much sought after for cabinet work, tool handles, and the like. It is a very strong, tough timber which is not used for construction only because its other uses are so much more valuable.

Supplies of grafted and seedling pecan trees are available reasonably readily. Seedling trees generally produce nuts, although often not as early or as prolifically as grafted varieties. However, variety selection for Perth is still a somewhat open subject, and varieties which have produced well overseas or elsewhere in Australia do not necessarily perform well here. The comment below in the section on Macadamia stock from Queensland applies to pecan also. Some varieties which appear reasonable for Perth include Western Schley, Nellis, Williamson, Wichitaw, and Success. A large number of new varieties of pecan are becoming available from the U.S., mostly from Texas, and these may turn out to be more suited to more humid east coast climates.

One- and two-year old pecan seedlings are generally available at $3-6 each, depending on quantity and quality. Grafted trees cost around $15-20 each. A small number of grafted pecans are produced locally. A single tree will usually bear nuts although a variety mix is usually recommended for good pollination.

Macadamia. There are two species of macadamia used for nut production, *Macadamia tetraphylla* and *Macadamia integrifolia*. Both are natives of the rain forests of northern New South Wales and southern Queensland. Both are fairly dense, medium size evergreen trees with relatively shallow root systems. The *Integrifolia* species has been commercially developed in Hawaii, and is generally better suited to more tropical, humid conditions, although it

grows quite well in Perth. *Integrifolia* has spherical, smooth-shelled hard nuts of very high oil content and excellent flavour; it tends to be everbearing.

The *tetraphylla* species produces similar nuts except that they are somewhat more oval in shape and have tiny dimples in the shell. The nuts are also generally higher in sugar and lower in oil than *integrifolia*s. *Tetraphylla*s typically show more seasonal behaviour, generally flowering in Spring and fruiting in Autumn. They have proved more successful in southern California, which of course is much closer in climate type to Perth than is Hawaii. If a choice exists, it is probably the best choice for Perth.

Technically, the two species can be distinguished by other characteristics. *Integrifolia* flowers (borne on long streamers called racemes) are cream, the leaves smooth-edged on mature trees, with stalks (petioles), and usually three to the whorl. *Tetraphylla* flowers are pink, mature tree leaves still have prickly edges, leaves lack petioles and are four to the whorl. On the garden scale both nuts are excellent choices, although commercial processors need to distinguish the two species because their roasting behaviour differs. Isolated trees of either species will certainly fruit, although yields may be improved by cross pollination.

Grafted trees are available fairly readily of *integrifolia* selections, such as 660, Own Choice, Hinde, Renown, Nutty Glen, and of some selections which are probably hybrids. Based on Californian and New Zealand experience, the best variety for home gardens is a *tetraphylla* or hybrid selection called Beaumont, but this is not readily available, nor is any range of *tetraphylla*s. Most macadamia propagation and grafting is done in Queensland, and this has two disadvantages for Perth growers. Firstly, the emphasis is on *integrifolia* selections, as better suited to Queensland's more humid tropical conditions. Secondly, handling during transport and fumigation (and often re-potting) leads to traumatized stock which often does not establish well. There may be some improvement with increase in local propagation expertise, and with entry of New Zealand stock possible. However, there is often little choice.

Grafted macadamias sold in local garden centres are almost all imported from Queensland and are relatively expensive ($20 - 30 each). Very small trees air-freighted in can be bought in quantity at around the $10 mark, but often need a year's attention before being really suitable for planting out.

Other Species. Whether a planting is on conventional monoculture, same-age lines, or uses the species-integration approach (see below), the opportunity exists to intermingle other species of nut or fruit trees to improve early returns or maximise overall yields. The choice of such plants is very wide, and only a brief mention of some possibilities and some factors to be borne in mind can be given here.

As is normal, high-value crops usually involve higher inputs (especially labour), or higher risk (such as a new or unproven fruit without an established market). With new crops, potential profits may be very much higher, even if not assured. A good point with tree crops is that although lead times are longer than for annuals, their high-profit periods may be much

longer, eg avocados which fetched $4 each when first available still bring in $2 each some 4-5 years down the track, while kiwano, an annual crop, have dropped from $3.00 each to 59c each in a single year.

Almond. Shorter-life nut plant, early producer, hardshell varieties recommended for home gardens due to parrot attack; two varieties blooming at same time needed.

Cherimoyer. Fruit related to custard apple, based on Californian experience has excellent prospects here, really first-class fruit.

Guava. Robust quick-producing fruit tree, thrives here. Hazelnut. Understorey shrub with possibilities, two varieties recommended, generally grown in cooler climates than Perth.

Carob. Grows and produces well; most trees male or female; produce not readily sold here.

Berries. (Raspberry, blackberry, etc..) high-value, high-labour, high-perishability crop, quick returns, good yields possible.

Feijoa. Good prospects, fruit readily sold.

Bunya. Ultimately large tree, long time to yield, excellent nuts, excellent timber.

Mango. Worth investigating.

Casimiroa. (White sapote). Very good prospects but as yet unproven.

Fig. Established market, easy to grow.

Mulberry. Grows like a weed, produces heavily, someone should develop it as a commercial crop.

TREE PLANTING AND ARRANGEMENT

Arrangement and spacing in commercial nut orchards is dominated by the need to use mechanical equipment for harvesting, pruning, spraying, and the like. In a suburban garden these factors are irrelevant, and a completely different approach which assumes hand labour and species integration is likely to be much more satisfactory.

Under natural conditions, trees, including nut trees, form part of a particular plant ecology, which embraces a range of species from tall trees down to ground-level herbs. Such ecologies are intrinsically efficient because they have evolved to make best use of the conditions and species present, through the pressures of natural selection. If the species integration is applied at the home garden level, using a range of different plants to fill out the appropriate

ecological spectrum, much better overall yields can be obtained from the mixed planting than are possible from any one species in isolation.

In practice this means mingling plants of different ultimate heights and at different stages in their life cycles. Naturally most people will choose plants which have useful nuts or fruits, but other plants which will improve the soil and the micro-ecology are also indicated. The ultimate aim is to produce a situation in which the component parts slowly change over the years as particular plants are added, grow larger, are taken out, or are 'released' as competing plants are removed, but in which the overall yield is at a maximum. This situation of micro-change but macro-stability is one of the best approaches to what has been called permaculture.

In a conventional nut orchard, tree spacings are typically 10 metres apart, more for ultimately larger species, less for smaller ones or for more recent techniques such as hedgerow planting. All the trees in the orchard are of similar age and size. Planting density is typically 125 trees to the hectare.

In the integrated-species approach, trees of the same species will be of different ages and heights and will be mixed in with other species of similar diversity. Very much higher densities can be used, as the trees are like 'shift workers', not all active or demanding at the same time. For example, a planting with tall upper-storey pecans over mid-level macadamias will have the pecans in full leaf and exposed to plenty of sun in the summer, the period of most activity, while in the cooler winter the macadamias will receive most of the light through the then leafless pecans. Both trees benefit from the others' presence.

IRRIGATION

While both pecan and macadamia are relatively hardy and drought-resistant once established, watering and fertilizing are important in the early years. Also, in later years there is no doubt that better yields can be obtained from applying more water. The break-even point between getting higher yields and the cost of applying more water to get those yields is highly variable and no generally applicable figure can be stated. In addition, pecans can be deep rooted enough to tap local water tables, leading to much reduced need for surface water application. Also, in a mature integrated-species garden, where much of it will approach closed-canopy conditions, water need is reduced because leaf-transpired water tends to be recirculated under the canopy. For the same reason, some species such as macadamia and avocado will establish, grow, and fruit better under a canopy as they prefer the higher humidity present there.

Methods of irrigation will depend on available water sources. If a bore supply is available, conventional sprinklers on pop-ups or risers, controlled by a time clock, give good results. Butterfly sprinklers set below tree canopies give good water spread and penetration. Pecans will thrive with large dollups of water dumped from a tank into a basin round the trunk, at intervals of one or two weeks. Trickle irrigation is more suited to the commercial pattern of same-size, same-spaced, same-species trees.

TREE NUTRITION

In a mature, integrated-species planting, demands on nutrition from outside are not high if organic-matter recycling is practiced. In the earlier stages, use of chemical fertilizer or manure will often be helpful. Hand application of a normal orchard fertilizer such as 'Vigran', two or three times a year, is probably sufficient.

YIELDS AND PLANTING DENSITY

As a general guide, most nut trees come into bearing at around the same rate as do citrus. That is, with well-selected grafted varieties, bearing starts 2 or 3 years after planting, and builds up to a 'mature' level after 7-10 years, with suitable care. Seedlings tend to come into bearing later, produce nuts with a wide spread of qualities, but are often more vigorous and produce an ultimately larger tree (partly because the grafting process diverts vegetative growth into fruiting activity). However, unlike citrus, many nut trees continue to expand production well after the initial decade, and have potential lifetimes extending to centuries.

Any commercial nut orchard should expect to produce at a minimum rate of 1500 kg/ha when it reaches 'full bearing', with 3000 kg/ha more normal, and 6000 kg/ha perfectly possible under good conditions. Of course, at the higher rates of yield, the law of diminishing returns may have set in, and it may not be economic to produce at this rate. A good individual tree may yield a yearly average of 50 kg of nuts; the record, for a huge pecan tree some centuries old, is around 7500 kg in one season.

The current commercial trend is to plant closer and monitor tree growth conditions to produce as early as possible. This trend has not yet reached the stage as with stonefruit, now planted as little as 1 m apart and trained onto trellises, because selection of suitable dwarf clones of nut species is still much further off.

In the home-garden situation, the above figures would indicate a possible production of 600 kg from a quarter acre (0.1 ha) fully planted to nut trees. Such yields are certainly possible, and total all-species yield may be considerably higher, from an integrated-species situation. Yields from highly-intense horticultural activities have reached 60 tonnes of fruit per hectare, equal to 6 tonnes per quarter acre. As fruits contain much more water than nuts, 1 kg of nut yield may substitute for 5-10 kg of fruit yield.

A fully-planted quarter-acre block could contain as many as a hundred individual nut and fruit plants, although obviously only a proportion of these will be mature, large upper-storey trees; a single large pecan could itself extend over a quarter acre. Areas only partly planted will obviously produce less in proportion. With only a single nut tree planted, yield at maturity may reach the 50 kg level noted above. Much higher yields are known of, for example a single 60 year old chestnut at Dwellingup has produced over 300 kg of nuts per year.

Traditional Fruits in their Context in Papua New Guinea

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People appear to have settled on the mainland of Papua New Guinea some 50,000 years ago. These early settlers were hunter-gatherers who lived off wild game, seafood and plants - nuts, fruits, roots, shoots and leaves - which could be gathered in the bush. The hammer stones and stone mortars and pestles uncovered from time to time in various parts of the country, and whose origins are unknown to present populations, were probably used by these hunter-gatherers to break the nuts which seem to have been an important item of their diet. About 9,000 years ago, however, people in the highlands had established gardens (making them amongst the earliest known agriculturalists in the world) and by around 4,000 BC agriculture seems to have largely replaced hunting and gathering as a means of subsistence.

Today the vast bulk of Papua New Guinea's population are still subsistence farmers, and though they produce introduced cash crops and consume imported foods such as rice and tinned fish, for most villagers the major activity is the production of the basic staples which sustained their forefathers: banana, taro, yam, sago, and the later arrival, sweet potato.

New plants, such as corn and papaya, as well as the sweet potato, arrived from tropical America even before the Europeans arrived in Papua New Guinea, and following European settlement various plants, including tropical fruits such as pineapple, soursop, custard apple, fivecomer (carambola), guava, passionfruit, avocado and species of mango, were introduced from America and South East Asia.

To some extent these new plants, and the availability of imported foods from trade sources, appear to have reduced the consumption of some of the less common bush foods; indeed in some parts of the country young people's knowledge of bush foods is dwindling. On the other hand, what sometimes seems surprising is that many more of the common tropical fruits are held in low esteem by Papua New Guineans (the most common use of avocados, for example, seems to be as a pig food), while others such as rambutan, mangosteen, and durian were introduced around the turn of the century but never took on.

In an earlier article in this yearbook ('Some nut-bearing plants in Papua New Guinea', WANATCA Yearbook vol. 10, 1985, pp 19-27), E.E. Henty has described edible nuts, mostly indigenous, occurring in Papua New Guinea. In what follows I provide a layman's listing of indigenous (or what appear to be indigenous) fruits.

Banana, plantain - ***Musa*** spp.
Bananas are the staple food of many people in coastal Papua and in the Markham valley, and an important supplementary food in many other parts, growing up to an altitude of over 2,000 metres. There are a large number of varieties of banana, many of which have been introduced since European contact; the Adzera people of the Markham Valley have (at least) 36 words for banana. Some wild varieties, however, do not produce edible fruits. Most are cooking bananas, which are cooked like root crops. They are starchy and dense and, especially when boiled, usually rather flavourless. Sweet 'eating' bananas are less common. In some parts of the country, bananas are picked green and buried until the fruit ripens. The very large fruit of one variety is said to take years to ripen and is always cooked over the flames.

Fig. 1. Introduced banana (triploid) - left; Traditional banana (diploid) - right

Breadfruit - ***Artocarpus altilis, A. incisus***
The fruit of this tree is a supplementary food in many parts of Papua New Guinea. The round green fruit, which may weigh up to about five kilograms is ready to eat when the flesh feels soft and milky sap forms on the rind. The flesh is yellow and has a strong sweet smell. It may be eaten raw but is usually baked whole. In parts of the Sepik a delicious 'bread' is made from breadfruit, grated coconut and sago, wrapped in leaves and cooked on an open fire. Some fruit have seeds about the size and texture of chestnuts. In parts of the highlands people eat the seeds and throw the rest of the fruit away.

Taun (Tokpisin) - ***Pometia pinnata***
This common lowlands tree produces an edible fruit about the size of a small plum, which may be green, red or black. It is especially popular among the Boiken people of the East Sepik, who used to hold annual taun festivals.

Bukbuk (Tokpisin) - ***Burckella obovata***
This is a delicious fruit, about the size of an apple, which grows on a tall forest tree. It has a bright green soft skin, and white flesh with a single almond-shaped seed. The fruit, when ripe, has the texture of an avocado and a delicious flavour somewhat like a custard apple, but less sweet. It appears to be common in Mime Bay but occurs also on the New Guinea mainland and in New Britain.

Polynesian Plum - ***Spondias dulcis***
This tall tree yield a small, yellow, pear-shaped fruit with a prickly seed, which is firm, juicy, aromatic and slightly acid. The fruit is well known in Fiji (where it is known as *wi*) but in Papua New Guinea, apparently, is seldom eaten (though it is relished by pigs and cassowaries).

Mango - ***Mangifera*** spp.
Some species of Mango (*M. minor* and *M. foetida*) appear to be indigenous to Papua New Guinea, but the fruits of these are fibrous and taste of turpentine. Introduced species (such as *M. indica*) are now more common.

Malay Apple/Rose Apple (Tokpisin laulau) - ***Syzygium malaccense/S. jambos***
The Malay apple is a small, pear-shaped, bright pink, red or white fruit with a crisp but light white flesh which is faintly sweet and aromatic. It appears to be indigenous. The rose apple is similar in colour to the related Malay apple, but is larger and more rounded and its flesh is drier. Until recently, species of *Syzygium* were regarded as members of a larger genus, *Eugenia*. Some other species of *Eugenia* also produce edible fruit, among them *E. tierneyana* which bears a small red fleshy fruit which has a sharp taste.

Indian Mulberry - ***Morinda citrifolia***
The *Morinda citrifolia* is a small tree with broad, shiny leaves. It produces a pale yellowish-green fruit, about the shape of a pine cone, which when ripe has a white almost transparent flesh and smells like Camembert cheese. The fruit is considered poisonous unless absolutely ripe. A nutrition survey report in 1947 described the fruit has having 'a disgusting smell and taste but.. . considered palatable by the natives. The taste is somewhere between Camembert and a custard apple. It appears to be mainly a famine food. At other times it is fed to pigs.

Nipa Palm - ***Nypa fruticans***
The seeds of the nipa palm contain a rather tasteless jelly which is sometimes eaten by people living in the swamps where the palm occurs.

Fig.2. Sago palm (left); Carambola or Five-Corner (right)

Wild Figs - ***Ficus*** spp.
Nearly all species of Ficus (which belong to the same family - Moraceae - as the breadfruit) yield edible green leaves or fruit. Usually the fruit of Ficus is a bush food and not a regular part of the diet. The only fruits I have tasted were dry and had little flavour. They can be very astringent. Those recorded as being eaten include *F. botryocarpa* , which yields small figs; *F. copiosa; F. cynaroides; F. dammaropsis; F. itoana* (which has a cauliflower-like fruit); *F. pungens; F. virgata ; F. wassa*.

Mangrove -***Bruguiera*** spp.
In some coastal areas the germinating seeds of the mangrove are eaten, mostly as a famine food. The long, cigar-shaped 'fruits' (actually, propagules) are first boiled and the softened skin scraped off. The propagule is then cut into pieces and soaked in salt water until soft, in the process getting rid of excessive tannin. Finally the water is squeezed out to leave a coarse brown mash which is mostly starch and has little flavour.

Garcinia - ***Garcinia*** spp.
I have never, in Papua New Guinea, come across the purple fruit of the mangosteen (*G. mangostana*), the sweet exotic fruit common in southeast Asia, though I understand it was introduced in some areas before the Second World War. But other species of *Garcinia* appear to be indigenous. In the Samarai I have found a small, yellow, round garcinia fruit with a sweet pulpy centre.

Other fruits which have been recorded and eaten in Papua New Guinea include:

Amomum spp. -*Amomum* is a large herb which is cultivated as a boundary marker. Its fruits are sometimes eaten as a snack. They are said to taste a little like passionfruit.

Antidesma bunius -the currant tree; a small tree which bears small, cream, red or purple fruits which have an acid pulp.

Avicenna sp. - a mangrove plant with edible seeds.

Coccoloba uvifera - the seaside grape, a small tree with an astringent fruit.

Dillenia spp. - a family of shrubs and small trees which produce a tart fruit.

Dracontomelum mangiferum - the New Guinea walnut, produces seeds with edible flesh.

Ehretia microphylla - a small shrub with an edible round yellow fruit.

Flacourtia rukam - the Indian plum; a red berry, bitter but edible raw and cooked.

Freycinetia spp. - a forest tree which produces edible fruit.

Madhuca sp. - a tree with fleshy fruits.

Nephelium spp. - a genus of trees which include the rambutan and lychee.

Phalena papuana - a small shrub which produces a sweet fruit.

Pithecellobium dulce - a small tree with an edible fruit.

Solanum nodiflorum - a black nightshade; the small berries of this plant may be eaten when they are ripe (black). They are sweet but without a strong flavour. The green berries contain toxic alkaloid.

Sonneratia spp. - another mangrove plant which produces an edible fruit.

Ximenia americana - a small coastal tree known variously as yellow plum, wild olive or wild lime. It produces a yellow plum-like fruit with a large stone and a very acid flesh (in South Africa the fruit is used to make a kind of beer).

Of all these fruits, however, I must confess that, apart from bananas and breadfruit, the only two which still evoke fond memories are the **taun** and **bukbuk**. The **taun** perhaps lingers in the memory more for its ceremonial associations than its taste, but the **bukbuk** is probably the most enjoyable fruit I have eaten.

[Editor's note: the following beautifully-illustrated book by Dr May contains much additional information on native foods and cooking in Papua New Guinea]:
May, R.J. : *Kaikai Aniani . a guide to bush foods, markets and culinary arts of Papua New Guinea*. Robert Brown & Associates, Sydney; 1984.

[Line drawings reproduced with acknowledgement from]:
French, Bruce: *Food Crops of Papua New Guinea*. Vudal College of Agriculture; 1987.

Plant Quarantine and Variety Introduction

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Why have Plant Quarantine?

Australia, and Western Australia in particular, is free from many of the serious pests and diseases affecting crops in other parts of the world. These pests and diseases not only add to the costs of production but also limit access to potential export markets. For example, in contrast to Australia, New Zealand's freedom from fruit flies has allowed it to enter the prized Japanese market.

Four examples of serious diseases not present in Western Australia are:

1. Fireblight of Apples and Pears
This is an extremely infectious and destructive bacterial disease of apple and pear trees. A native of North America, it spread to New Zealand in 1920, reached the United Kingdom in 1957 and Poland and the Netherlands in 1966. Fireblight has caused havoc in horticultural industries particularly in eastern and mid-west U.S.A. One season of active fireblight development in a pear orchard can be enough to seriously damage sufficient trees and make any further commercial production uneconomic.

2. Brown Rot of Pomefruit
If brown rot of pomefruit is introduced into Australia it is likely to cause serious losses to apple and pear production, and to further aggravate the brown rot problem on Eastern States stonefruits. It occurs throughout western and southern Europe. It is a different organism to that which causes severe losses in stonefruit crops in the Eastern States of Australia.

3. Plum Pox Virus
This is an insect-transmitted virus disease of plums, peaches and apricots. It is particularly destructive in commercial plantings in middle and eastern Europe. Crop losses can be almost 100 per cent through premature fruit drop, discolouration of the fruit flesh and 'pox'-like indentations on the fruit skin.

4. Citrus Canker
This bacterial disease is one of the most serious diseases of citrus and is currently causing considerable damage on South America. If introduced to commercial citrus orchards in Australia, it would seriously affect production in moist, coastal regions, and costly spray programmes would be required for its control in other areas. It is thought to have originated in South East Asia. The disease was recorded in Australia in 1912 and fortunately it was successfully eradicated by 1923.

In 1984 it was detected in Florida, U.S.A. and immediately an eradication campaign was started. Over 20 million immature citrus plants have so far been destroyed as an eradication measure. There is no known cure, and the only way to stop the disease is to destroy infected plants.

Any of the above diseases could be easily introduced into Western Australia by a returning traveller simply bringing back a piece of infected budwood for propagation. Plant quarantine measures are designed to protect our horticultural industries from damaging pests and diseases, while still allowing the controlled entry of varieties needed to improve our competitive position. The exact quarantine measures depend upon whether propagating material is from overseas or interstate.

Varieties from Overseas

The Commonwealth's Quarantine Act, administered by the Australian Quarantine and Inspection Service of the Department of Primary Industry, is responsible for quarantine procedures for plant imports from overseas.

The Department of Agriculture in Western Australia acts on behalf of the Commonwealth in this State. The Commonwealth provides the finance for quarantine glasshouses, screenhouses, fumigation facilities and plant pathology! entomology services for the treatment and disease screening of imported plant material. Generally post-entry quarantine involves imported plants being fumigated to kill insect pests and then being grown in a quarantine glasshouse where they are screened (checked) for disease.

In 1984 a review of plant quarantine policy for nursery stock entering Australia was prepared by plant quarantine in Canberra. The review highlighted important advances both in our knowledge of pests and diseases and in horticultural technology (e.g. tissue culture) since the 1950's. As a result, plant quarantine has now adopted a flexible attitude to quarantine requirements for both the quantity of plants which importers may introduce and also the conditions of post-entry quarantine. As the health risk varies with the pest and disease status in the country! area of origin, each application to import is treated on its merits.

Areas of interest to tree crop growers where changers have occurred or are occurring follow:

1. Sponsorship
The requirement for private importers of fruit and nut crops to be sponsored by a state Department of Agriculture has been withdrawn. Applications to import these crops will be treated in the order received so long as no one importer monopolises the available resources.

2. Multiple Introductions
plant quarantine will still endeavour to limit multiple introductions of the same variety where propagating material can be made available from public sources or where private importers are willing to consider requests for material from intending importers.

3. Patented varieties
In the absence of legislation recognising Plant Variety rights, Plant Quarantine will not give defacto recognition to overseas patents. Protected propagating material may enter as any public variety. Plant Quarantine will not hold or distribute propagating material without the approval of the importer.

4. Quarantine Impediments and Health Risk
Post-entry quarantine impediments will be imposed according to perceptions of health risk. For example, temperate fruit varieties do not have to undergo virus indexing in post-entry quarantine if they are from accredited sources where material is regularly indexed and kept in isolation. Tissue culture plants from certain accredited sources may enter with few, if any, quarantine impediments.

Elite stock of some species with accepted health status certification may enter Australia subject to fumigation against arthropod pests, without post entry quarantine. The plants must be proliferated in vitro and raised on benches in inert media in pressurised, insect screened plant houses.
Plant Quarantine is also considering proposals for reducing the period for disease screening of plants in post entry quarantine. If accepted, the quarantine period for stonefruit could be reduced from two years to six months. Procedures are also being examined to allow the safe introduction of some plants (including citrus) which have been prohibited for many years.

5. Fees
For a fee, private importers can now have plants virus indexed in post-entry quarantine. This fee is in addition to fees devised for inspection, fumigation and care of plants in quarantine.

6. Import Permits
Import permits are required for each overseas import. Application forms (QP 36) are available from the Plant Industry Inspection Branch, Horticulture Division, Department of Agriculture, Baron-Hay Court, South Perth 6151 - telephone 368 3333. Applications are generally forwarded to Canberra for approval. The particular quarantine impediments, according to the perceived health risk, are written onto the import permit.

As illustrated above, plant quarantine is endeavouring to facilitate the entry of new varieties so our horticultural industries have access to overseas material without the need to smuggle material in and jeopardise the livelihood of fellow growers by inadvertently introducing an exotic pest or disease.

Seeds

Most tree crop seeds may be imported without permit or restriction on quantity, subject to inspection on arrival.

The exceptions, which may only be imported under permit are:

Avocado -	May be imported from New Zealand or Norfolk Island. From other areas growth in post-entry quarantine would be required.
Chestnut -	(Castanea spp. and related genera). May be imported from New Zealand.
Coconut -	
Citrus -	May be imported from countries free of Citrus Canker subject to treatment with 8 hydroxyquinolene sulphate or streptomycin.
Coffee -	May be imported from countries free of Coffee Rust.
Eugenia -	Prohibited from South America and the Caribbean. Small quantities subject to fungicide treatment from elsewhere, apart from New Zealand.
Prunus -	Prohibited from countries where Plum Pox exists (Europe and Middle East). Must be certified free of viruses from other countries.
Psidium -	As Eugenia.
Walnut -	Must be treated against Codling Moth.

Varieties from Interstate

This State's Plant Diseases Act is responsible for quarantine procedures for interstate plant imports. Quarantine procedures are presently being reviewed to recognise changes in nursery technology and pest and disease control, the review should result in improvements to interstate trade of disease free material.

Because of Black spot of apples in the Eastern States *all apple material* must undergo a period of growth in a quarantine glasshouse before release. At present this period is two growing seasons, but investigations are underway for new techniques and procedures which could reduce this period to six months. All other fruit crops (except grape vines) can enter Western Australia in commercial quantities provided certain restrictions are complied with. The following extract from the publication "Summary of Requirements for the Entry of Plant Material into Western Australia from Interstate" lists the present restrictions for most fruit crops:

"Fruit types commonly imported into Western Australia are listed herein. Other fruits not listed and liable to carry pests or diseases may also be subject to restrictions. In such cases and for further information contact the Department of Agriculture at the Kewdale Inspection Centre on (09) 458 5857 or at Baron-Hay Court, South Perth on (09) 368 3333.

All commercial consignments should be clearly marked with the name and address of the grower and packer.

In this document 'certified' means 'accompanied by a certificate issued by the Department of Agriculture of the exporting State or Territory' in the form of the 'Plant Health Certificate for Interstate Movement of Plant Material in Australia'.

FRUIT TREE TYPE	RESTRICTION CODE
Stonefruit	
- includes almond, peach, nectarine, plum, cherry and quince	13, 17, 18, 29/30,31
Other fruit trees including	
- avocado, nuts, berry fruit, carambola, custard apple, guava, litchi, pawpaw, babaco, rambutan, sapodilla, kiwifruit, passionfruit, olive, pear and mango	13, 17, 29/30,31
Citrus	
- orange, grapefruit, lemon, mandarin, tangelo pomelo, cumquat, etc.	13, 17, 27, 29, 30, 31.

Note: Alternative mandatory treatments are separated by a slash (/)

Restriction Codes - Explanations

13: Free from soil unless from premises that have been approved by the Western Australian Department of Agriculture to treat soil.

17: a) Plant material from any State or Territory, other than South Australia or Tasmania, must be accompanied by a declaration made by the grower before a Justice of the Peace or before an Officer of the Department of Agriculture in the State or Territory of origin to the following effect:

(i) That the tree or plant has been grown at a distance greater than 45 metres from any grape vine or root thereof: and

(ii) That no phylloxera exists or has existed in the nursery or garden in which the tree or plant has been growing: OR

(iii) That the tree or plant was grown in a nursery approved by the Western Australian Department of Agriculture.

b) The above conditions do not apply to aseptic cultures of plant material grown on agar in sealed flasks (i.e. tissue culture).

18: Certified to have been dipped or thoroughly sprayed in an aqueous solution of benomyl at a strength of not less than 0.1% active ingredient in a manner so as to immerse all portions other than the root. The consignment is to be free from dead growth and free from any growth which has borne a flower.

27: Certified that the plant material was grown in an area free from Citrus Leaf Miner (*Phyllocnistis citrella*) and bears a label giving the address of the place where the plant was grown.

29: Importation is subject to:

a) Disinfestation treatment on arrival; or

b) Pre-consignment disinfestation, which is only accepted from nurseries approved by the Western Australian Department of Agriculture. Consignments must be accompanied by a declaration from an approved nursery, specifying that the following treatment was applied:- "Thorough spraying using a mixture of 6 ml Diazinon (80%) and 120 ml superior white oil to 10 L water."

30: Certification that fumigation with Methyl Bromide has been applied to another State or on arrival is required. The following rates of treatment may be applied: 56 gJm3 at 5° - 10°C; 48 g/m3at 11°- 15°40 g/m3 at 16° -20°; 32 g/m3 at 21° - 25°; 24 g/m3 at 26° - 30°; 16 g/m3 at 310 and above. Treatment for 2 hours for actively growing and 2.5 hours for dormant and evergreen vegetation is required.

31:

a) From /Victoria, New South Wales, Queensland and Tasmania - Certified as examined and found free from European and Red Mite or from nursery approved by the Western Australian Department of Agriculture as free from European Red Mite or certified as grown and packed at least 50 km from a known outbreak of European Red mite. Does not apply to aseptic cultures of plant material grown on agar in sealed flasks (i.e. tissue culture).

b) High Risk plants subject to European Red Mite are:
FRUIT TREES:- *Cydonia* - Quince; *Eriobotrya* - Loquat; *Malus* - Apple; *Mespilus* - Medlar; *Pyrus* - Pear; *Juglans* - Walnut; *Prunus* - Almond, Cherry, Peach, Plum, Apricot
ORNAMENTALS AND OTHERS:- *Amelanchia* - Serviceberry, Juneberry; *Aronia* - Chokeberry; *Chaenomeles* - Flowering Quince; *Cotoneaster* - Cotoneaster; *Crataegus* - Hawthorn; *Photinia* - Photinia; *Pyracantha* - Firethorn; *Quillajar* - Soapbark tree; *Rhaphiolepis* - Indian Hawthorn; *Sorbus* - Rowan, Mountain Ash; *Stranvesia* - Stranvesia; *Ulmus* - Elm; *Rosa* - Rose; *Aesculus* - Horse Chestnut; *Castanea* - Sweet Chestnut; *Populus* - Poplar; *Salix* - Willow; *Ribes* - Berry Currants

Conclusion

Significant technological advances in recent years are enabling Western Australia's horticultural industries to quickly take advantage of new varieties without the risk of introducing exotic pests and diseases. There is no justification for growers or nurserymen to try and "beat the system" by smuggling in material and placing Australia's horticultural industries at risk.

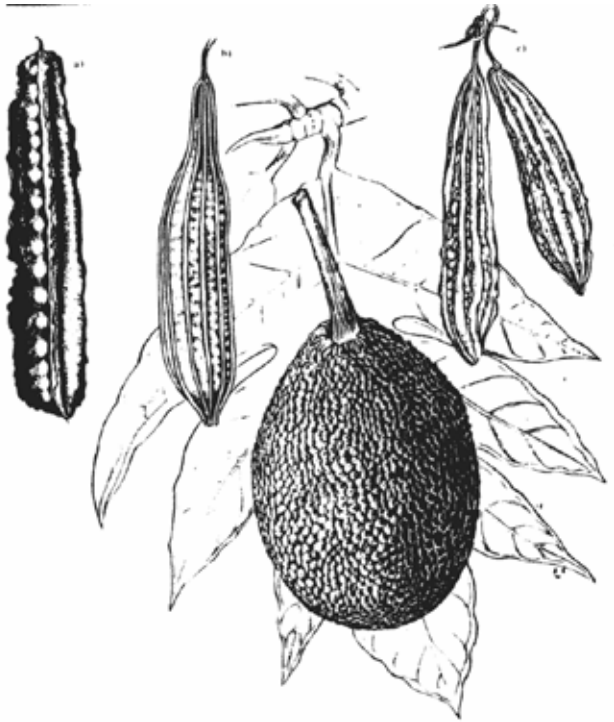
Fees

inspection and supervision fees are payable as appropriate.

Seeds	- imported by mail	- $10.00 per postal packet
	- imported as cargo	- $26.00 plus $0.70 per unit, subject to a maximum charge of $250.00
Tissue Culture		
	- by mail	- $10.00 per postal packet
	- as cargo	- $26.00 plus $0.50 per flask, subject to a maximum charge of $800.00
Elite Stock		
	- Inspection	- $15.00 plus $13.00 per half hour
	- Fumigation	- $26.00 per consignment
Plants	- Inspection	- $15.00 plus $13.00 per half hour
	- Fumigation	- $26.00 per consignment
	- Supervision	-$26.00 plus $1.00 per plant, subject to a maximum charge of $360.00

Clearance of Cargo

- Lodgement of Plant Quarantine Entry - $3.00



Fruits from Papua New Guinea (l to r) *Winged bean pod, fluted pumpkin, breadfruit, bitter cucumber*

Ginkgo - Tree of Antiquity

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Ginkgo biloba - the Maiden Hair Tree - is the sole living representative of a group of trees that were present on earth some 200 million years ago, and the genus has survived extinction by having been grown in Japan and China for hundreds, and probably thousands of years as specimen trees in the grounds of temples and shrines. The epithet *Ginkgo* is a synthetic Sino-Japanese word based on both Chinese and Japanese ideograms describing various features of the tree. It is of interest to note that despite this derivation from these two Asian countries the epithet is often misspelt as 'Gingko' in many authoritative books and articles.

In many articles and textbooks, trees belonging to the genus *Ginkgo* are often referred to erroneously as 'living fossils' because fossilised ancestors of the genus have been found in rocks dating from the late Permian, while closely related species have even been recorded from the Devonian and Lower Carboniferous strata. Why this genus has survived virtually unchanged, in the morphological sense, for such a long period of time is not understood, but a theory put forward by R. T. Major in 1967 suggests two reasons for their extended life span.
Firstly, the long time interval from one generation to the next (they reproduce up to an age of 1000 years) precludes frequent changes in their genetic make-up, and secondly, the presence of antifungal, antibacterial and insecticidal chemicals in the plant make them highly resistant to microbial and insect attack.

More recent support for the argument that resistance to insect attack may be a factor in explaining the genus 'longevity was provided by Wheeler (1975), who carried out an extensive study of the insect associates of *Ginkgo biloba* in Pennsylvania in the U.S.A., and who concluded that *Ginkgo* can be characterised as a tree species "most immune to insect attack".
While this conclusion may be, in some ways, understandable, as the trees in question were introduced species into a new environment and thus would not have had time to develop close associations with an insect flora, Wheeler makes the valuable observation, based on the work of Hase (1955) that even in its natural environment in Eastern Asia *Ginkgo* has evolved no intimate insect/host relationship and "Perhaps its relative immunity to insect attack has aided survival..."

Apart of being a tall and handsome tree, *Ginkgo* also produces edible nuts which are eaten as a delicacy in various countries in Asia. This paper examines the history, growth characteristics and economic value of this tree and argues for its wider use both as a stately tree of 'eye-striking' beauty and as a potential nut producer.

Historical Background

The first reference to *Ginkgo* in the western world occurred in 1712 when an employee of the Dutch East Asia Co, Englebrecht Kaempfer, published an account of his travels in Japan, where he used his considerable talents as a naturalist to explore the Island community in detail and observed, growing in the grounds in various regions, the remarkable tree we now know as *Ginkgo*. In 1712 he published his 'Amoenitates exoticae' in which he describes for the first time *Ginkgo* which he referred to as "Arbor nucifera folio Adiantino", which describes both the nut-bearing quality of the plant and a reference to its leaves shaped as the maidenhair fern.

Hadfield (1978) gives a short but authoritative account of some less known features of this tree, based on personal correspondence between himself and an Edward Cahen. He also referred to a book "The Origin and Cultivation of Shade and Ornamental Trees" by Hui Lin Li, a scientist and taxonomist, published in 1963.
The origin of the epithet is confusing and Chinese epithets for the tree are Yin-bsing 'silver apricot' or 'silver almond' or even *Ya-chueh*, 'duck food', and *Pai-kuo* 'white fruit' in which the epithets 'silver' and 'white' refer to the colour of the nut. The Japanese ideograms are written as Icho, Ginnan and Ginkyo and it is from this latter epithet that we have accepted the modem term '*Ginkgo*' (first referred to in Hadfield) in 1712 from a misprint of 'ginkjo' (i.e. *Ginkgo*) (Wedemeyer 1965).

Varieties and Cultivars

Despite being a monospecific genus, *Ginkgo biloba* exists in many different forms and cultivars have been propagated in the western world, primarily for shape, while the Chinese have listed and have propagated cultivars specifically for their fruit characteristics.

From descriptions found in the early literature, *Ginkgo biloba* is a tall, somewhat columnar tree about 30 metres tall with considerable girth. St. Barbe-Baker (1952) mentions a present day tree from Kialing in Szechuan province in China, as being 100 ft high with a girth of 24 feet, while a similar tree in Japan has a girth in excess of 30 feet. In England specimen trees at Melbury, Longleat and Sherborne are 90 feet tall but with much smaller girths, though trees with larger girths can be found in Germany and Italy. Botanical descriptions of *Ginkgo biloba* can be found in many floras both from Asia and from the western world, and they all provide identical basic features of the tree. The description given here is a synthesis of notes taken from various sources.

The tree is deciduous with a trunk attaining 18-20 feet in girth and a height of up to 100 ft. The general shape of the tree is pyramidal and sparsely branched when young, becoming more spreading on maturity. The bark is grey and in older trees, becomes deeply furrowed. The branches are irregularly whorled and bear branchlets which themselves bear short spur shoots bearing clusters of leaves. Leaf stalks are up to 3 inches long and the blades are fan-shaped and 2-3 inches across. The leaves are light-green when young, becoming golden-yellow in the autumn. The leaf blades are divided into 2 lobes with numerous branching parallel veins.

The trees are dioecious and male flowers appear as pendulous catkins developed from short shoots. Female flowers also arise from short shoots in pairs or threes, each bearing a stalked, naked ovule with a basal, collar-like rim. The seeds have a yellow, fleshy coat inside which is a woody shell enclosing the edible kernel. On falling to the ground the outer, fleshy covering of the seed decays and emits the disagreeable odour of butyric acid. The decaying pulp also contains a skin irritant producing an effect similar to that of poison ivy.

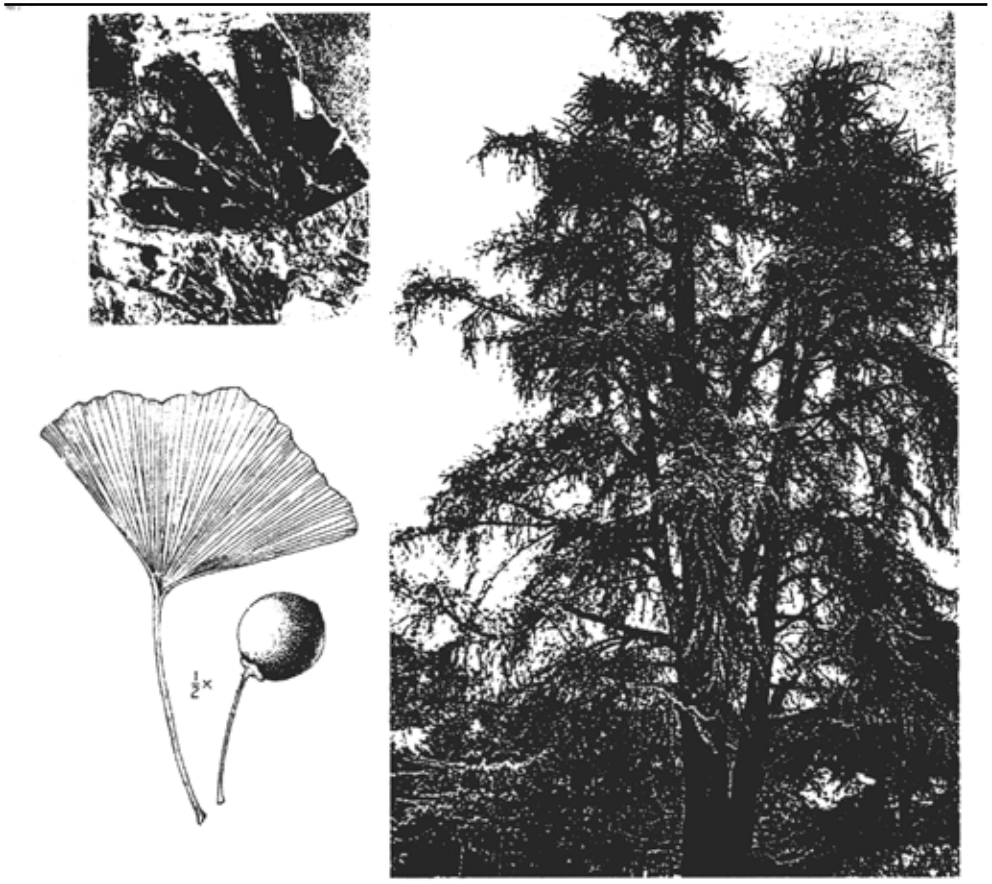
A curious feature of ancient *Ginkgo* trees is the appearance of gnarled, peg-like structures which grow downwards and which, on reaching the soil level, develop true roots and leafy branches. Dallimore and Jackson (1948) describe trees that bear growths attaining a length of 12-16 ft and 1 ft in diameter; these eventually develop into new trees.

It is most unlikely that *Ginkgo* trees exist anywhere in the world in the wild state though some authorities have suggested that an area of some ten square miles near Changhua Hsien in the Chekiang province of China, where the trees appear to have grown and propagated spontaneously for some time, may represent the only known natural stand. However, it cannot be resolved whether they are the remains of an ancient forest or whether they represent recent 'escapes' from cultivated stock commonly grown around temples. The argument that *Ginkgo* trees have survived as a result of their significance in the Buddhist religion, however, has been refuted by at least one Chinese authority (Li, 1963).

As with other, old-established breeding stock, *Ginkgo* exists in a wide range of cultivars, and a recent survey of both North America and Chinese cultivars has been published by Santamour et al (1983) in which they list all of the known cultivars from the original check list prepared by Maunsell Van Rensselaer - formerly director of the Saratoga Horticultural Foundation - together with cultivars selected for fruit production in the People's Republic of China.

A complete list is not appended here as it is available in the publication cited above, but mention is made of the more common cultivars along with their original describer.
Aurea (Nelson) Beissner - leaves golden yellow in summer.
Aurea - Variegata Seneclauze - large leaves with broad yellow bands.
Autumn Gold Rensselaer - oval, upright crown, staminate.
Fastigiata Henry - columnar tree with erect branches.
Laciniata Carriere - large more deeply cut leaves.
Ohatsuki Ohwi - penduncles of the fruit broad and wing-like.
Pendula Carriere - branches more or less weeping.
Santa Cruz Scanlon - umbrella form, low and spreading.
Saratoga - dense compact habit and a distinct central leader.
Variegata Carriere - leaves variegated with yellow.

The Chinese varieties were first enumerated by Tsen (1935) and descriptions were given in Chinese pictograms. Basically he divided the cultivars into three major groups viz: var. *typica*, var. *huana* and var. *apiculata*. Each group relates to the shape of the fruit, and sub varieties within each cultivar illustrates minor variations in morphology. The three groups in



Images of the *Ginkgo*

1) Fossil *ginkgo* leaf, 150 million years old; 2) Modem Leaf and fruit; 3) Form of mature tree; 4) Fruit and leaf attachment; 5) Leaf, male and female flowers Sources: (1,3) **International Book of Trees** (H. Johnson); (2) **Trees** (USDA Yearbook, 1949); 4) **Tree & Shrub Expert** (D.G. Hessayon); (5) **The Treasury of Botany** (J. Lindley)

the Chinese language are known as 'plumstone' shaped *Ginkgo*; 'finger-citron' shaped *Ginkgo*; and 'house-bell' shaped *Ginkgo*.

The distribution of established cultivars of *Ginkgo biloba* in Europe and the North American continent depends on their vegetative propagation from lateral branches or branch buds, though these cultivars have proved, in the past, to be less than successful in that they continue to develop as branches rather than as upright trees (Santamour et al. 1983). These authors note that until these propagation problems can be successfully resolved "we will not be able to utilize the best germplasm in the species". It is surprising, with such a widespread interest in modern methods of propagation by means of explants and tissue culture, that nurseries interested in the propagation and dissemination of genetically acceptable cultivars have not resorted to this rapidly developing area of biotechnology.

It is even more surprising when one considers that as early as 1982, Kausch & Homer successfully produced callus tissue from dark-grown explants of *G. biloba* on defined solid media under a controlled environment, while later Makino et al. (1985) demonstrated marked cytodifferentiation in callus tissue derived from this species, including the elaboration of vascular modules bearing well-differentiated phloem and xylem tissues.

Pharmacological uses of the tree

The importance of *G. biloba* in ancient Chinese medicine has been recorded in many treatises and a mere perusal of these ancient texts indicates that this plant possesses seemingly miraculous properties. We note, for instance, that extracts of the bark and wood is 'soothing'; 'warms the lungs'; 'reduces flatulence'; and 'soothes asthma'. Furthermore, the extract 'reduces diuresis'; 'strengthens dental enamel'; 'reduces the risk of rabies following dog bites'; and 'prevents dermatological itching'. Finally, the extract is also said to reduce wrinkles in old men!

Like many other universal panaceas *Ginkgo biloba* and its endless string of curative properties was treated with some scepticism by the western world until fairly recent research, employing modem diagnostic techniques, began illustrating some truly remarkable properties of the plant. Amongst the most important of these is undoubtedly the effect of various extracts of the tree on the cerebral functioning of the brain, and numerous publications along these lines have been forthcoming during the last decade or so.

For example, Le Poncin-Lafitte et al. (1980) showed that extracts made from leaves of *G. biloba* increased the blood flow associated with normalisation of cellular energy in rats undergoing experimentally induced cerebral micro-embolism. Later, in 1984 Karcher et al. showed that a similar extract has been used therapeutically to increase peripheral and cerebral blood flow, and experimental animals receiving the extract survived hypobaric hypoxia for a much longer period than control animals. In human patients Vorberg (1985) demonstrated a statistically significant regression of the major symptoms of vertigo, headache, and short-term memory following the oral application of *G. biloba* extract.

More recently, Baitsch (1986) has shown that a commercial preparation of *G. biloba* extract (Rokan) can function as a good alternative to conventional medication in patients suffering from diabetes mellitus and inoperable arterial disease. Numerous publications based on the effect of *G. biloba* extracts on neuro-transmitters in rabbits, rat erythrocyte osmotic lysis, guinea-pig ileum, rabbit aorta contractions etc. are far too numerous to cite, but suffice to say that *G. biloba* extract does have some profound pharmacological effects on mammalian tissue and is the source of widespread and continuing research. Whether trees of *Ginkgo* would constitute a viable commercial crop for the extraction of various drugs remains, at this stage, an open question.

The Germination of *Ginkgo* seeds

Ginkgo trees begin bearing seeds when they are 30-40 years old, and the seeds may be picked either from the ground or directly from the tree (Alexander, 1974). If the seeds are allowed to fall to the ground (usually after the first frosts of the season) a large percentage of the seeds have immature embryos which continue to mature during the next 6-8 weeks (Lee 1956). The soft-coated seeds are stored in a warm place until the fleshy strongly-smelling outer layers can be washed off; this reduces the overall yield of nuts to 25% of the original weight of fleshy fruits. Cleaned, dry seeds can be kept in closed containers at a range of temperatures between 41°F and 70°F (Hatano & Kano, 1952).

The seeds of *Ginkgo* are very different from those of angiosperm seeds which have food reserves in the form of a well-defined endosperm and, possibly, aleurone cells, in that the embryo of *Ginkgo* seeds is surrounded by the female gametophyte which functions as the main region of storage tissue. In addition, most *Ginkgo* seeds possess only partially developed embryos on maturity, and embryogeny continues until the embryo is about 1 cm long, after which no further development occurs. If such seeds are planted in soil, very low germination rates are recorded, eg 32% (Swingle, 1939). However, following stratification very high levels of germination can be achieved - up to 90% under natural conditions (Alexander 1974).

In order to examine the role of dormancy in seed germination in *Ginkgo*, West et al. (1970) investigated the combined action of both cold stratification and gibberellin on mature seeds. They showed that non-stratified seeds remained dormant and eventually decomposed in the potting soil, while seeds that had been stored at 2°C for 1, 2 or 3 months showed germination rates of 90%. Removal of the hard, outer seed coat in non-stratified seeds resulted in only slight enhancement of germination but an exogenous application of gibberellic acid to non-stratified seeds produced levels of germination approaching those of stratified seeds. This apparent relationship between gibberellic acid and the effects of stratification was unequivocally demonstrated when ethyl acetate extracts of stratified seeds were shown to contain approximately 100 times more GA_3 equivalents than non-stratified embryos. West et al. (1970) concluded that while stratification is essential for adequate germination rates in *Ginkgo* seeds, an application of exogenous Ga_3 will largely substitute for stratification to promote germination.

The Nutritive Value of the Seeds

Ginkgo seeds are used extensively in Chinese cooking and they are an important ingredient for stuffings, soups and stews. The outer seed coat is first cracked and removed and the inner, brown, papery layer is sloughed off after the seeds have been soaked in hot water. The seeds can then be added to soups and stews, particularly to pork tripe as in the famous Cantonese dish Pai Kuo Chu Tu T'ang. The seeds are also added to sugary syrups containing either the 'white fungus' (*Sparassis* sp. or *Tremella*) or Chinese dates (*Zizyphus jujuba* Mill). Despite their wide acceptance in culinary dishes, caution is suggested among the indigenous Chinese of Hong Kong, China and Taiwan regarding the excessive consumption of the seeds. This may be due to the naturally present alkaloids present in the seeds - a feature commonly identified in the Chinese community in that pregnant woman are advised to eat the nuts, albeit sparingly, one month prior to birth for ease of delivery during labour.

In recent years the seeds of *Ginkgo biloba* have been the subject of extensive analytical research and workers in a number of Asian countries have examined the seeds with regard to their compositional and nutritive status. For example, the Japanese workers, Urakami, Oka & Han (1976) examined the purified lipid fraction from the nuts and showed that they were composed of 90.6% neutral lipids, 7.5% polar lipids and a very small fraction of glycolipids; the main fatty acids in the triglyceride fraction were oleic acid and linoleic acid while those in the phospholipid fraction were palmitic acid.

Similar results were provided by Chung & Shin (1976), working from Seoul in Korea, who also examined the compositional data of leaves of *Ginkgo* as well as the nuts. Analysis of the glycolipids derived from the albumen fraction of mature nuts by Kameyama and Urakami (1979) showed them to be composed of mainly digalactosyldiglycerides (64.1%) and monogalactosyldiglycerides (31.2%) with the residue composed of a glucose-linked cerebroside (4.7%). Confirmatory data on the lipid composition of *Ginkgo* nuts was provided by Tsuyuki et al. (1979) who analysed the lipid fraction from the albumen fraction of *Ginkgo* seeds. These workers also identified various sterols such as β-sitosterol and stigmasterol.

Cultivation

Little has been recorded in the literature regarding the parameters for growth and cultivation of the *Ginkgo* tree, though Heit (1967) states that seeds should be sown in November (in N. America), preferably in furrows and covered with 2-3 inches of soil and a sawdust mulch. Alexander (1974) quotes one nurseryman's observation that approximately 50% of viable seed produce usable seedlings.

Sources from the Chinese literature indicate that the tree has been widely cultivated since the Sung period but no details of any silvicultural practices are appended to these reports. It is generally said to be able to withstand cold climates, needs a well drained soil, and can grow on both hills and plains. One factor that has recently been reported, and which is an important parameter for successful establishment of the tree, is the presence of vesicular-arbuscular mycorrhizal associations under natural conditions. For example, Fontana (1985) considers natural infection of *Ginkgo* roots to be a common phenomenon and experimental inoculations under controlled conditions with *Glomus epigeum* Daniels et Trappe enhanced the growth of seedlings.

Natural and synthetic associations were morphologically identical and were characterised by an abundance of intracellular hyphae and where intercellular colonisation was rare. Ultrastructural details of the infection of roots by various species of Glomus were provided by Bonefante-Fasolo and Fontana (1985) who showed that while the pattern of fungal colonisation in *Ginkgo* was somewhat different to that found in Angiosperms, the colonisation pattern is host-controlled rather than under the influence of differing species of the symbiont.

Ginkgo biloba in the Antipodes

There is no information in the literature on the commercial growing of *Ginkgo* in either Australia or New Zealand, though both countries have climatic regions that are acceptable to the plant. The tree is very slow growing and is known in a Chinese idiom as the "Grandfather! Son tree" in that the grandfather plants the seeds and the grandson harvests the fruit.

The nuts are commercially exploitable but only on a very small scale. The nuts are, by no means, an important, and certainly not a major, part of the Asian diet. There appears to be a sufficient supply in all countries that have been examined to date and unless the tree, or its constituent chemicals, can be exploited for reasons other than a minor culinary delicacy, it would be difficult to argue for its extensive cultivation. It is however a particularly striking tree and perhaps more use could be made of it in planting schemes and as a specimen tree of outstanding beauty.

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Addresses of Useful Organisations

This list of addresses will be printed each year. Please notify the Editor of any errors or omissions.

Australia

Australian Capital Territory
Forestry Branch, Department of Primary Industry, Banks St., Yarralumla, ACT 2600,

New South Wales
Department of Agriculture, PO Box K220, Haymarket, NSW, 2000.
New South Wales Nut Growers Association, PO Box 289, Goulburn NSW, 2580
Society for Growing Australian Plants, 860 Henry Lawson Drive, Picnic Point, NSW 2213

Northern Territory
Department of Primary Production, PO Box 4160, Darwin, NT, 5794.

Queensland
Australian Macadamia Society, 146 Virginia Ave, Hawthorn, Q. 4171.
Department of Primary Industries, PO Box 46, Brisbane, Q. 4001.
Rare Fruit Council of Australia, PO Box 707, Cairns, Q. 4870.
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Department of Agriculture and Fisheries, 25 Grenfell Street, Adelaide, SA, 5001.
Pistachio Grower's Association Australia, PO Box 34, Paringa, SA 5340.
South Australian Nut and Tree Crops Association, 184 Longwood Rd, Heathfield, SA, 5153
Woods and Forests Department, 135 Waymouth Street, Adelaide, SA, 5000.

Tasmania
Department of Agriculture, GPO Box 192B, Hobart, Tas. 7001.

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CSIRO, Horticultural Research Station, Merbein, Vic. 3505
Department of Agriculture, Scoresby Horticultural Research Station, PO Box 174, Ferntree Gully, Vic. 3156.
Victorian Nut Growers Association, PO Box 69, Wangaratta, Vic. 3677.

Western Australia
Department of Agriculture, 3 Jarrah Road (West), South Perth, WA, 6151.
Department of Conservation & Land Management, 50 Hayman Rd, Como, WA. 6152
Permaculture Association of WA, PO Box 430, Subiaco, WA, 6008.
Western Australian Nut and Tree Crop Association (Inc.), PO Box 565, Subiaco, WA, 6008.

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Society of Ontario Nut Growers, RR1, Niagara-on-the-Lake, Ontario. L0S1J.

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Instituto de Investigaciones Agroopecuarias, Casilla 439/3, Santiago.

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Institute Interamericano de Ciencias Agricolas de la OEA, Turrialba, Costa Rica.

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Food and Agriculture Organisation of the United Nations, Via Terme di Cararalla, 1-00100, Roma.

Korea
Institute of Forest Genetics, Seung Kul Park, Swon, Kyunggi-Do, Korea.

New Zealand
Crop Research Division, DSIR, Private Bag, Christchurch.
Lincoln Agricultural College, Lincoln College, Canterbury.
New Zealand Tree Crops Association, PO Box 1542, Hamilton.

Spain
Spain: Centro De Experimentia Agraria, Apartado 415, REUS, Tarragona.

United Kingdom
Overseas Development Natural Resources Institute, 127 Clerkenwell Rd, London ECIR 5D8.

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Agri-Silviculture Institute, PO Box 4166, Palm Springs, California 2263, USA.
California Macadamia Society, PO Box 1290, Fallbrook, California 92028.
California Rare Fruit Growers, Fullerton Arboretum, California State U., Fullerton, CA 92634.
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Illinois Nut Tree Association, 1498 Urbandale Dr, Florisant, Missouri 63031.
Indiana Nut Growers Association, 9805 E.100 St., Zionsville, Indiana 46077.
International Association for Education, Development, and Distribution of Lesser Known Food Plants and Trees, PO Box 599, Lynwood, California 90262.
International Tree Crops Institute USA Inc., Route 1 Gravel Switch, Kentucky 40328, USA.
International Tree Crops Institute USA Inc., PO Box 1272, Winters, California 96594, USA.
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Nebraska Nut Growers Assn, 207B Miller Hall 8N, University of Nebraska, Lincoln, NE 68583.
North American Fruit Explorers, Route 1, Box 94, Chapin, Illinois 62628.
Northern Nut Growers Association, RR3, Bloomington, Illinois, 61701.
Nut Growers Association of Oregon, Washington, and British Columbia, PO Box 23126, Tigard, Oregon 97223,
Ohio Nut Growers Association, 1807 Lindbergh NE, Massillon, Ohio 44646.
Pennsylvania Nut Growers Association,PO Box 93, Allentown, Pennsylvania 18105.
People of the Trees, 1102 Snyder, Davis, California 95616. USA.
Rare Fruit Council International, 3280 South Miami Avenue, Miami, Florida 33129,
Tree Crops Research Project, 230 East Roberts, Cornell University, Ithaca, New York 14853.
United States Pecan & Field Station, USDA-ARS, PO Box 579, Brownwood, Texas 76801.

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