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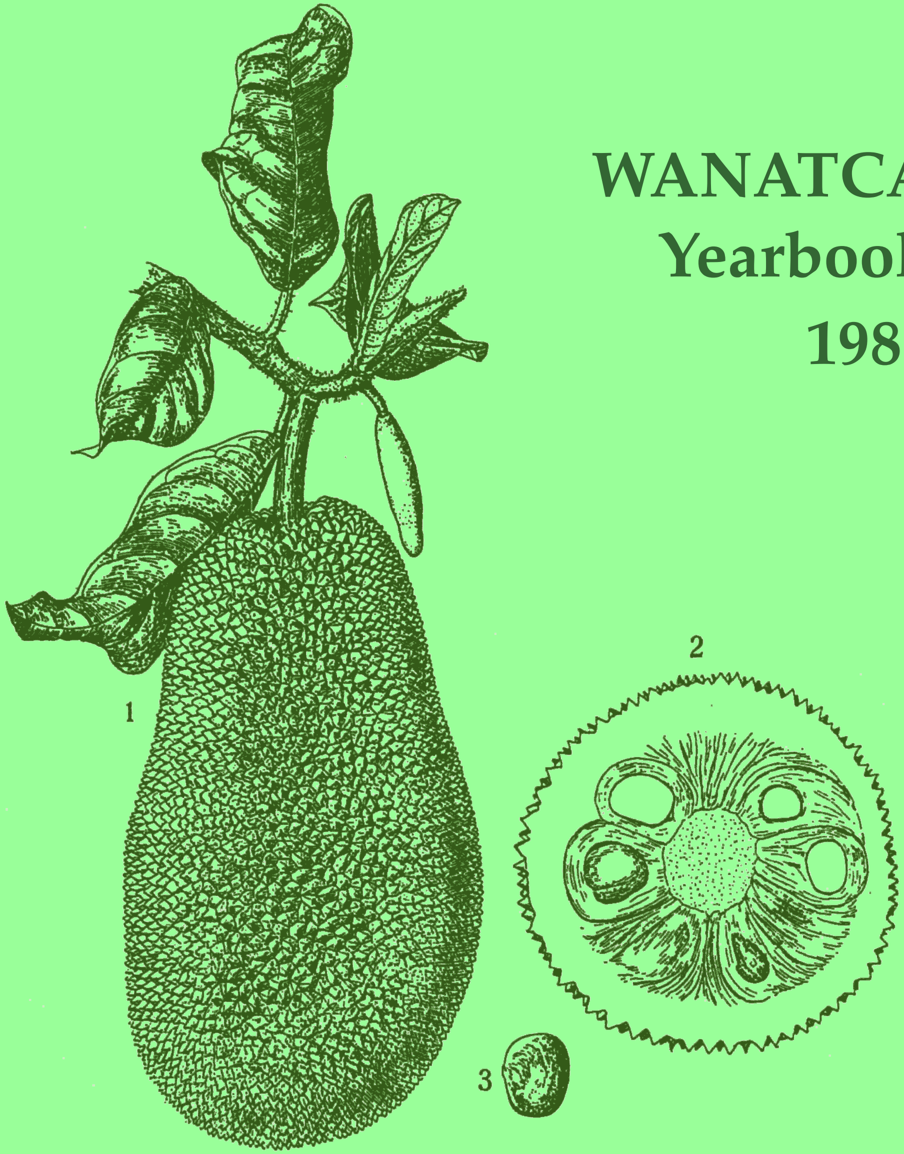

The Chempedak, *Artocarpus champeden*

West Australian Nut and Tree Crop Association (Inc.)

Yearbook 13 • 1988

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West Australian Nut and Tree Crop Association (Inc)

WANATCA Yearbook

Volume 13

1988

West Australian Nut and Tree Crops Association (Inc.)

P0 Box 565, Subiaco, WA 6008

Publications
The Association publishes a quarterly magazine 'Quandong' and the Yearbook. Members receive all publications of the Association as part of their subscription.

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

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CONTENTS

ZONE RECOMMENDATIONS FOR SELECTED TREE CROPS

NUTS

ZONE	1	2	3	4	5	6	7	8	9	10	11	12
Almond	-	-	-	-	-	-	W	R	O	O	W	W
Brazil	R	O	W	-	?	?	-	-	-	-	-	-
Bunya	?	?	?	-	-	O	W	R	R	R	W	-
Cashew	R	R	O	-	?	W	-	-	-	-	-	-
Chestnut	-	-	-	-	-	-	?	O	R	R	W	?
Coconut	R	O	W	-	-	O	-	-	-	-	-	-
Ginkgo	-	-	-	-	-	?	O	R	R	R	O	W
Hazel	-	-	-	-	-	-	-	O	R	R	W	-
Jojoba	-	-	?	O	O	O	R	O	O	O	R	R
Macadamia	R	W	W	W	W	O	O	R	R	F	W	W
Marula	?	O	?	?	?	?	R	O	O	O	R	?
Oak	-	-	-	-	?	?	O	R	R	R	O	O
Parana Pine	?	?	?	-	-	?	W	R	R	R	W	-
Peanut	R	R	R	W	W	W	W	W	W	W	W	W
Pecan	-	-	-	W	W	R	R	R	R	R	W	W
Pistachio	-	-	-	W	?	O	R	O	O	R	R	W
Quandong	O	O	O	O	O	O	R	R	R	R	R	O
Stone Pine	-	-	-	-	?	?	O	R	R	R	R	O
Tung	O	O	O	-	W	O	O	R	R	R	W	O
Walnut	-	-	-	-	-	-	?	O	R	R	W	-

FRUITS

ZONE	1	2	3	4	5	6	7	8	9	10	11	12
Arbutos	-	-	-	-	?	?	O	R	R	R	O	-
Asimina	-	-	-	-	-	-	?	O	R	R	?	-
Blueberry	-	-	-	-	-	-	?	R	R	R	W	-
Casimiroa	?	?	?	-	?	O	O	R	R	R	O	?
Cherimoya	?	O	W	-	?	W	O	R	R	R	?	-
Date	R	R	R	W	W	R	O	O	-	-	R	R
Eugenia	O	O	O	-	?	O	R	R	R	O	?	-
Feijoa	-	-	-	-	-	?	?	R	R	R	W	?
Jujube	O	R	O	O	O	O	O	R	O	R	R	O
Mango	R	R	W	?	W	R	R	R	O	?	?	-
Nashi	-	-	-	-	-	-	?	R	R	R	?	-
Persimmon	?	?	-	-	-	O	O	R	R	R	O	?
Raspberry	-	-	-	-	-	?	?	O	R	R	W	W

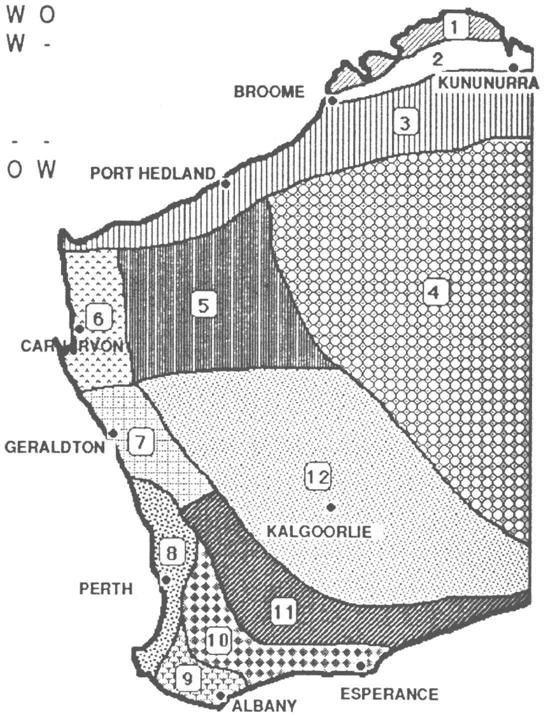
FODDER TREES

Leucaena	R	R	W	?	?	W	R	?	?	-	-	-
Tagasaste	?	?	?	W	W	O	R	R	R	R	O	W

KEY

R= Recommended
O= Should grow
W= Water control needed
F= Frost protection needed
?= Uncertain

GROWING ZONES OF WESTERN AUSTRALIA



PIGS, WIND AND DIRT:

SOME NUT MYSTERIES REVEAL'D

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Dirt

Tom Speer, a pioneer of nut growing in Western Australia, and one of nature's gentlemen, once gave me this advice: "If you want to grow good chestnut trees, David", he said, "throw in some dirt from around a mature chestnut tree when you plant them".

Now that was practical advice, and you may have heard similar advice on the planting of other species too. I would say that we are just starting to open up all the theoretical bases behind simple rules of thumb like that suggested by Tom Speer. We are just beginning to comprehend the incredible ecological complexity of that handful of dirt that went in the hole.

One of the areas here where we thought we had a fair picture was in relation to leguminous plants. Many leguminous plants, including a huge range of current or potential crop trees, are able to fix nitrogen directly from the air. This enables them to grow rapidly and to establish and survive in nutrient-poor conditions, so they include many first-class colonizers of poor or worked-out soils. Our Australian wattles are prime examples.

Nitrogen-fixing in legumes came to peoples attention early because it was very visibly expressed, in the form of nodules growing on roots. These nodules are the homes of the symbiotic bacteria which actually fix nitrogen from the air, that is, produce nitrogen containing compounds which serve directly as plant foods.

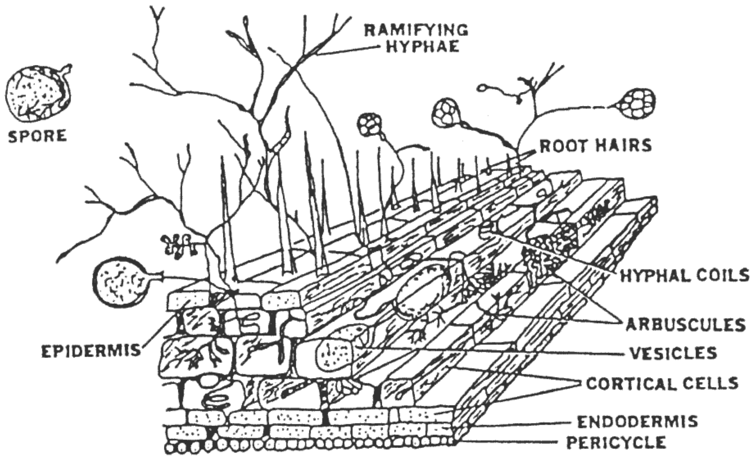
Since the legume story came to light, more and more groups of plants have been found to have nitrogen-fixing processes acting symbiotically with them. One very important group is the **casuarinas** or she-oaks, almost all of which are Australian natives. They are completely unrelated to the legumes, and their nitrogen-fixing symbiotes are quite different to those of legumes as well, being closer to fungi than bacteria. However, it is their nitrogen- fixing ability which has enabled them, also, to function as first-class colonizers and survivors, growing rapidly in nutrition-poor beach sands and in arid wastelands.

Other quite unrelated groups include the **alders**, typically northern-hemisphere temperate trees, and **heaths**, growing and surviving in very acid moorland conditions. Then there are the **cycads**, a primitive southern-hemisphere group sometimes called zamia palms. The symbiote of the cycads is an algae, which grows as a sort of green envelope round the true plant roots.

And very recently we are beginning to find nitrogen fixers which are not even in or on their symbiotic partners, but are only in the soil nearby.

Some of the symbiotes are notable for other things than nitrogen fixing. In particular, symbiosis between plant roots and soil fungi, known as mycorrhizae, is believed to have a major influence on uptake of otherwise-unavailable phosphorus. These mycorrhizae, which can either surround plant rootlets or grow right within them, have been identified with almost all temperate nut-bearing species [Miller, 1986].

The practical use of this sort of knowledge has itself been closely linked with the legumes. Extracts from root nodules and soil around legumes is now available commercially to 'inoculate' legume seed - to add a microbiological component at the time of planting seed. This technique has often been spectacularly successful in establishing legume crops on new ground.



Structure of a fine root which is endomycorrhizal

However, these successes have been mixed. Some inoculants work with many species, others are good only with a single species and do not work with close relatives. Even within a species, a given strain of the inoculant may work with only some of the 'races' or varieties of the species. And in many, many species, including some which are highly-successful fast growing colonizers, it has not been possible to isolate any inoculant at all.

I want to suggest to you that this is one of those cases where 'The more we know, the more we know we don't know'. Our knowledge to date in this area has mostly related to plant nutrition through symbiotic nitrogen-fixers. I have a strong hunch that this is only the tip of the iceberg, and that in the future we will reveal a complex and interlocking soil ecology, round the roots of our tree crops, extending well beyond that of simple nitrogen fixation.

Perhaps others of you who have tried to establish a new tree species may have had a parallel experience to mine. With a new species, I have sometimes found that establishment and growth have been poor, and have not got better even though attempts have been repeated over several years. We could put this down to lack of local knowledge of the conditions needed.

Occasionally, however, I have found that a new species suddenly' comes good'. Suddenly you seem to have' got the knack' of that species, and thereafter you can produce good plants which grow well and fruit successfully. Now the question I want to ask you is this: is this sort of success purely due to increase in local expertise, or is there something in the soil, perhaps something which develops in the soil, which makes it happen?

Proposition 1: "New tree crops need a suitable soil ecology, either introduced or adapted from local, for success" .

To move out now from legume symbiosis to a much wider viewpoint. It seems to me that symbiotic nitrogen fixing, through bacteria, fungi, algae, or whatever, may be just one example of a big range of living, plant growth-assisting mechanisms which have evolved. Some of these will apply to all plants, others only to particular families, genera, species, or even clones, and of these many will only operate under particular conditions - humidity, salinity, swamp decomposition, or whatever.

Then there is the other side of the coin - mechanisms by which plants promote their own good by protecting themselves against attack by animals, including insects, or by suppressing the growth of other plants in competition with them. This does have special local application, for it has been suggested that Australian plants, as a class, have the best plant-protection mechanisms of all the world's flora [O'Brien, 1985]. Of this, more later.

Out of this jumble of thoughts and information, we can perhaps extract one general rule, relating to 'fast-growing trees'. This is, of course, a relative term, one which we apply to trees which thrive and grow more rapidly than competing species, especially under adverse conditions. The proposition here is that most, perhaps all, fast-growing trees possess soil based mechanisms which allow them to do better than 'the rest'.

Proposition 2: "Fast-growing trees have good nitrogen-fixing symbiotes".

We think we know what this advantage is with, say, casuarinas or wattles. With eucalypts and pines, it may be symbiotic root fungi; with the Proteaceae, the macadamia family, the proteoid roots, which may not be true roots at all, are probably important. With others such as Paulownia, we really don't know.

Winds

When you think about it, a great many nut trees are wind-pollinated. This is true of the pecan, hazel, walnut, pistachio, chestnut, jojoba, the nut pines, and others. Why should this be so?

Pollination mechanisms are another complex area where we are just beginning to work out the whys and wherefores. Accurate observations of the actual processes, many of them amazing and beautiful, have been noted down in the past by keen-eyed naturalists and botanists [Bristow,1978]. But the underlying reasons for these processes being favourable, and thus preserved or enhanced through evolution, have not always been clear.

In the case of the high proportion of nut crops being wind-pollinated, high in comparison to, say, fruits, I will put the proposition that it is a matter of pollen economy. Every ovum in a flower, every potential seed, needs at least one pollen grain to pollinate or fertilize it.

Proposition 3: "Wind pollination in nut crops reflects pollen economy".

Wind pollination is clearly a wasteful way of getting pollen transferred, since the wind will not purposefully move from one flower to another, in contrast to an insect vector. (Incidentally, it is not quite as chancy as you might think, wind-pollinated plants have developed a series of aerodynamic features to direct wind-borne pollen to the right place.)

The word 'nut' is defined many ways, but usually implies a large edible seed of some sort. And this large size is, I believe, tied in with wind pollination. The point is, that a plant which produces a small number of large seeds needs much less pollen to fruit successfully than does one which produces a large number of small seeds.

So I am saying that if you are a plant which produces large seeds, and you are wind-pollinated, you can survive with much less pollen than if you produce small seeds. This is interesting, but of course it begs the question of why you are wind-pollinated at all. There are plenty of nut trees which aren't wind-pollinated, the coconut is a good example, that is one of the largest seeds known.

There is another characteristic which tends to apply to wind-pollinated trees (and it does not apply to wind-pollinated herbs, such as grasses). The trees are often ones which have evolved to grow under 'scattered' conditions - conditions where small groups or individuals are scattered sparsely over a landscape, or strung along a creek bed. These conditions are usually arid ones, not able to support a forest or jungle type of ecology.

Arid conditions, with sparse tree populations, seem also to favour another tree characteristic - self-infertility. If you look at this point for a range of fruit or nut plants, you will find it is true. Moreover, the more arid the conditions, and the more sparse the tree density, the stronger the tendency towards self-infertility.

Proposition 4: "Arid conditions. wind pollination. and self-infertility go hand in hand".

The extreme cases are those of full dioecy, with male and female flowers on separate plants. This is true of jojoba and pistachio, both desert plants. It is also true of the date palm. Then there is the almond, with perfect flowers, but with almost all varieties self-infertile. Chestnuts, hazels, and pecans are more intermediate types which show some self-infertility but not a complete one.

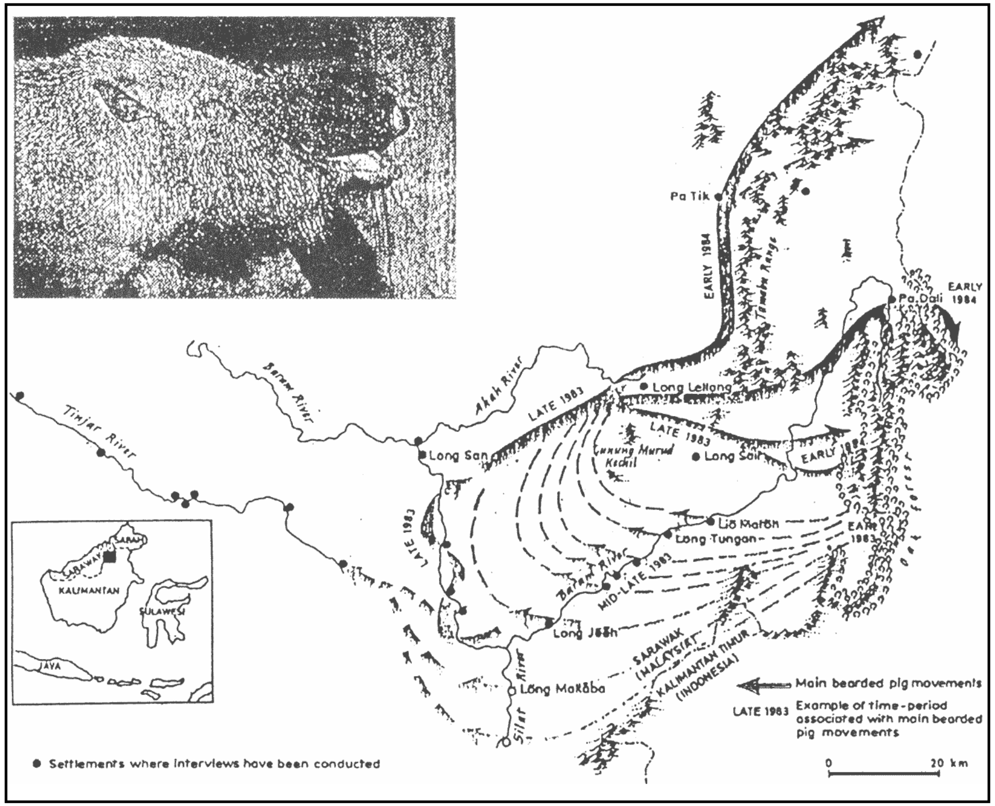
The interesting thing is that these self-infertile trees are at one end of a continuous range. The date palm is famous for its ability to survive in the desert. However, the majority of palms grow in much more humid climates, and most of these are not self-infertile. While the almond is self-infertile, the peach, a very close genetic relative, is not.

This brings us to two points. One is simply the question, is this deduction of any importance to practical tree croppers? We will return to this later. The second is a philosophical question -- why should arid-climate plants tend toward self-infertility? I have not really worked out the answer to this yet, but it must have some evolutionary or survival advantage. I would welcome suggestions on this.

Pigs

A fascinating story about the Bearded Pigs of Borneo appeared in one of the 1985 issues of 'New Scientist' [Caldecott, 1985]. These wild pigs can exist in very large numbers, and are notable for the migrations they make over the north part of the island. Apparently when the conditions are right, a veritable legion of pigs may appear, stream through an area like a conquering army, and pass on towards their next destination, leaving a proportion of their number behind in the villagers' cooking pots.

Interestingly enough, a lot of the information on these pigs has come from records of the Sarawak Education Department, on school meal requirements. When the pigs are running, they provide a self-delivering source of food for feeding the students in the remote bush schools, and their movements show up in the diminished demand for other foods which have to be provided by the authorities.



Migrations of the Bearded Pig, Sus barbatus barbatus, *in Borneo*

What fuels these amazing migrations? The answer is **nuts**. The pigs migrate to vacuum up the falling harvests of two groups of very nutritious nuts. One group consists of the oily Illipe nuts produced by the giant Dipterocarp species such as *Shorea*. In that part of the world, the Dipterocarps are perhaps the most important component of the tropical forests.

The other group consists of tropical oak species. These oaks are not true *Quercus* species, but are mostly *Lithocarpus* species, rather closer to the Chestnuts, and certainly to the tropical chestnuts in the *Castanopsis* family. Like chestnuts and acorns, the nuts are high in starch. Put these together with the oily Illipe nuts, and you arrive at a good balanced diet - for a pig.

Both the Illipe harvests and the Oak harvests run in strong cycles. I am talking here about biological harvests, the fruiting levels produced by the wild trees, rather than human harvesting. An interesting thing is that the cycles for the two groups of nuts, Illipe and Oak, run quite independently, though each cycle does apply over all the species within a group.

Each cycle has a well-defined form, building up to a climax and then falling with a crash. Cycles are often two years apart, but may be three, four, or even one year long.

The time of the Big Bonanza comes when both nut harvest cycles happen to peak simultaneously - then it really is a case of Pigs In Clover. With the right timing of the two cycles, the pig population literally explodes, producing a horde of pork running over the countryside, seeking to expand itself to infinity.

Luckily they never quite reach infinity. There is a Boom, and after that the inevitable Bust. Bad news for the pigs - but what about the nut trees? Who thinks about them?

Look again at this situation from the point of view of the Trees. What do they get out of all this, and why do they do what they do? Why do they save all their energy for these bonanza harvests, instead of producing the same amount each year?

Back once more to the pigs. There they lie, fat and bloated in a sea of surplus nuts, unable to stuff down another morsel. They may know that bad times will come, but they just can't find the room to take another gram on board to see them through the bust. It's physically impossible to cram any more in.

Now we shift to a year later. The only pigs still on the scene are looking a lot thinner. Almost no harvest of nuts this year, and their reserves of fat are long used up. The females are too gaunt to breed and raise young, and the adult population is being continually reduced by predators, animal and human both. So the pig population falls.

But all around them, another population is increasing. From the surplus nuts that the pigs couldn't stuff down, nourished by the fertilizer carpet they left, a whole new generation of nut trees is rising. Now we see the reason for the bonanza harvests. Produce a great big harvest only one year in six, or eight, and you can drop them on a nut -eating population that is too small to eat everything you offer them, so they leave plenty over to grow into new trees. If you dispensed the same amount of nuts each year, the pig population would maintain itself at the level where it would eat every one.

Proposition 5: "Irregular bearing is a predator defense mechanism".

This, then, I suggest, is the basic reason for biennial and irregular bearing in nut and fruit trees. It is a survival mechanism to suppress the predator population by slowly eking out their food and then suddenly hitting them with more than they can manage - killing them softly with a smile.

However, you can see that for this mechanism to work, all the trees must have come to an agreement that this year is THE one, the big one. And so we have another question, which is, how do the trees do it? How does every almond tree in California know that this is an on season, and not a rest year?

The pat answer is that a tree fruits heavily, and then needs to build up its reserves over the next year or so until it is in a physiological condition to support another crop. But if you look at this answer critically, you can see it cannot be true. If it was, pure chance would move a proportion of the trees into the big-harvest condition each year, so that if the trees were on a 3-year cycle, one-third of them would fruit heavily in any given year. Experience tells us that this does not happen. And you see that if it did, the feast -and- famine treatment dealt out to the Borneo pigs just wouldn't happen either.

We are still not certain of the mechanism behind this situation, but it looks as if the answer may be in the pollen. There is evidence that in heavy-fruiting years, some trees produce a sort of 'super-pollen' which greatly raises the productivity of trees which it fertilizes [Brock, 1986].

You can see that with a mechanism like this, and especially with widely-ranging wind pollination, one super-pollen producing tree can 'infect' a huge number of trees around it. The super-pollen would act as a chemical signal, just like the chemical signals passed around in ant nests and bee hives. The whole hive acts something like a single organism, passing messages between its parts by chemical and other signals. In the same way, a complete locality of nut trees which has a simultaneous heavy/light fruiting pattern also has aspects of being a single organism.

Proposition 6: "All trees of a given species in the same area can act in concert".

The Logic Shop

Finally, a brief look at some of the logic behind these situations, and how we, as fruit and nut producers, can use this logic to get better results.

To get the maximum benefit from what we find out from research and observation, we need to take, always, what might be called the 'system' or 'holistic' view. Most of what we do or see tells us WHAT happens, and not WHY. To get more useful answers, we should more often ask 'Why?'.

The overriding answer to this question is always the same - things happen because plants, indeed all living creatures, have evolved to suit that spectrum of conditions and circumstances and events which optimises their benefits and futures. That is a long-winded way of saying that Natural Selection operates.

Plants by their nature are mostly immobile. They have to live as part of a larger community. In the first section of this paper I talked about dirt, and you could see how important to tree growth such things as soil-inoculating bacteria and fungi were. Usually, in setting up a new tree crop, we obtain the seeds and scion wood from a distant source and go from there. You can see that in so doing, we are pulling out just a small fraction of what we need from that distant ecosystem where the trees originated. Often there are things already present locally which will substitute, but not always.

I suggest that there is a fruitful field of investigation in what might be called 'whole-ecology' introduction of tree crops. One aspect of this is to get introduced, into the soil, all those things which the crop plant needs for effective growth. I have wondered if, perhaps, most soils contain micro-organisms which can **adapt** over time to act in symbiosis with a new tree crop, so that when this benign 'infection' of the species occurs, the tree 'takes off'. This might be the explanation for the 'threshold' effect I mentioned earlier.

Proposition 7: "Soil microorganisms may adapt to suit an introduced species".

Perhaps this process could be speeded up by chopping or boiling up parts of a plant to be introduced and mechanically incorporating them into the soil where the trees are to grow. It is even possible that this process occurs naturally through the spread of pollen by wind - pollen is typically very light and can travel a long way. Perhaps it 'prepares the ground' for expansion of the plant species.

Proposition 8: "Mechanical incorporation of shredded parts of a new species in the soil may help it establish".

On the matter of overcoming self-infertility in plants, I suggest a technique is to look for varieties adapted to more humid climates, expecting to find less self-infertility here, and use these for breeding out self-infertility. This has, in fact, already been suggested to eliminate self-infertility in almonds, by crossing and back-crossing with the peach [Janick,1975].

Proposition 9: "Self-infertility may be overcome by breeding with plant relatives from more humid climates".

Lastly, one brief example of overcoming problems created by a plant's evolved protection mechanisms. Leucaena, *Leucaena leucocephala*. has achieved prominence as a tropical fodder tree, but a major problem had to be overcome. Leucaena leaves contain a toxic substance, mimosine, which if ingested in large quantities makes stock listless and 'unthrifty'. You can see that this is, in fact, a subtle plant protection mechanism - again, killing them softly with a smile. The problem was solved, in a *second-order* way, by introducing into the stomachs of stock an organism which could neutralize mimosine - an adaption to beat an adaption.

Another, more temperate, fodder tree is tagasaste. 'Tag' does not have mimosine or similar problems, and its leaves are palatable and nutritious. One might ask the usual question - 'Why?' I think it is because tagasaste evolved on the Canary Islands, in the absence of grazing animals - it had no need to protect itself.

Putting these two together, we could come up with a possible *first-order* solution to the leucaena problem. The genus is native to Central and South America and the Pacific, and may have representatives on some of the scattered islands which produce leaves free of mimosine. A total of one and a half million lupin plants were tested to find just five which were free of a toxic principle, and it was these five which were used to build the sweet-lupin industry. To avoid the need to test 5 million leucaena trees, if we go to situations where presence of the toxin has no advantage, we may well find toxin-free individuals.

The same logic applies to other more obvious protecting mechanisms, such as thorns. To find individuals in a thorny species which lack thorns, look in a place where the thorns would serve no purpose for the plant. And so the list goes on.

If I can finish off with one further generalization, it is this: if there is a problem, a solution may be found by looking somewhere where the problem *does not exist*, and asking, 'Why?'.

Proposition 10: "To solve a problem. look where it does not exist".

References

Bristow, A. (1978): *Sex Life of Plants*. Reference International Publishers. Brock, R. (1986): Washington University Record. 11(15). Dec. 4.

Caldecott, J. (1985): *New Scientist*. 15 August, 32-35.

Miller, D.D. (1986): *Northern Nut Growers Association: Annual Report* 77:81-84.

O'Brien, T.P. (1985) Pp 1-24 in: *Food Potential of Seeds from Australian Native Plants*. ed. G.P. Jones. Deakin University Press.

Janick, J. (ed.) (1975): *Advances in Fruit Breeding*. Purdue University Press.

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THE AUSTRALIAN NUT INDUSTRY AND THE DEVELOPMENT OF CHESTNUTS

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INDUSTRY SIZE

Situation at present

According to the Australian Bureau of Statistics, in Victoria in 1985-86 the area planted with nut trees was 1000ha. The total number of trees planted was about 300 000, including 200 000 trees under 6 years of age.

Approximate production: almond (kernel), 870t; chestnut 250t; hazelnut 20t; walnut 80t, giving a total of 1220t

Situation in 5 years time

Present trends seem to indicate that the expansion in the Victorian nut industry experienced over the last 15 years could slow down and, in respect of almonds, hazelnuts and walnuts, in the medium term the rate of additional plantings may not exceed 10-15 % of the area planted at present. However, according to the results of the DARA (Department of Agriculture and Rural Affairs, Victoria) project *Market development research for chestnuts*, growers intend to plant a further 50 000 trees within the next few years (pers. comm.). Any significant changes in the market outlook would have a bearing on the actual realisation of these trends. Based on current statistical data on tree numbers, total nut production in 1992 is estimated as follows: almond (kernels), 1800t; chestnut, 650t; hazelnut, 80t; and walnut, 120t, giving a total of 2650t.

It is not expected that there would be a significant change in the number of growers, as any increase in numbers could be counterbalanced by the integration of some of the smaller plantings by part-time growers.

Changes in imports

The following table gives the current position:

Current imports of temperate nuts (1985-86)
(Source: Australian Bureau of Statistics)

	In shell		Not in shell	
	t	$'000	t	$'000
almond	106	350	2189	7826
hazelnut	132	258	1451	7482
pistachio	393	1969		
walnut	733	1325	2008	8347
other edible nuts	401	2133		
TOTALS	1765	6035	5648	23655

Allowing an increase in local consumption of 2% per annum, and considering the above projected production estimates and the production in other states, by 1992 Australian almond production should satisfy about three-quarters of local demand. With hazelnuts and walnuts, however, projected increased production will not have a significant effect on import requirements in the medium term.

Implications

The significant increase in almond production will result in the gradual substitution of imports by local product. In the long term the entire demand may be satisfied by local production, provided it can regularly supply the required quality. Currently the almond industry is protected by a tariff of 12%, so the local price may be up to 12% higher than the world price. With increased production, abolition of this tariff is a possibility. With hazelnuts and walnuts there is an opportunity to further increase production to satisfy local demand, although, in the case of walnuts, some of the demand could be taken up by pecans produced in NSW.

MARKETS

There is no data available on nut disposal on the various markets, so the table below on likely changes in disposal is based on estimates.

According to the table, as long as our almond production is viable at world prices -- plus 12% tariff, if applicable -- local produce will substitute for imports. It would be desirable to increase the proportion of nuts of better quality which could demand higher price on the fresh market. In the long term the industry may have to face up to over-production. This would necessitate increased local consumption or development of export outlets.

Disposal of nuts, 1985-86, 1992-93

	Total consumption* t	%	Disposal 1985-86 t	%	Disposal 1992-93 likely t	%	desired t	%
Almond								
Fresh - local	1500	38	470	54	900	50	1500	83
- export	-		-		-		-	
Proc'd - local	2500	62	400	46	900	50	300	17
Chestnut								
Fresh - local	50	100	250	100	300	46	350	54
- export	-		-		50	8	150	23
Proc'd - local	-		-		250	38	100	15
- export	-		-		50	8	50	18
Hazelnut								
Fresh - local	380	25	20	100	40	50	40	50
- export			-		-		20	25
Proc'd - local	1150	75	-		40	50	20	25
Walnut								
Fresh - local	1225	50	80	100	120	100	120	100
- export	-		-		-		-	
Proc'd - local	1225	50	-		-		-	
- export	-		-		-		-	

* Australian production, plus nuts imported in 1985-86 expressed as nut-in-shell equivalent.

For the disposal of the greatly increased chestnut production, two main thrusts will be necessary: intensive promotion on the local market to increase demand for fresh and processed produce, and development of an export market. In this regard freedom of chestnut blight puts Australia in a favourable position.

The relatively small projected increases in hazelnut and walnut production in the medium term should be taken up to a large extent by the fresh market To achieve a greater degree of import substitution, productivity of varieties with types of nuts sought on the market for processing has to be improved.

Local Market - fresh

Projected changes in the use of distribution channels in the medium term are as in the table which follows. According to the table, average percentage for the three categories of nuts being sold at the wholesale market in 1987 is 28. This figure is projected to drop to 20% by 1992. So the wholesale market cannot have a major effect in the formation of the price, rather the price will be determined by the world price, through the price of nuts imported, or, in the case of chestnuts, through local supply and demand trends.

In the case of almonds, hazelnuts and walnuts, an increasing proportion of fresh sales occur in the form of nuts not-in-shell (kernels). So, before selling, the nuts have to be cracked in a packing house and often the kernels are blanched or roasted. This need for extensive post harvest handling and the suitability of the produce for long storage in prepacked form facilitates distribution through supermarkets or retail chains.

Projected Changes in Nut Distribution Channels

	Almonds 1987 %	Almonds 1992 %	Chestnuts 1987 %	Chestnuts 1992 %	Hazelnuts, Walnuts 1987 %	Hazelnuts, Walnuts 1992 %
Wholesale market						
- agents, carriers	20	10	70	50	10	10
- growers	10	10				
Direct sales						
- at farm, or P.Y.O.	-	-	10	10	10	10
- to supermarket or retail chain	70	80	20	40	80	80

At present most imported hazelnuts and walnuts are cracked overseas before importation and sold here by the importing agent. Local nuts are sold in the shell at the farm gate or the wholesale market. With chestnuts, the sales pattern is more similar to that with deciduous tree fruit.

Currently with almonds, hazelnuts, and walnuts, the local produce demands a premium on the fresh market compared with imported nuts. Every effort will have to be made to retain this situation to be able to effectively compete with imports, particularly once the volume of local production approaches total demand, as will be the case with almonds in the medium term.

Export market

No Australian nuts are being exported at present, however, in the case of chestnuts, export markets will have to be developed, because of the projected overproduction in the medium term, which will subsequently become greater. Currently some investigations are in progress to assess the feasibility of export for fresh and processed chestnut into South East Asia and Japan. When developing this market, produce quality is of utmost importance, and, depending on nut size and quality of the varieties planted, rate of packout could have a profound effect on profitability. In addition to market research and development, further work will be needed on varieties, orchard management and cool storage.

There also may be a potential to export fresh chestnuts, hazelnuts and walnuts to other countries in the northern Hemisphere where there is a high consumption of nuts (France, Germany, Scandinavia). Assessment of this potential would need extensive market research.

Processing market

In Australia almonds and hazelnuts have been mainly used for processing. With walnuts a relatively greater proportion has been sold in the shell on the fresh market. More recently there has been increasing interest in the use of fresh, unprocessed food, and this trend also increased the sale of fresh nuts. According to the tables, the volume that is being processed is estimated as between 50 and 75% of the total consumption (including imports). With chestnuts all produce was sold on the fresh market, as local production has not been sufficient to satisfy local demand. However, in European countries chestnuts have been used in everyday cooking and baking over several centuries, and there is a potential to promote the traditional use of processed chestnuts (flour, savoury and sweet dishes, marron) in local and export markets.

Almonds, hazelnuts and walnuts are mainly processed for use in confectionery, chocolates, meal, spread, flavouring and cosmetics. Further development of the processing market in general will help to expand overall demand in the medium term. In the long term, because of the relatively low orchard management costs in established groves and feasibility of mechanical harvesting, processing, for at least part of their crop, should be a viable outlet for most nutgrowers.

SUMMARY

In Australia nuts are among the few primary products where, because of shortfalls in production, significant volumes have to be imported. In 1985-86 the value of imports was $29.7M. So there is opportunity for export substitution through increased production.

Problems and likely solutions

---High development costs and long period to "break even".
• Identification of varieties with market acceptance and high productivity.
• Greater efficiency in production, harvesting and post harvest handling to reduce costs and improve nut quality.

---Lack of infrastructure for post harvest handling. distribution and market development for chestnuts. hazelnuts and walnuts.
• Establishment of packing house(s) with cracking equipment and other handling facilities for hazelnuts and walnuts.

---Projected oversupply in chestnuts.
• Continuation of research in post harvest handling and cool storage (to extend market availability).

• Implementation of the recommendations of the DARA market development research report.
• Development of export markets in a co-ordinated effort, in addition to work done at present by some organisations.

---General lack of awareness in nutritional value of nuts.
• Promotion of fresh and processed nuts through education and market development

List of proposed projects

In order to overcome the above problems, the following projects are suggested to be undertaken, with inputs from DARA and other Government and/or private organisations and industry, as appropriate:

	Chestnut	Hazelnut	Walnut
To reduce costs and improve productivity:			
Assessment of local and imported varieties	*	*	*
Selection of non-suckering strains for rootstocks		+	
Assessment of pollinizers		*	
Effect of pollen on nut development	+		
Determination of pollinizer density		*	
Assessment of growth regulators	*		*
Develop training, pruning methods	+	+	+
Determination of irrigation needs	+	+	+
Testing leaf analysis standards	+	+	*
Prevention, control of Phytophthora infection	*		
Effect of tree density on productivity	+	+	*
Assessment of mechanical harvesting equipment	+	+	+
To provide post harvest handling and distribution:			
Assessment of handling and packing methods	+	+	+
Control of mould infection in storage	*		
Develop cracking and sorting equipment	+	+	+
Develop national quality standards	*	*	*
To organise market development and promotion			
Develop infrastructure for promotion and distribution on local market	+	*	*
Conduct export market research and develop infrastructure for reliable supply	*		
Develop and promote new products	+	+	

* High priority + Lower priority

[Based on a paper delivered at ACOTANC-88. Lismore, NSW, August 1988].

WALNUT AND PERSIMMON PRODUCTION IN CHINA

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I first met Chinese horticulturists in January 1985 at a fruit tree pruning demonstration in Hondo, Texas. A group of visiting Chinese agricultural specialists, including horticulturists, foresters and agronomists, were visiting from the Beijing Academy of Agricultural Sciences. I didn't know then, but these contacts would lead me to an enjoyable and informative trip to one of the oldest countries in the world. The scientists were guided by Dr and Mrs Alfred Cheng of San Antonio.

One of the visitors, Shaun Ming Daun, was a childhood friend of Dr and Mrs Cheng in China. Also attending was Mr Tao Tie Nan, Director of the Walnut Experiment Station of Men Tou Gou District of Beijing Municipality, with whom I had initiated a plant materials exchange. I provided him with English walnut scions and seeds of Texas walnut (*Juglans microcarpa*) for trial in China. Texas walnut is the principal rootstock used for trials of non-native walnuts in Texas. Mr Tao invited me to visit his experiment station in China. I visited him there the following year.

In June 1986, Mr Sterling Evans, former Chairman of the Texas A&M University Board of Regents, offered financial support for me to travel to China to study horticultural production methods and to select promising fruit and nut varieties for importation into Texas. I gladly accepted. I requested help from Dr and Mrs Cheng to plan an itinerary for me. Mrs Cheng forwarded my request to her friend Mrs Shawn Ming Daun in Beijing, who made arrangements with Chinese officials for my visa and travel in China.

I left San Antonio on September 29 and arrived in Beijing on October 1, where I was greeted by my guide and interpreter for Beijing Municipality, Mrs Shaun Ming Daun. My travel in China included visits to horticultural experiment stations, orchards, and vineyards in the Beijing Municipality, Shandong Province, Shanxi Province, and Shaanxi Province.

Beijing Municipality

On October 2, I visited the Beijing Walnut Experiment Station in the Men Tou Gou District of Beijing Municipality, where I discussed walnut culture with the Director (Mr Tao Tie Nan, who had attended my demonstration in Hondo, Texas), and his staff of 14 scientists and technicians.

Their station produces many thousands of grafted improved English walnut trees for distribution in the region. Most of the trees are bench-grafted and then planted in the nursery row. I requested scion wood from two outstanding walnut varieties. One was a terminal bearer named 'Crystal Fragrance' with a kernel percentage of 69%, and the other a numbered variety that is a lateral bearer with a kernel percentage of 65%. Mr Tao showed me seedlings of *Juglans microcarpa*, which he grew from seeds, and a walnut cultivar of the S-2 variety from scionwood I gave him in Texas. Both were growing well in the nursery. This station also works with apples, pears, and jujube.

The Nan Kou State fruit and Dairy farm was my next stop. The Director, Mr Pan Bing Rong, had attended my demonstration in Texas. Mr Pan conducted me on a tour of his farm which included a visit to the apple orchards containing Red and Golden Delicious varieties, spaced 7.6 x 7.6m, that average one tonne of fruit per tree. On this day, my guides also took me on a tour of the largest city square in the world at Beijing. Thousands of visitors come to view the many monuments and magnificent floral displays in the square. That evening a Polish bee specialist and I were the honoured guests at a banquet in a famous old restaurant in Bei Hae Park given by Mrs Chin Hang, Director of the Beijing Academy of Agricultural Sciences.

On October 4, I met Mrs Li Gang-Li, a horticulturist with the Department of Horticulture, Beijing Agricultural University. She accompanied me to the other provinces in China and served as my interpreter. On this day, Mrs Li, Mrs Shaun, and two horticulturists of the Pomology Institute in Beijing and I visited persimmon, hawthorn, peach and jujube orchards and native walnut groves in Pin Gu County. The largest orchards were of persimmons, which sometimes covered entire valleys. All persimmon varieties (*Diospyros kaki*) were grafted onto seedlings (*Diospyros lotus*) and the other fruit trees were all grafted cultivars. The walnuts grow as single trees, along the edges of fields and in small clumps, and were all seedling trees.

Shandong Province

We travelled by train to Jinan in Shandong Province. We were met by Mr Song Ji-Sheng, a staff member in charge of foreign affairs, and his driver. We accompanied them to Tai'an where we met Mr Li Zhensan, pomologist and director of the Fruit Science Institute of Shandong, and his staff. Upon the invitation of Mr Li, I gave a slide presentation on pecans, walnuts and high density apple production in Texas. The scientists asked many questions about uses of native Texas walnuts, as a rootstock to adapt English walnut (*Juglans regia*) to high pH sites and our use of sulphur to modify soil alkalinity so that dwarf apple rootstocks grow satisfactorily. I distributed samples of Wichita pecans to the assembled scientists, who expressed great interest in growing pecans in their province.

The walnut specialists at this station developed 10 walnut varieties which they plant in the new high density, 3 x 4 m trial orchards they established in cooperation with farming villages in the region. The varieties are resistant to anthracnose and bacterial blight and are precocious, lateral bearers with high kernel percentage. Average yield of these flood irrigated orchards is 2250 kg/ha in the 5th leaf (the oldest of the high density orchards). They plan to remove half the trees at the beginning of the 8th growing season. They I1se the wood of trees thinned from the orchard for mushroom culture. We visited three of these high density orchards. We also visited a walnut orchard near the foot of Mt Tai which is used for the production of scionwood.

On the morning of October 7, we toured an area where persimmons are grown on the mountainsides. Below, in the valley, grain and vegetables are produced. There are many square miles of continuous persimmon orchards in this area. Vast quantities of persimmons were being dried on the tops of buildings, on concrete slabs or packed soils. The persimmon specialists explained that the varieties ripen at different times and so there is fresh fruit from early September through November.

That afternoon we travelled by auto to the Confucius Temple and tomb. Early on October 8 we motored back to Tai' an then ascended Mt. Tai, one of the five highest mountains in China, by car and by cable car. Then we hiked to the summit, 1540m above the Valley. According to my Chinese companion, this is the mountain that Confucius had climbed (he walked all the way). He recommended that others would benefit if they did the same. That evening we drove to Jinan and boarded a train to Taiyuan in Shanxi Province.

Shanxi Province

My interpreter, Mrs Li, and I arrived in Taiyuan on October 9, where we were met by Hao Tuo Lan, Director of the Foreign Affairs Office. Then we met with Liu Xueqin, Deputy Director of the Forest Research Institute of the Shanxi Province. Mr Liu gave us the following statistics on walnut production within the province. There is a total of 22 000 000 trees, of which 9000 000 are bearing trees which produce 20 000 000 kg of nuts per year, an average of 2.2 kg per tree. Most production is from seedling and native trees. They expect a considerable increase in nut quality and quantity when newly planted improved varieties become productive. According to Mr Liu, late frosts are the greatest hazard to walnut production in the province. The latest frost was on April 18 in 1986.

Mr Liu gave me a copy of his research report on removal of catkins to increase nut production. Catkins were removed in March from the majority of walnut trees in the orchard (some strategically placed trees with catkins were left to ensure adequate pollination). This system increased nut yield 45% above production on trees where catkins are allowed to develop. Catkin removal is performed by hand labour for about 10 cents per tree. I suggested that he might want to experiment further with some work I had done with walnuts in Uvalde, Texas, where I grafted single limbs of trees in late June with catkin bearing dormant scions after next years male flower initials appeared. This resulted in next years male flowers being stimulated to develop all over the tree when those on the scion began to bloom. My experience did not show adverse effects on nut production the following year because male flowers from surrounding trees provided pollination. Mr Liu plans to try this method because it requires less labour to graft one limb than to climb all over the tree removing catkins. That evening we toured persimmon orchards and visited a temple in another town.

The next morning we visited the Pomology Institute of Shanxi Province near Taigu where an intensive breeding program for apple rootstock is being conducted. They developed rootstocks that thrive on high pH soils (to a pH of 8.3). This was interesting since Texas soils also have high pH and no adapted apple rootstock. The Chinese scientists developed rootstock from their native apples (*Malus baccata*) that modify tree growth. They had trees from extreme dwarf to standard sized trees that are adapted to high pH soils.

That afternoon we visited the walnut breeding farm in County chi where scientists have developed four outstanding walnut varieties from an initial planting of 3 000 seedlings of seeds collected in Sinking Province near the Soviet border. The varieties are large, thin shelled, and lateral bearing, with kernel percentages of 68, 67, 67, and 56%.

This station also experiments with table grapes. We tasted a very large green seedless grape from Bulgaria and a large pink seeded Chinese grape called Tiger Eye. The latter is one of the tastiest grapes that I've eaten.

We also visited with Qi Shou Chun, Deputy Director and Associate Professor. He is chief of post harvest storage research at Taigu. We toured underground fruit storage facilities he developed for apples, pecans, jujubes, and hawthorns. According to Mr Qi, this storage method is more efficient and economical than any controlled atmosphere fruit storage above ground.

We went shopping and sightseeing in the city of Taiyuan. On the evening of October 11 we boarded the train for Xi'an in Shaanxi Province.

Shaanxi Province

As we travelled south along the Yellow River we saw many large orchards of walnuts and persimmons. Orchards of apples, jujube, and pears were less abundant. We arrived in Xi'an on Sunday October 12. We were met by our guide Mr Wang Yi Tang, Foreign Affairs Officer for the Xi'an Forest Bureau.

On Monday morning, Mr Wang and the county Extension Agent took us to visit a farmer who grows persimmons as a part of his farming operation. He: had 40 persimmon trees which produced from 500 to 1000 kg of fruit per tree annually. He sells the surplus beyond family needs for about 3 cents/kg. After transportation costs he received $1000 per year from his orchard. This is one-fourth of his total annual income of $4000 (14 800 yuan Chinese).

We climbed a mountain to visit a forest ranger headquarters where birds are being trained to control insects in a selection of coniferous forests. Birds are kept from migrating by supplementing their food requirements with ground rabbit meat. The rabbits are raised at the station. The birds are released to range over the forest and eat insects for most of the day. They are signalled in the evening by a whistle and return for their ration. The foresters say that they provide control of harmful insects in the area. The ranger's family attends the birds.

Our next stop was a pomegranate orchard of 400 four-year-old trees. The owner made a profit of $4050 on the 1986 crop. During the remainder of the day we visited the site of the famous terra cotta soldiers near Xi'an. The clay soldiers are being excavated by the Chinese government. The soldiers are positioned in parade formation and have deteriorated little since they were buried in front of the Emperor's Palace over 1000 years ago.

On October 14, Mr Wang showed us a 20 year old persimmon orchard where 50 kg per tree are produced each year. We also visited kiwi vineyards in the foothills of the Qin Mountains. Kiwis are indigenous to the area. Australians and New Zealanders collected here and developed their kiwi industries. Chinese scientists now have an intensive selective breeding program with kiwis and continue to find new wild plants in these mountains. Kiwi fruits in China sell for about 24 cents per kg.

We visited a 300 year old chestnut orchard which produced 250 tonnes per year. The Japanese purchase the nuts for about 48 cents/kg. Next we went shopping in Xi'an. On October 15, we met with a group of provincial foresters and horticulturists and the main topic was persimmons. Shaanxi Province is the birthplace of the Chinese persimmon industry and 150 million kg are produced there annually. One county experiment station has 90 persimmon varieties. Much of the persimmon crop is dried. However, the many varying maturity dates among the varieties make it possible for consumers to obtain fresh fruit from September 1 through early November. The varieties vary in size and the largest average 500 g each. Walnut culture is widespread in Shaanxi Province, but the average yield is low.

Later Activities in Beijing Municipality

On October 17, I visited the Forestry and Fruits Research Institute of Beijing Agricultural Service Academy. Mrs Shan Ming Duan was my guide and interpreter at this meeting with Mrs Wang Yi-Lian, Director and her staff of scientists. Mr Li Yiyuan conducted a tour of the many interesting projects under study: 1) the removal of husks from walnuts by ethrel treatment (my friend Dr. Alfred Cheng in San Antonio is translating this publication from Chinese to English for me); 2) high density pear orchards on dwarfing stocks of *Pyrus botufolia*, with an average production of 75 t/ha for 5 years, with the first crop being produced the third year; 3) walnut breeding rootstock and variety evaluation; and 4) peach apple and hawthorn breeding and development programs.

We visited with Mrs Xi Sheng Ke, associate professor (Department of Tree Crops, the Institute of Forestry , The Chinese Academy of Forestry , Wan Shon Shan, Beijing) on Monday, October 20. We toured the walnut experiment station where she is conducting many of her walnut trials and experiments. She explained that her research objectives included development of thin shelled high quality walnuts on lateral bearing trees that are insect and disease resistant.

We visited two farm families on October 21. In each family the head of the family told us that their income had increased under the present capitalistic system. A farmer can rent the land for life and even pass it on to his children. This was an improvement over the old system, where he worked in a communal farm where everyone was paid a salary. Both farmers with whom I talked had increased their income over 630% under the present system.

I was invited by Mrs Wang Yi-Lian, Director of Forestry and Fruits Research Institute of Beijing Agriculture Science Academy, to give a lecture on my work in Texas. On October 23, I gave a colour slide presentation to a rather large group including Mrs Wang's staff scientists and visiting scientists from other institutions and universities. Mrs Li Gang-Li was my interpreter on this occasion. The program included work on pecans, both planted and native orchards; walnuts, and high density apples. There were many questions from the audience regarding varieties, rootstocks, spacing, yields, marketing, irrigation and fertilization. Mrs Wang distributed samples of Wichita pecans that I had given her to the audience and it was apparent that they liked them.

Summary

Eighty percent of the Chinese people are involved in agriculture. The government and universities are making great efforts to assist farmers and improve agriculture. Chinese farmers can lease their land for life and even pass lease privileges to their children. They sell produce at the best price and keep what they earn. China has increased production in the last 5 years and now exports grains and fibre that previously were imported. One Chinese scientist said that many believe farmers are getting rich. He added, "If this is the case, it is good, because if our farmers are rich we are all rich."

Chinese horticulturists and foresters have made great progress toward developing high quality walnuts. They are early bearing, high quality, highly productive and disease resistant. It is likely that soon they will produce more walnuts than any other country. They are now the world's largest persimmon producer. Research work on other fruits and nuts is equally intensive.

The Chinese foresters and horticulturists in all the experiment stations seemed eager to exchange plant materials and technology with their American counterparts. They all had to obtain government approval before exporting plant materials.

I was impressed by the agricultural research and productive development in China. I was awed by the temples, clay soldiers, Great Wall, and other national treasures. I enjoyed the beautiful countryside, the cities, and the culture. I have many pleasant memories and I will always remember the friendly and gracious people that I met in China. I hope that they will remember me and that my trip was of mutual benefit to our countries.

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ARTOCARPUS: BREADFRUITS AND JACKFRUITS

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INTRODUCTION

The genus *Artocarpus* belongs to the large family MORACEAE which includes, amongst many other genera, *Ficus* (the Figs) and *Morus* (the Mulberry). The name *Artocarpus* is derived from the Greek words artos meaning 'bread' and karpos meaning 'fruits' and the name was coined at the end of the seventeenth century to describe the bread-like qualities of the fruit after baking.

A number of species exist, some of which are useful for their latex while two species, *A. altilis* (syns. *A. communis*; *A. incisa*) - the Breadfruit tree- and *A. heterophyllus* (syns. *A. integra* and *A. integrifolia*) - the Jackfruit tree - are the most important and are the subject of this article. Some confusion has resulted in some popular layman's literature by reference to the 'African Breadfruit tree', but this belongs to the species *Treculia africana*, also belonging to the Moraceae. Regrettably, in many publications the nutritive values of various breadfruits are given without due reference to the exact genus under discussion.

Both Breadfruits and Jackfruits are tropical plants and the former, it is thought, is a native of the Malayan Archipelago, where it has been cultivated since antiquity (Popenoe, 1920). Some authorities however (e.g. Burkill, 1966) have argued that the genus is Polynesian in origin and was transported to the West Indies first, abortively, in 1789 and later, successfully, in 1793 but before that had already passed westward into Malaysia.

Crawford (1802) suggests that the Javanese obtained it via the Moluccas when trading for spices and it was certainly in Penang in 1802 (Hunter, see Burkill, 1966) and in Malacca in 1836 (Low, 1836). The Jackfruit on the other hand is thought to be of Indian origin (Burkill, 1966) and both Theophrastus and Pliny record the fruit in their writings; Pliny describes the fruit "where of the Indian sages and Philosophers do ordinarily live" (Popenoe, 1920).

In this paper we look at the history, biology and economic value of these two important species of *Artocarpus* and indicate their value as fruit and nut trees of great potential in the Asia/Pacific region and attempt to discuss their possible relevance to Australasia.

The Species

The genus *Artocarpus* was originally assigned to the family Urticaceae, and a number of authorities retain its position there (vide Burkill 1966). However the genus, along with *Ficus*, was transferred to the Moraceae, based firstly on the fact that the Urticaceae are herbaceous while the Moraceae are trees, and secondly on the fact that genera in the Urticaceae have erect ovules while those of the Moraceae are pendulous (Corner, 1962). The genus has a number of species which are described below, though much synonymy has crept into the taxonomy and most modern authorities now accept only a very few valid species.

Artocarpus J.R. & G. Forst is a monoecious genus of trees with about 50 described species in S. E. Asia and Polynesia. The petiolate leaves are spirally arranged and are either simple or pinnate. Buds are clothed in large stipules which drop off. The flowers, either male or female, are very small, numerous and sessile on a fleshy rachis forming a dense inflorescence. Male inflorescences are borne singly, either in leaf axils or directly on the trunk, and have hairy perianth lobes and one stamen. The female inflorescence is also borne either in a leaf axil or on the trunk and is often prickly. Flowers have an entire or bifid stigma, a single ovary and a long style. Compound fruits (syncarps) are developed from enlarged flower heads, and the seeds are large with no endosperm and are surrounded by fleshly material derived from the calyx. The seeds are separated one from another by undeveloped female flowers. The tree has a thick, white latex in all parts.

Despite the availability of descriptions of about 50 species in the literature it is obvious that much synonymy has occurred and, for instance, Backer and van Den Brink (1965) in their Flora of Java list only 7 substantiated species while Burkill (1966) lists 16 for Malaya. In this article only the more economically important species are described along with their synonyms.

1. The Breadfruit

Artocarpus altilis (park) Fosberg. (syns: *A. communis* J .R. & G. Forst; *A. incisa* (Thunb.) LJ. The Breadfruit Tree.

A tall, (12-18 m) straight, spreading tree, all parts containing a thick, white viscid latex. Leaves are large, 30-100 cm long by 25-65 cm wide, 3-7 lobed, hairy on the nerves on both surfaces though sometimes glabrous above. Stipules, 16-20 cm long." Male inflorescence is cylindric on a peduncle 3-6 cm long. The female inflorescence has a conical apex and the stigma has two branches; the syncarp (fruit) is globose or ellipsoid, green, 20-30 cm in diameter with prickles. Seeds may be present or absent in some varieties. The seeded form grows wild in the Pacific region and propagates itself freely.

The seedless varieties have been selected for cultivation and have a firmer and less sweet flesh. The flesh of the seeded varieties is not much eaten but the seeds can be fried, roasted or boiled and are referred to as "bread-nuts". The timber from the tree is yellow and resistant to white ants (Burkill, 1966). The latex can be used for caulking boats.

2. The Wild Breadfruit
Artocarpus elastica Reinw. ex Bl. (syns: *A. kunstleri* Hook. f; *A. blumei* Trec).

A large tree reaching 45 m, found throughout Malaysia. Leaves are simple, elliptic, stiff and leathery 20-40 cm long by 15-20 cm wide, with rough hairs on both upper and lower surfaces. Male inflorescences are 5-15 cm x 1-4 cm in size, finger-like, hanging from a 4-6 cm stalk. Female inflorescences are globose, the syncarp held on a stalk 8 cm long, and green at first turning to cream or dark yellow when mature. Fruits shaggy or woolly with soft recurved spines; seeds have a white pulp (aril) with a nauseous, rancid smell when ripe. The bark is easily peeled off and is used as clothing by jungle tribes in Malaya. The timber is yellow and susceptible to insect attack. The latex is very sticky and is used for catching birds. The fruits are normally eaten by monkeys and squirrels but are also eaten by children, being very sickly sweet. The seeds can be roasted and they contain an oil but only in very small quantities.

3. The Jackfruit
Artocarpus heterophyllus Lmk. (syns. *A. integra* Merr.; *A. integrifolia* Linn f.) - the Jack fruit (syn. Jak).

The tree ranges from 9-23 m high with a straight stem and a dense irregular crown. The leaves measure 10-25 cm by 5-10 cm and are glossy and evergreen; the petiole is 1-3 cm long and the stipules are 3-8 cm long. The inflorescences are axillary; the male flower heads are oblong, 4-8 cm long and dark green and the peduncle is 2- 5 cm long. Female inflorescences are similar in size. Syncarps (fruit) are ellipsoid, golden-yellow, with a strong foetid smell, measuring 20-35 cm by 10-15 cm and bearing sharp, conical warts, borne on a fruit stalk 7-12 cm long on the main trunk. Seeds are surrounded by a waxy-yellow pulp and the seeds are covered in a thick gelatinous jacket.

The pulp of the fruit is eaten either fresh or preserved in syrup. Unripe fruits are used as vegetables or pickled and used as condiments. The rind of the fruit is fed to livestock. The yellow timber yields a yellow dye and the latex is used in bird lime.

4. The Monkey Jack
Artocarpus rigida (syns. *A. echinata* Roxb.; *A. muricata* Hunter) - The Monkey Jak.

A large tree up to 25 m tall; leaves small 5-12 cm long, obovate and hairy on the underside. Inflorescences develop on the leafy twigs. Male flower heads are finger-like, 3-6 cm long and borne on velvety stalks 2-5 cm long. Fruits (syncarps) are small, 5 cm in diameter, oblong, having a velvety surface with distinct hexagonal patterns, suspended on a stalk 2 cm long.

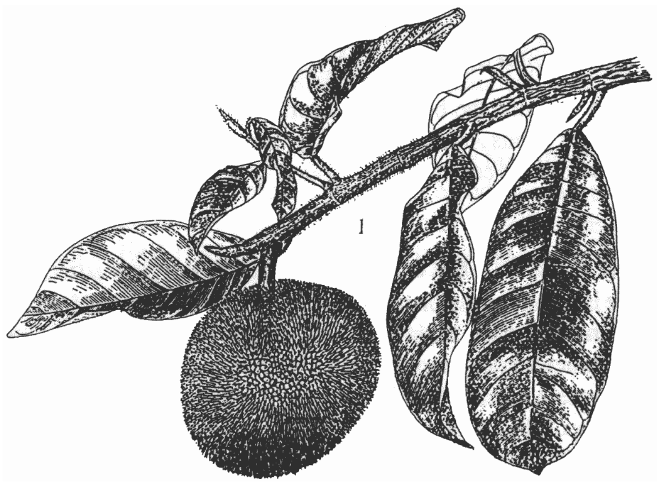
The latex is used for calico weaving when mixed with wax and is also used in sealing wounds to human skin & flesh. The timber is yellow to red-brown in colour and though brittle it does not split on seasoning. The yellow pulp of the fruit is eaten and is very agreeable. It is under-*utilis*ed as a crop plant and shows potential as a fruit tree in tropical regions.

This tree is described from Java (Backer & van Den Brink, 1965) as *A. rotunda* Hoult. Panzer.

5. The Bintawak
Artocarpus anisophyllus Miq. (syn. *A. superba* Becc.)

A very tall tree up to 30 m with a dark, glossy, rounded crown. Leaves are massive and leathery, 30-90 cm long with 8-12 pairs of stalked, alternate leaflets and a terminal leaflet; leaflets of 2 sizes: large leaflets being 20-30 cm long. Inflorescences borne on leafy twigs. Male heads are finger-like; 5-8 cm long on a 5 cm long stalk. Syncarps are massive, oval or rounded, 10-15 cm in diameter, yellowish-olive brown or darker with thick, blunt spines. Fruit stalks 4-8 cm long with the apex sunk into the fruit. Seeds with a thick orange pulp.

The timber is durable and the tree is very distinctive in having alternating large and small leaflets which are deciduous in one piece. Comer (1962) has called the tree the 'Tree of Glory', "in deference to its having crowned itself with such distinction".



The Monkey Jack, *Artocarpus rigida*

6. The Marang
Artocarpus odoratissimus Blanco - The Marang.

A tree native to Borneo and the Philippines, having large fruit with a white, sweet, aromatic flesh which is said to be superior in every way to both the Breadfruit and Jackfruit. The fruits are 15 cm long and have a thick skin densely covered with short, soft, yellowish-green spines. "The rind is thick & fleshy, the flesh white, sweet and juicy, aromatic and of a pleasant flavour; the flesh separates into segments which cling to the central core; each segment contains a whitish seed 1 cm long. When the fruit is ripe, by passing a knife around and through the rind, with a little care the halves may be separated from the flesh leaving this like a bunch of white grapes" (Wester, in Popenoe, 1920). The seeds can be removed and are frequently eaten roasted.

The tree, which grows wild, is of medium height and bears large, dark green leaves which can be either entire or three-lobed; each leaf is 45-65 cm long.
The tree is strictly tropical and Popenoe (1920) suggests it is unlikely to grow in regions

where temperatures fall below 32°C. It prefers a moist atmosphere and abundant rainfall. The fruits ripen in August in the Philippines. Apart from the six species described above, all of which are tropical in distribution, Southern China has a number of native species of *Artocarpus* which have recently been described in *The Flora of Guangdong*. These species are appended here for completeness and interest only; there is no indication that they have any commercially exploitable value.

A. nitidus ssp. *lingnanensis* (Merr.) Jarr. (Syn. *A. lingnanensis* Merr.); *A. styracifolius* Pierre (Syn. *A. bicolor* Merr. & Chun); *A. tonkinensis* A. Chev. ex Gagnep.; *A. hypargyreus* Hance.

Having outlined the botanical description of what appear to be the more important species within the genus *Artocarpus* we can now examine the history, biology and economic status of the two most commonly exploited species, viz: *A. altilis* and *A. heterophyllus*.

THE BREAD-FRUIT TREE, *Artocarpus* *utilis*

There is some confusion regarding the origin of the Breadfruit tree. Some authorities consider it to a native of the Malayan Archipelago (Popenoe, 1920) from where it was carried to the West Indies while others (Burkill, 1966; Purseglove, 1975) consider the tree to have originated in Polynesia. Baum (1903) states that ''The open-boat journeys of the Polynesians in their peopling of the Pacific islands are marvelous from the point of view of seamanship alone.... Probably a hundred species of plants were introduced into Hawaii by the Polynesians, and as a majority of their food-producing plants were propagated by cuttings alone, the difficulty in successfully carrying them across a wide expanse of ocean in open boats is obvious", while Popenoe (1920) suggests that Spanish voyagers who visited the Solomon Islands in the sixteenth century encountered the Breadfruit, as probably did Dutch & Portuguese mariners and explorers. The tree was certainly seen in 1686 by Captain William Dampier in Guam, and this sighting gave the world its first accurate description of the tree and its fruit.

The introduction of the Breadfruit into the New World has been described by several scholars, and perhaps the most concise account is given by Purseglove (1975) in his treatise on Tropical Crops:

''The story of its introduction into the New World is well known. Banks, Cook and other travellers in Polynesia brought back descriptions of the tree from which 'bread itself is gathered as a fruit'. West Indian planters hoped that it would provide a staple diet for their slaves and petitioned H.M. George III to mount an expedition for its collection. The King was graciously pleased to comply with their request. Sir Joseph Banks, who had been to Tahiti on Captain Cook's first voyage, 1768-1771, suggested that Lieutenant William Bligh should be sent to Tahiti to collect breadfruit plants and transfer them to the West Indies. Banks had been made President of the Royal Society in 1778, a position he was to occupy for nearly half a century. The British Government chartered a ship. Banks superintended the whole equipment and named her the *Bounty*. Bligh, who had been on Cook's third voyage, 1776-1780, when he was master of the *Resolution*, had also visited Tahiti. It was on this voyage that Captain Cook was killed in Hawaii. The *Bounty* sailed from Spithead on 23rd December, 1787 and arrived at Tahiti on 26th October, 1788, sailing via the Cape of Good Hope.

Due to the time taken to propagate the breadfruit (a botanist and a gardener were attached to the expedition), Bligh remained on Tahiti until 4th April, 1789, when he sailed with 1,015 breadfruit and other plants in 774 pots, 39 tubs and 24 boxes. Then occurred the famous mutiny of the *Bounty* led by Fletcher Christian near the Friendly Islands on 28th April, after which Bligh and 18 men performed the astonishing feat of crossing the Pacific in a small open boat, landing on Timor on 14th June, 1789, having covered a distance of 3,618 nautical miles. Bligh arrived back in England on 14th March, 1790.

The mutiny created world-wide interest, not only in itself, but also in the breadfruit. Bligh returned to Tahiti in 1792 in the *Providence* and successfully carried breadfruit plants to St. Vincent and Jamaica. The original breadfruit tree planted by Bligh in 1793 still stands in the Botanic Gardens in St. Vincent, and in 1966 H.M. Queen Elizabeth II planted a scion from it nearby.

Breadfruit had already reached eastern Malaysia before the Bligh epic. Breadfruit reached Penang about 1802 and Malacca in 1836. It has now been carried throughout the tropics."

Propagation

As we have seen *A. utilis* produces two distinct varieties of fruit; those with seeds - frequently referred to as 'breadnuts' - and a seedless variety. Naturally, propagation of these two varietal types differs considerably and in this section we discuss some of the methods adopted to develop a new fruit-bearing crop.

Fruits of the seeded variety of Breadfruit have little commercial value as they have little or no edible pulp. The seeds are, however, used to produce rootstocks onto which high-yielding non-seeding varieties can be grafted. The seeds germinate readily, but lose their viability within a few weeks (Purseglove, 1975; Rowe-Dutton, 1976) and must therefore be planted immediately they are removed from the ripe fruit. Despite their being an exclusively tropical tree, Ibarez (1968) observed that breadnuts retained their viability after cold treatment at 4°C for 15 minutes. Further work to establish whether this method of storage prolongs seed viability has not been carried out (Rowe-Dutton, 1976).

The most commonly exploited breadfruit trees are undoubtedly the seedless varieties and a considerable body of research has been carried out to develop suitable methods for the vegetative propagation of these varieties. The methods adopted for this purpose have been reviewed by Rowe-Dutton (1976) in a comprehensive paper produced under the auspices of the F.A.O. and the Commonwealth Bureau of Horticulture. In the conclusions to her paper this author makes the following pertinent points:

"The breadfruit has a high food value and culture of the crop might usefully be extended, provided that seedless varieties of superior quality are selected. Among characters that should be considered in selection is *ease of vegetative propagation*". From this remark it can be safely concluded that propagation is not easy and that continued efforts are needed to establish a simple and reliable method.

Attempts at bud grafting have not been very successful. Rowe-Dutton (1976) reports unsuccessful attempts at shield bud grafts in the Philippines and a 50% success rate when grafts were attempted on root stocks of other species of *Artocarpus* in Java. Some success was reported in India but details of the grafts were not given. These results "do not suggest that anyone has been greatly impressed by the value of grafting for the propagation of breadfruit ...." (Rowe-Dutton, 1976).

The traditional method of propagation has been by means of root suckers but the method is both slow and unreliable, and Rowe-Dutton suggests that heavy losses are incurred during transplanting. She suggests potting up young suckers at an early stage and growing them on. In traditional methods of husbandry in the Pacific Islands and South India the suckers, along with a section of root, are lifted when they are 30-40 cm tall or when the stems have become woody and bear lobed leaves. In Tahiti such suckers are wrapped in banana leaves to reduce water loss. A report from the Philippines (Rivera Lopez et al., 1975) suggests that good size roots can be severed and divided into sections 30 cm long which are placed in sand under intermittent mist. The tops of the developing suckers, bearing 4-5 nodes, are removed and rooted in sand supplemented with 3-indolebutyric acid. Rooted cuttings that have been transplanted into a soil/peat mixture can be planted out six months later.

By far the most reliable method for propagating breadfruit is by means of root cuttings - a method devised as far back as 1913 in the Philippines. Cuttings should be taken at the end of the dry season (Wester, 1920) and placed in coarse sand. The cuttings are placed diagonally in trenches so that the thickest end protrudes, and kept in the shade and sparingly watered. Plants ready for planting can be obtained within 14 months.

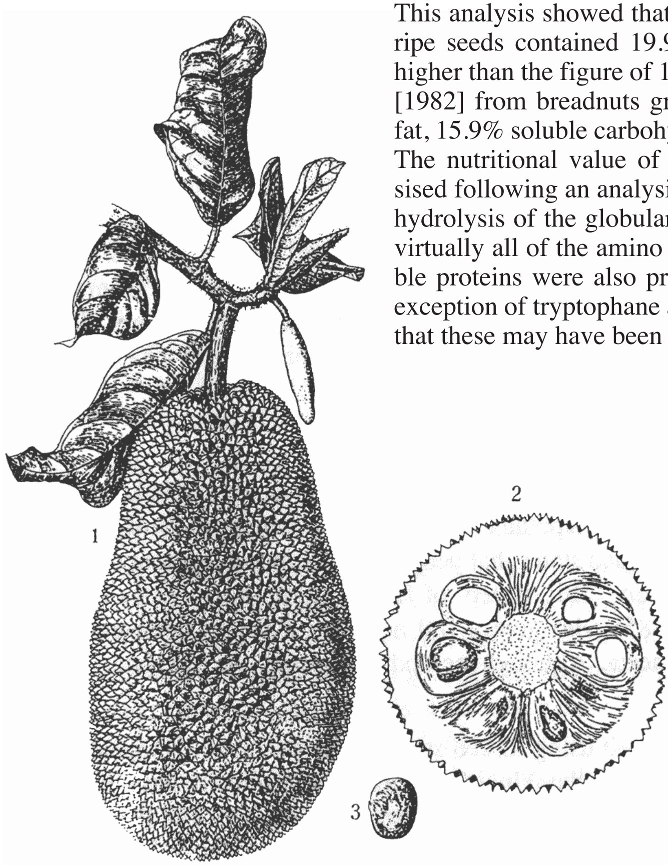
Ground layering of the tree is not a successful method, whereas air layering (i.e. marcotting) gave satisfactory results in India. Stem cuttings are also reported as being successful, but only when growth promoting substances such as indolebutyric acid are applied. One major problem in such a method is the handling of stem cuttings possessing, as they do, such very large leaves.

Nutritional value of the fruit and seeds

Seeds: We have seen that *A. altilis* occurs as two distinct varietal forms: those with seeds and seedless forms. Although the seeded variety is less commercially important as they produce little usable pulp, the seeds themselves - Breadnuts - are used as a supplementary food source in various regions of the tropics. Generally the seeds are either boiled or roasted and are said to taste like chestnuts. Undoubtedly the seeds have a high nutritive value, but because of the greater food yield to be derived from the pulp of seedless varieties the seeds play only an insignificant role in the diet of many people.

The potentially high nutritive value of Breadnuts has been tacitly assumed by native people since the fruit were first introduced into their diet some centuries ago, but their importance was not fully realised until a thorough chemical analysis of Breadnuts from Colombia was made by Quijano & Arango (1979).

This analysis showed that flour produced from ground, ripe seeds contained 19.9% total protein (fractionally higher than the figure of 16.4% obtained by Achinewhu [1982] from breadnuts grown in Nigeria), plus 12.8% fat, 15.9% soluble carbohydrates, and 3.9% crude fibre. The nutritional value of the nuts was further emphasised following an analysis of amino acids present after hydrolysis of the globular proteins, which showed that virtually all of the amino acids present in other vegetable proteins were also present in breadseeds, with the exception of tryptophane and lysine. The authors claim that these may have been degraded during hydrolysis.



The Chempedak, *Artocarpus champeden*

The oils present in the seeds were further analysed by Achinewhu and Akpapunam (1985) who showed that the total unsaturated fatty acid content of refined oil was 59.9% and the principal fatty acids were linoleic (30.4%); oleic (24.5%); palmitic (19.3%) and stereic (17.3%).

Another noteworthy feature based on the chemical analysis of the breadnuts was provided by Bravo, Graham & Padovam (1983) who showed that seeds grown in Puerto Rico contained, in addition to high levels of proteins, carbohydrates and fats, high levels of Ca, K, Fe, and niacin when compared with other tree nuts.

Pulp: However, despite the localised consumption of breadnuts in some areas of the tropics there can be no doubt that the major food source from *A. altilis* is derived from the fruit pulp. The value of the pulp can be fully appreciated when it is realised that each tree can produce

200 fruits/year which, when dried, produce 6 tonnes of breadfruit meal (i.e. pulp) per hectare; this compares favourably with corn meal yields from *Zea mays* (maize). The value of *A. altilis* as a crop plant is further enhanced in that, once the trees are established they require very little maintenance (Bowers, 1981).

The native methods of preparing breadfruits are numerous and vary with each tropical location. For instance, Safford (quoted in Popenoe, 1920) writes that in Polynesia:

"It is eaten before it becomes ripe, while the pulp is still white and mealy, of a consistency intermediate between new bread and sweet potatoes. In Guam it was formerly cooked after the manner of most Pacific island aborigines, by means of heated stones in a hole in the earth, layers of stones, breadfruit, and green leaves alternating. It is still sometimes cooked in this way on ranches; but the usual way of cooking it is to boil, or bake it in ovens; or it is cut in slices and fried like potatoes. The last method is the one usually preferred by foreigners. The fruit boiled or baked is rather tasteless by itself, but with salt and butter or with gravy it is a palatable as well as a nutritious article of diet."

In Malaya Burkill (1966) states that:

"The fruit of some races is edible shortly before it is ripe. It may be sliced and baked, or it may be boiled, in which condition it suggests a potato. It is sometime eaten in the form of a biscuit. It makes a good preserve." Burkill also states that peoples of Polynesia ferment the fruits in soil pits as a means of preservation. This system of fermentation has recently been fully reported by Atchley & Cox (1985) who give a full account of the various methods of fermentation employed in Micronesia. Although methods vary from one Micronesian island to another the basic method is:

"Ripe seedless breadfruit is harvested using forked sticks to snap the peduncle, causing the fruit to fall. Men and women then scrape the skins off the ripe breadfruit with sharpened cowrie shells. An example of such a scraper is in the Alele Museum in Majuro. The fibrous core is removed and discarded before the fruit is cut into small pieces and put into a burlap bag. In ancient times coconut-leaf baskets were used for this purpose. The bag is then tied with twine braided from fibres from the coconut mesocarp and submerged in seawater in the lagoon for 2 h. During this period the bags are beaten with sticks or trodden upon to soften the breadfruit sections. After the breadfruit reaches the desired soft consistency, the bag is removed from the lagoon and brought to shore, where it is beaten with sticks to remove excess water. The bags are placed on banana leaves and allowed to drain for several days. Possibly some fermentation occurs during this stage, as the breadfruit becomes considerably softer. The product is stored in wooden boxes, which are lined with fresh banana leaves, or when available, plastic. The box is relined with fresh leaves once a week. After fermentation for a month in the wooden box, the fermented breadfruit or bwiru is ready to eat.

In this condition, the bwiru can be stored indefinitely as long as the leaves lining the box are changed. The surety of preservation of bwiru was recognized by early missionaries as a method that they could adapt for their own cultural needs: previously prepared bwiru could be substituted for fresh breadfruit on the Sabbath."

Atchley & Cox (1985) state that "Breadfruit preservation in Micronesia shows some striking differences and similarities to related techniques in Polynesia". The major difference appears to be that Micronesians immerse the breadfruit in seawater whereas Polynesians do not. These authors conclude that:

"In both Micronesia and Polynesia, however, fermented breadfruit allowed survival in the face of famine from storm, drought, warfare, or other catastrophes .... "

In other regions of the tropics fermentation systems are not used and the storage of fresh fruit becomes a problem. Work carried out in Trinidad by Passam et al (1981) indicated that storage of the fruit at 14°C for 10 days in polythene bags was acceptable, though if the fruit had been immersed in boiling water for 2-5 mins and then frozen at -15°C, the flavour, colour and texture of the fresh fruit could be maintained for 11 weeks. This finding differs from that of Thompson, Been and Perkins (1974), who previously showed that while low temperature storage was effective, chilling injury occurred at temperatures below 12°C.

The chemical composition of Breadfruit from Nigeria in relation to its nutritional status was mentioned by Bowers (1981) who showed that the dried fruit contains 87.9% dry matter, 3.4% crude protein, 3.4% fibre, and 77.6 M.F.E. Similar studies on Breadfruits from Puerto Rico by Graham & de Bravo (1981) showed that the protein content varied from 4.6-5.9% in the skin; 6.0-7.6% in the stem plus heart; and 3.8-4.1 % in the pulp. The content of crude fat varied from 2.3-3.9% in the skin; 1.6-4.4% in the stem plus heart and 1.1-2.6% in the pulp. The major carbohydrate was starch and at all stages of maturity the fruit contained high levels of Ca, K, Fe, niacin and riboflavin. An analysis of the starch from breadfruit pulp was reported by Loos, Hood & Graham (1981) who showed that the sequential hydrolysis of freeze-dried starch yielded an amylose content of 18.2%; beta-amylolysis was 58% while debranched amylopectin contained chains with a degree of polymerisation of 15 and 38-45.

Breadfruits from Samoa were analysed by Wotton and Tumaalii (1984) at various stages of maturity and gave the following figures: crude protein was 2.9-5.1 %; fat, 0.8-1.9%, fibre, 2.9- 6.6%; ash, 1.9-4.1 %; total sugars, 10.0-3l.8% and starch S3.4-75%. In immature fruits fructose was the main sugar, but this was replaced by glucose and sucrose as maturation proceeded. Levels of Fe, Na, P, Ca and K were thought to have some nutritional importance.

Due to its starchy content attempts have been made to utilize breadfruit flour as a source of dough for Western diets, and in Nigeria, Olatunji & Akinrele (1978) examined the qualities of wheat flour that had been diluted with flours from certain tropical plants including breadfruit. They found that levels of non-wheat flour in excess of 10% of the total mix gave unsatisfactory results. Different results were obtained by Arceley & Graham (1984) who showed that bread, cakes and puddings containing high levels (up to 75%) of breadfruit flour were well accepted by members of the tasting panel in Puerto Rico, indicating the usefulness of breadfruit flour as a supplementary dietary product.

THE JACKFRUIT, *Artocarpus heterophyllus*

Undoubtedly this tree originated in India and was introduced into East Africa by Arab traders (Purseglove 1975) and into other tropical regions where it "forms a very important article of food with the natives of the Eastern tropics" (McMillan, quoted in Popenoe, 1920).

An early traveller to India, John de Marignolli, writing in 1350 states:

"There is again another wonderful tree called Chake-Baruke, as big as an oak. Its fruit is produced from the trunk, and not from the branches, and is something marvelous to see, being as big as a great lamb, or a child of three years old. It has a hard rind like that of our pine-cones, so that you have to cut it open with a hatchet; inside it has a pulp of surpassing flavour, with the sweetness of honey, and of the best Italian melon; and this also contains some 500 chestnuts of like flavour, which are capital eating when roasted."

The fruit is divided into many cavities bearing the seeds, each being surrounded by a soft brownish pulp with a rather strong odour and an aromatic flavour similar to that of banana. Some explorers have spoken disparagingly of the fruit and Popenoe (1920) quotes one writer, Thomas Firminger, as stating:

"By those who can manage to eat it, it is considered most delicious, possessing the rich spicy flavour and scent of the melon, but to such a powerful degree as to be quite unbearable to persons of weak stomach, or to those unaccustomed to it". Burkill (1966) says, "the taste is mawkishly sweet and mousy, agreeable to natives of the East but not to Europeans".

For an historical summary of the origin of the Jackfruit and its transportation to various regions of the world, the account given by Popenoe (1920) is the most concise.

"The tree grows wild in the mountains of India and is ordinarily considered indigenous to that country. Alphonse De Candolle believed that its cultivation probably did not antedate the Christian era. At the present day it is common in many parts of India, particularly in lower Bengal, and McMillan observes that it has become semi-naturalized in Ceylon. In the Malayan region it is a common fruit-tree. The worthy Father Tavares states that it was introduced into Brazil by the Portuguese about the middle of the seventeenth century. It is now abundant in many parts of that country, particularly about Bahia. William Harris gives the following account of its introduction into Jamaica:

'It was amongst the plants found on board the French ship bound from the Isle of Bourbon to Santo Domingo, which was captured by Captain Marshall of H.M.S. Flora, one of Lord Rodney's squadron, in June, 1872, and was sent to Mr Hinton East's garden in Gordon Town. It was again introduced in the early part of 1793 when Captain Bligh of H.M.S. Providence brought it with other plants from the island of Timor in the Malay Archipelago. The tree is common all over the island, and is naturalized in the Cockpit country.'

In Hawaii it is not abundant. It has never been a success in California, the climate having proved too cold for it. In southern Florida, however, there are several fruiting trees, but on the shallow soils of that region they do not grow to large size, and the fruits which have been produced were not of good quality. The species is probably too strictly tropical in its requirements to be entirely successful in any part of this country" [i.e. the United States of America].

Propagation

Jackfruits produce many seeds and Rao (1965) has recorded, in India, up to 500 seeds per fruit in some varieties. Curiously, there appears to be no apparent relationship between the size of the fruit and the number of seeds it produces (Sonwalkar, 1951), additionally there is a wide variation in individual seed weight between 1 g and 7 g per seed. Most seeds bear one embryo but polyembryony has been reported from Indian planting trials and Shanmugavelu (1971) demonstrated that treating seeds with gibberellic acid increased the number of twin seedlings - a condition he attributed to an increase in the concentration of auxins in the embryo. He also argued that incipient polyembryony is more common than was previously thought, but it requires external stimulation by means of chemicals to manifest itself in the field.

As with Breadfruits, the seeds of Jackfruits lose their viability soon after they are removed from the fruit, though if they are stored in coir-dust or sand they can remain viable for 1 month provided their cotyledons do not dry out (Rao, 1965). A study conducted in the Philippines by Fernandez (1982) showed that storage of seeds under a saturated atmosphere in air-tight bottles at 16°-18°C extended their viability to 1.5 months. Large seeds germinate more rapidly than small ones (Sonwalkar, 1951), but there is a great variation in time and percentage germination rates even in seeds of the same size. The application of various growth substances to accelerate germination has been attempted but with somewhat inconsistent results (Rowe-Dutton, 1976).

Most seeds are germinated to produce sturdy rootstocks for future grafting, and the techniques for seedling management are now fairly standardized. The following account is taken from an article by Rowe-Dutton (1976).

"When four planting positions were compared by Sonwalkar (1951) in India, he found that it was best to plant the seeds either flat or with the embryo pointing downwards. When the embryo was pointed upwards, the seeds took much longer to germinate, and when the narrow end was pointed upwards the percentage germination was slightly lower.

Sonwalkar also showed that planting the seeds in their jackets, that is, without removing the fleshy perianth lobes, was very detrimental, resulting in only 20 per cent germination.

For rootstock production in Java, jackfruit seeds were planted in propagating beds at a spacing of 40 x 40 cm under light shade, where they were left until ready for budding .... In India seeds for rootstocks are either planted in seed-beds and transferred to pots within six months, or planted directly in pots .... Lifting seedlings from the beds, however, is a problem, because the long, delicate tap-root is easily injured and bare-root seedlings do not transplant well. It is generally recommended to raise the seedlings in containers or, in the case of trees on their own roots, to plant the seed in situ ....

If the seed is planted in seed-beds, the seedlings should be potted up before the food reserves in the cotyledons are exhausted (Richards, 1950; Rao, 1965). Potting up as late as the six -leaf stage has led to 20 per cent mortality .... It is said that seeds can be germinated satisfactorily in pieces of coconut husk containing enough soil to cover them; they are then planted out in the field with the husk .... Other containers commonly used are clay pots, bamboo baskets or small bamboo pots, but seedlings in such containers do not remain healthy for more than a month or two.... Plants in bamboo baskets can be planted with the basket intact, thus avoiding any root disturbance ....

In common with breadfruit, Jackfruit trees raised entirely from seedlings exhibit great variability in yield, fruit characteristics and fruit quality. In order to counter this and establish useful non-variable trees it is necessary to propagate Jackfruit trees vegetatively and a considerable amount of research is still in progress on the 'Post efficient way that this can be achieved".

Rowe-Dutton (1976) has summarised the most commonly used methods up to the time she wrote her paper, but considerable progress has also been made since that date.

Jackfruits have been propagated on rootstocks but no work has been done on the selection of clonal rootstocks. Budding, as in breadfruit, gives variable results, but Rowe-Dutton (1976) suggested that from her survey, at least, patch budding seems to be the most promising. This conclusion was confirmed more recently in Uttar Pradesh by Singh et al (1982) who compared the efficacy of 'patch', 'chip' and 'T' method of bud grafting and concluded that the maximum success rate (90%) was obtained by using the 'patch' method.

Various methods of layering have been tried with some success, but Jackfruit does not normally produce root suckers, and even when it does, propagation by this method is not normally successful. Ground layering has been attempted in various localities and the 'etiolation' method has proved very successful in Malaysia (Lambourne, 1935). In this system young plants are laid down and covered with soil and the soil level is increased gradually as the young shoots grow upward. The long, etiolated shoots root easily and grow rapidly.

Air layering appears to be the most satisfactory method of vegetative propagation in Jackfruit and many innovative methods have been attempted, particularly in India. For example, Mukherjee & Chatterjee (1978) etiolated the cut shoots with black cloth and stimulated root growth by treating the etiolated shoots with 10,000 ppm of IBA, resulting in a 100% rooting success and a 91.7% survival rate. Rooted cuttings have been produced from some cultivars, but the success rate is not high though a better success has been achieved by the application of rooting growth stimulators such as IBA (Chatterjee and Mukherjee, 1980). The use of ferulic acid has also enhanced rooting of cuttings in West Bengal (Dhua et al., 1983).

Perhaps the most promising method for future use is the development of new plants from callus tissue produced from selected cultivars, though at present only one research group has reported such work in the literature. Srinivasa et al (1981) reported that juvenile shoots of *A. heterophyllus* cultured on MS basal medium containing auxin and cytokinin resulted in multiple shoot indication through the stimulation of secondary buds. However, rooting of the new plants occurred only rarely, and thus this innovative method of propagation needs further research before it can be adopted commercially.

Nutritional value of the fruit and seeds

Although not as widely distributed as Breadfruit trees, Jackfruits are consumed in considerable quantities in some tropical countries, and in parts of southern India, for instance, the fruit

has become a standard part of their diet in some seasons of the year (Thomas, 1980). In some tropical countries, however, the Jackfruit is regarded as much inferior to the breadfruit, as the taste is less acceptable to certain palates.

Popenoe (1920) mentions that: "The fruit is eaten fresh or it may be presented in sirup or dried like the fig." This author quotes another traveller as stating that

"If the edible pulp of the fruit be taken out and boiled in some fresh milk, and then be strained off, the milk will, on becoming cold, form a thick jelly-like substance of the consistency of blanc-mange, of a fine orange colour, and of melon-like flavour. Treated in this way the fruit affords a very agreeable dish for the table. Father Tavares has this warning: "It must be eaten when full ripe, and not at meal times; a cup of cool water should be taken immediately afterwards, never wine or other fermented drink, since these, when combined with the jaca, are poisonous." He adds that the seeds, boiled or roasted, are very pleasant and that they are used, pulverized, in making biscuits. The ripe fruits are often fed to cattle in Brazil".

Despite these seemingly disparaging remarks the Jackfruit holds an important dietary place in various areas of the tropics and its potential has not, perhaps, been fully exploited. A recent survey of its usefulness by Thomas (1980) outlines the many numerous ways that the fruit can be used in culinary dishes.

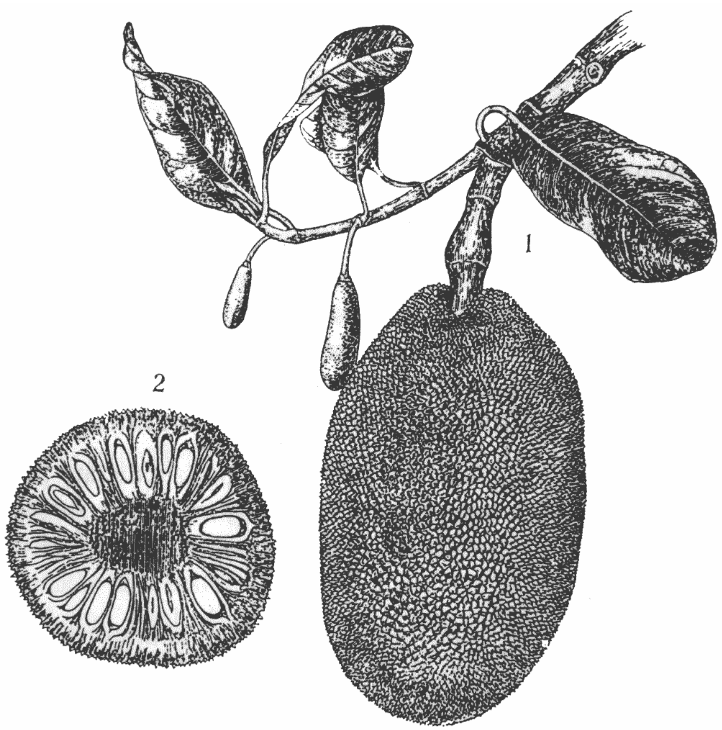
"The most popular edible part of the multiple fruit is the fleshy and juicy perianth surrounding the individual fruits or achenes. From the standpoint of edibility of the pulpy perianth, the different varieties of jackfruits are broadly classified into two groups, one with the soft and melting pulp, and the other with the firm and fleshy pulp.... The latter is more popular as ripe fruit. The juicy pulp of this group is eaten fresh or preserved in sugar syrup. As fruit salad, it is extremely popular among the natives of the East .... Though the ripe pulp of the other group is not very popular as fresh fruit, in recent years it is gaining popularity in the East in the preparation of a delicious sweet known as 'halva'.

The juice extract of the melting pulp is mixed with sugar syrup, coconut milk and butter, and cooked over gentle fire until it becomes thick and nearly solid. Cooled and preserved, it keeps well for several months. The unripe pulp or 'flakes' of both groups are fried and used like potato chips. There are several culinary preparations in the East, especially in India, Malaysia and Sri Lanka. Cooked with scraped coconut, chillies, salt and turmeric, it forms a popular food with rice for the people of Kerala.

The seeds, too, are used as vegetables and are equally popular in culinary preparations. Roasted or fried like groundnuts, they are very tasty. Stewed with meat, they form a good side dish with rice. Braised like meat and vegetables, they are delicious .... Young flower clusters or spikes are eaten in Java as 'roadrak' with sugar syrup and agar-agar. Also, very young fruits are used for soup there. Grated young fruits, mixed with dry prawns, coconut milk and some condiments form a delicious side dish with rice for the Malays. The rind, the fleshy rhachis and the narrow ribbon-like structures inside the syncarp form favourite feed for the cattle."

Both the pulp and seeds contain high levels of nutrients and an analysis of Hawaiian fruit showed the pulp to be rather high in protein and fibre and low in acids, while the seeds have a high starch content and very little sugar combined with a protein content of approximately 5% (Popenoe 1920). Different figures were obtained on analysis of the pulp by Purseglove (1975) who showed it to be composed of: 73.1 % water; 0.6% protein; 0.6% fat: 1.8% fibre; 23.4% carbohydrate; and an ash content of 0.5%. Furthermore the seeds were shown to contain 51.6% water; 6.6% protein; 0.4% fat; 38.4% carbohydrate; 1.5% fibre; and 1. 5% ash.

Fruit from Brazil gave yet different figures on analysis: the pulp contained 1.6% protein; 0.2% lipid; 26.5% carbohydrate; 0.68% fibre; and 70.4% moisture. The corresponding figures for the seeds were: 12.2%; 2.0%; 75.7%; 7.3% and 3.0% (Tojal e Seara, 1975). Further analysis of the starch obtained from the seeds by Bobbio et al (1978) showed that it had an amylose content of 28.1 % and a D-glucose composition of more than 99%.



The Jackfruit, *Artocarpus heterophyllus*

Supplementary to these constituents the fruits contain appreciably high levels of pectin (Vilasachandran et al., 1985). In addition to its consumption by humans, trials in India on Jackfruit waste, i.e. the discarded portion of the fruit after removal of the seeds and edible pulp, indicated that with a content of 24.5% dry matter and DCP of 1.2% and a TDN of 19.9%, the material was eminently suitable for cattle feeding and was, in fact, superior to green grass (Ananthasubramaniam et al., 1978).

As with many tropical fruit, storage and subsequent transportation to distant sites is a major factor limiting the acceptability of the product to new consumers. In the Philippines, work by Giron et al (1973) on the effect of irradiation treatment on candied Jackfruit, showed that if the moisture content of the fruit was between 34% and 54%, the keeping quality was not

enhanced by irradiation. This work further indicated a level of moisture below 27% was necessary for irradiation to be effective. The most effective way of fruit preservation appears to be dehydration after immersion in 2% NaCl solution, followed by rehydration in water at 65°C containing 1% NaCl (Teaotia & Awasthi, 1968).

Conclusions

Both the Breadfruit and Jackfruit trees are plants of the humid tropics, and although Jackfruits are hardier and can thus be grown in less demanding conditions, the introduction of these trees, as commercial crops, into southern Australasia is doubtful. Where Jackfruit trees have been grown outside the tropics, as for instance in Southern Florida in the USA, they do not attain their full height and rarely produce fruit. Given their requirements for high temperature and high humidity the trees thrive in any moist, well drained soil. In the USA both Breadfruit and Jackfruit trees have been grown in greenhouses and propagation either from seeds or root cuttings has been successful. Rarely however do the trees develop fruit.

There can be no doubt that these two species of *Artocarpus* play an important role in the diet of many tropical peoples, and the evidence provided in this article indicates the obvious nutritional value of both these crops. Whether this nutrient source can be fully exploited by successful extraction procedures, thus facilitating its storage and transport to regions distant from the growing area, is a question for the future.

With increasing demand for high-energy foods in tropical developing countries it would appear worthwhile to exploit the food potential of these plants to a level hitherto unknown, and with the advent of genetic engineering and the new science of biotechnology (whereby selected strains can be developed from callus tissue), the future holds great promise both to scientists willing to devote time to this endeavour and to the ultimate recipients, the nutritionally under-privileged.

REFERENCES

Achinewhu, S.C. (1982). The nutritive qualities of plant foods: Chemical and nutritional composition of breadfruit (*Artocarpus utilis*) and climbing melon seed (*Colocynthis vulgaris*). Nutr. Rep. Int. 25, 643-647.

Ananthasubramaniam, C.R. et al. (1978). *Nutritive value of jack (Artocarpus heterophyllus. Lam) fruit waste for cattle*. Indian J. Nutr. Diet. .15, 12-16.

Arceley, A. & Graham, H.D. (1984). *Chemical evaluation and acceptance of food products containing breadfruit, Artocarpus communis, flour.* Caribb. J. Sci. 20. 35-41.

Atchley, J. & Cox, P.A. (1985). *Breadfruit fermentation in micronesia*. Econ. Bot. 39, 326-335.

Backer, C.A. & Bakhuizen van den Brink. R.C. (1965). *Flora of Java*. Vol. II. Noordhoff. Groningen, The Netherlands.

Baum, H.E. (1903) in *Plant World*, VI. (quoted in Popenoe. 1920).

Bobbio, F.O .et al. (1978). *Isolation and characterization of the physiochemical properties of the starch of jackfruit seeds (Artocarpus heterophyllus)*. Cereal Chemistry. 55. 505-511.

Bowers, R.D. (1981) *Breadfruit - a low energy requirement source of carbohydrate for the wet tropics*. Entwicklung & Landlicher Raum. 15, 11-13.

Bravo, E.N. de, et al.(1983). Caribbean Journal of Science, 19, 27-32.

Burkill, I.H. (1966). *A dictionary of the economic products of the Malay Peninsula*. Min. Ag. & Cooperatives. Kuala Lumpur. Malaysia. 2nd Ed.

Chatterjee, B.K. & Mukherjee, S.K. (1980). *Effect of different media on rooting of cuttings of jackfruit (Artocarpus heterophyllus Lam)*. Indian J. Hort. 37, 360-363.

Corner, E.J.H. (1920). *The classification of the Moraceae,* Gardeners Bull. Singapore. 19, 187-252. Crawford (1820). Hist. Ind. Archipel. 1:413 (quoted in Burkill1966).

Dhua, R.S., et al. (1983). *Propagation of jack -fruit (Artocarpus heterophyllus Lam.)*. Punjab Horticultural Journal/ 23, 84-91.

Fernandez, P.G. (1982). *Effects of air-drying moist storage and soaking on the physiology of jackfruit (Artocarpus heterophyllus (Lam)) seeds study conducted in the Philippines*. University of the Philippines at Los Baños. M.S. Thesis.

Giron, H.M . et al. (1973). *Effects of gamma radiation on the storage properties of candied jackfruit . (Artocarpus heterophyllus Lam*). Philippine Journal of Science. 100,177-188.

Graham, H.D. & De Bravo. E.N. (1981). *Composition of the breadfruit*. J. Food Sci. 46.535-539.

Hunter: in Journ. Roy. As. Soc. Straits Branch. 53, 113 (quoted in Burkill. 1966).

Ibanez, M.L. (1968). *The effect of cold on tropical seeds*. Turrialba. 73-4.

Lambourne. J. (1935). *Progress report on etiolated shoot method of propagation up to Sept. 1935*. Communication from Director Agric. F.M.S. and S.S ., 1935.

Loos, P.J. et al. (1981) *Isolation and characterization of starch from breadfruit*. Cereal Chem. 58 282- 286.

Low (1836). Soil & Agric. Penang. p.225 (quoted in Burkill. 1966).

Mukherjee, S.K. & Chatterjee, B.K. (1978). *Effect of etiolation and growth regulators on air-layering of jackfruit (Artocarpus heterophyllus Lam)*. Indian J Hort. 35 1-4.

Otalunji, O. & Akinrele.I.A (1978). *Comparative rheological properties and bread qualities of wheat flour diluted with tropical tuber and breadfruit flours*. Cereal Chemistry. 55, 1-6.

Passam, H.C., et al. (1981). *A note on freezing as a method of storage of breadfruit slices*. Tropical Science 23 67-74.

Popenoe, W. (1920). *Manual of tropical and subtropical fruits*. McMillan & Co. New York. 474 pp.

Purseglove, J.W. (1976). *Tropical Crops*. Vol. 1 and 2. Longman.

Quijano, J. & Arango, G.J. (1979). *The Breadfruit from Colombia - a detailed chemical analysis*. Economic Botany. 33, 199-202.

Rao, V.N.M. (1965). *The Jackfruit in India*. Fur. Bull.I.C.A.R. New Delhi. N.S. 34, 18.

Richards, A V. (1950). *A note on the cultivation of Singapore jak*. Trop. Agriculturist. 106. 12-13.

Rivera Lopez, C. & Rodriguez, S.J. (1975). *A method to obtain relatively uniform breadfruit trees (Artocarpus altilis) from a stockplant*. J. Agric Univ. P. R. 59, 77-78.

Rowe-Dutton, P. (1976). *Artocarpus utilis - Breadfruit; and Artocarpus heterophyllus - Jackfruit. in: The Propagation of Tropical Fruit Trees*. Hort. Rev. No.4. 248-290. F.A.O. and Commonwealth Agricultural Bureaux.

Shanmugavelu, K.G. (1970). *Effect of gibberellic acid on seed germination and development of seedlings of some tree plant species*. Madras Agric J., 57, 311-14.

Singh, U.R., et al. (1982). *Propagation of Jack-fruit by budding*. Punjab Hort. Journ. 22,103-105. Sonwalkar. M. S. (1951). A study of jackfruit seeds. Indian J Hort. 8, 27-30.

Srinivasa Rao. N.K . et al.(1981). *Tissue culture of the jack tree*. Current Science 50, 310-312.

Teaotia, S.S. & Awasthi, R.K. (1968). *Dehydration studies on jackfruit (Artocarpus heterophyllus Lam*). Indian Food Packer, 22, 6-14.

Thomas, C.A. (1980). *Jackfruit, Artocarpus heterophyllus (Moraceae), as source of food and income*. Economic Botany 34, 154-159.

Thompson, A.K., et al. (1974). *Storage of fresh breadfruit*. Tropical Agriculture 51, 407-415.

Tojal e Seara, L. (1975) *Bromatological study of jackfruit (Artocarpus integrifolia L.F.) with a view to obtaining industrial products*. Univ. Sao Paulo Press. Brazil. 78 pp.

Wester, P.J. (1920). *The breadfruit*. Philipp. Agric. Rev., 13, 223-9.

Wootton, M. and Tumaalii, F. (1984). *Composition of flours from Samoan breadfruit*. Journal of Food Science, 49, 1396-1397.

Vilasachandran, T. et al. (1985). *Evaluation of jack fruit (type 'Varikka') for pectin*. Agricultural Research Journal of Kerala. 20, 76-78.

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The Breadfruit, *Artocarpus utilis*

PAULOWNIA: A TREE FOR INTERCROPPING BETWEEN OTHER CROPS

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Paulownia trees are becoming a tree crop to grow between other tree crops. Not only do they provide all-important shelter, which has been proved to give up to 40% increased productivity to fruit and nut crops, but they also provide:

• Leaf fodder for livestock.
• Recycling of subsoil nutrients.
• Honey nectar from prolific flowers.
• Timber for sale at around 10 years - a much shorter time than other timber trees.

This latter point should not be overlooked. New Zealand tree croppers are hoping that Paulownia trees will give the top end of the horticultural products industry a 'home-grown' packaging material for high quality fruit and flowers.

Paulownia wood is half the weight of *Pinus radiata* wood - an important point when air freighting high-value horticultural produce. So Paulownia is a tree to study very seriously, especially as climate experts are now predicting that *Australia can expect increases in summer rainfall and decreases in winter rainfall over much of our continent*.

Paulownia is a summer rainfall tree (or does well with irrigation or good groundwater). It is thus a tree that is likely to be well-suited to many summer rainfall or irrigation areas from the Atherton Tableland to Tasmania.

If someone had set out to design a tree best suited to agroforestry, the end result would have to be something very similar to the Paulownia, or Empress Tree, of China. It has all the important attributes of multi-purpose use desired of an agroforestry tree, and it can only be faulted in the quality of its fuel wood. But it has a superb timber for plywood, packaging, furniture and other end uses. It provides excellent livestock fodder from its leaves, and it is a honey nectar producer of great value.

Besides that it is extremely fast-growing, and has a deep taproot system that scavenges subsoil moisture and nutrients, and does not compete with crops or pastures. Grown in a network or grid, or in wide-spaced rows, it can also provide shelter and shade for *micro-climate modification that increases farming productivity up to three times in some circumstances*.

Across the Yellow River floodplains it has helped a general food output increase of 30% in the forest-net and intercropping systems of agroforestry.

Paulownia, sometimes called the 'Empress Tree' or the 'Princess Tree', has been cultivated in China for at least 2600 years. The Latin name *Paulownia* was given to the genus by the Swiss Botanist, Thunberg, in the late 1700's. Up until the 1970s it was thought the genus had six species. But in 1973 Mr Zhu Zhao-hua of the Paulownia Research Group in the Chinese Academy of Forestry identified others, and the current total is nine.

Delving back in history, we find that a monograph on Paulownia was written in 1049 by Chen Chu. It recorded the cultivation of the tree and the use of its timber. Its "rediscovery" in the 1970s has seen the species come to a new position of economic importance in China.

We have a great deal to learn from China and its tree cropping. Points worth noting are:

• The People's Republic of China has given high priority to the development of agroforestry. The aim has been to significantly increase agricultural production and to develop timber and minor forest product output, on the same land. This has led its professional foresters into close partnerships with agricultural advisers and practical farmers.

• Agroforestry development in the People's Republic of China has had large-scale development over the last 10 years, so much so that it is believed that China has the world's largest agroforestry planting. It covers an *estimated 20 million hectares of farmland*.

• Native forests in the People's Republic of China currently cover about 12 per cent of the total land area. Most of the forests are in the north-east, with some coniferous forests in the south west (more than a million hectares of China's forests were destroyed recently by fire).

• Over the last 30 years much of China's forested areas have been cleared for agriculture, or for timber to fuel industry, or to provide housing. It has been realised that far too much forested land was cleared. Massive regeneration now has to occur in order to maintain timber and fuel wood supplies for an expanding population, and to protect the soil.

• However, it was also realised that the productive agricultural land could not have its food production jeopardised. Indeed, *tree-planting had a vital role to perform in increasing food output, through climate modification*.

• Thus, on the river floodplains of China various styles of agroforestry have been practised, with an intensive tree planting program being undertaken over the last 10 years. The forest cover on these plains has been increased from 2% to 10.7% in this time, to give a protective network for improved agricultural crop production - including many tree crops.

• The 'forest net' agroforestry on these plains now covers 3.2 million hectares of farm land, or 45.7% of the total area available for the "forest net" system.

• The 'intercropping' style of agroforestry now covers 940,000 hectares, or 57.7% of the area suited to it on the plains.

• In the 'four-sided agroforestry' (focussed on planting interconnecting networks of trees along roads, rivers, railways and in villages), some 4.9 billion trees have now been planted in the counties of the Chinese plains. Most are poplars or Paulownia, both of which are native to China.

• Agroforestry development in the People's Republic of China has accelerated over the last four years. The farm land area planted to agroforestry in the last four years represents one third of the 30-year planting total. From 1984 some 2.5 million hectares of "forest net" agroforestry has been planted on the plains of China.

• 'Intercropping' agroforestry since 1984 has doubled the 30-year total, and the last four years have seen 2.13 million ha of new intercrop agroforestry development on agricultural land.

• A census of agroforestry development on the agricultural plains of China has revealed that 145 counties now have the desired "standard of greening" (an average Chinese county being approximately 200,000 people on an area of roughly 70,000 hectares). This represents 34% of the counties in Beijing city and the provinces of Shandong, Hobei, Anhui, Henan, Jingsu, and Shanxi.

The *standard of greening* comprises:

• The cover of trees should be 10 per cent of the total farming area generally, up to 15% for areas suffering wind and sand erosion of a general nature, and 20% for areas suffering severe sand and wind erosion.

• At least 85% of a county should be protected by the 'forest net' agroforestry, in which square grids of trees (each square being from 4 to 6 hectares, but no more than 8 hectares) give micro-climate modification.

• From 50% to 80% of non-arable land should be planted to plantation forestry.

• Village land should be 30% planted to trees.

In 1986 a meeting of agroforesters from all the cities and provinces undertaking agroforestry decided that, in the five years to 1990, the agricultural plains of China would have 50% of counties with the desired 'standard of greening'.

• This target was considered achievable because of the widespread support of Chinese farmers for agroforestry. Using agroforestry they have been able to grow crops and raise livestock in areas where no food was grown before. In many of the areas badly affected by hot, dry winds, food production has been increased by three times. Overall, however, the Chinese river plains have seen an average increase of 30% in food output through agroforestry.

• Agroforestry has also given the Chinese farmers of the river plains another crop for income -- wood. They sell it for milling and for fuelwood. They also use poplar and Paulownia tree leaves for livestock fodder. Honey production comes from tree flowers, as do some Chinese herbal medicines.

• The development of agroforestry has greatly improved the micro-climate for crops and pastures, reducing the effect of dessicating winds at ground level (reduced evaporation and transpiration) at critical times for crop production. It has also improved the living conditions for people. Where before there had been an annual famine on the plains, now there is a saleable surplus of food.

• The important point about the success of the 10-year program of agroforestry development is that it had to be supported by practical farmers. They did immediately see benefits from agroforestry, as a result of an intensive extension program by foresters, agriculturalists and county and provincial officials. If there had been no economic benefit then the success would not have occurred. This is a lesson for other countries introducing large-scale agroforestry that modifies climate and improves crop and livestock production.

It is my view that Australian farmers (including tree croppers) can learn much from the Chinese use of Paulownia and Poplar in agroforestry that combines all other forms of crop production.

The name of their game is significant increases in productivity; that should also be the name of our game too.

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[Based on a paper presented at ACOTANC-88. Lismore. NSW. August 1988].

The Chinese Chestnut, *Castanea mollissima*

NASHI FRUIT: AN OVERVIEW

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The Name

Nashi has many synonyms, e.g. Asian pear, Oriental pear, apple-pear, sand pear and salad pear. The name Nashi, which in the Japanese language means pear, recently received the imprimatur of the Australian Apple & Pear Corporation because of industry support for this choice of name, rather than Asian Pear.

Names can be very important in the market place. Substitute tags may be required for marketing in some overseas countries. On domestic markets a catchy curiosity-arousing name that won't lead to confusion with other commodities makes sense. Besides, a distinctive name for this pear may tend to make it less market competitive with European pears with which Australian consumers are more familiar.

Origin

Cultivars of Nashi have been developed from breeding within the species *Pyrus pyrifolia*, *P. ussuriensis* and possibly other species of *Pyrus* native to Northern Asia. Most of our interest is in the leading cultivars of Japan. These are said to have resulted from improvement within P. *pyrifolia*. Most people in north coastal NSW will be familiar with China pears, old trees of which are plentiful as single specimens or small lots. Specimens of these have been identified as P. *pyrifolia* species though amongst the tree population it is thought some hybridisation has occurred. Fruit is variable, much of it being poor to fair in quality, often being characterised by the presence of grit cells. Fruit quality of modern Nashi cultivars is vastly superior to that of domestic China pears.

The Fruit of the Modern Nashi

There are some important differences between the fruit of Nashi, and European pear cultivars with which Australian consumers are familiar. These differences are such as to warrant the promotion and marketing of Nashi in Australia as a new commodity.

Most of the Japanese Nashi tend to be round-oblate in shape. The Chinese Nashi, Tsu Li and Ya Li, are roughly pyriform in shape and in appearance could be confused by consumers with some European pears.

With very few exceptions and in contrast to European cultivars, the calyces of Nashi are deciduous. Whereas European pears ripen best if harvested mature but very firm and allowed to ripen off the tree, Nashi will ripen satisfactorily if allowed to remain on the tree. As ripening proceeds the flesh of Nashi becomes more juicy and sweet, excepting near the core where it can remain quite tart, but the flesh remains firm and crisp. European pears soften with the ripening process. Grit cells are absent or almost so in modern Nashi cultivars.

The skin of cultivars of both types may be either clear green-yellow, partially russeted, or fully russeted and cinnamon-like in colour.

Status of Nashi

The first significant plantings of modem Nashi cultivars in NSW occurred in 1984 when about 7 ha (3000 trees) were planted. A further 95 ha (40,000 trees) were planted in 1985. Outside NSW, most other plantings have occurred in the Goulburn Valley, Victoria, where enquiries suggest that between 30 and 40 ha were planted or reworked up to the end of 1985, and where it is anticipated an additional 130 ha will be in the ground during 1986.

Australian production in 1986 is expected to be within the range of 60-100 tonnes, mostly produced in Victoria, and practically all consisting of Nijisseiki. Production will increase ap preciably in 1987 and beyond.

Research and Development

Formal research to which brief reference is made in this publication, is being undertaken by State Departments. Whilst good progress is being made it will be some years before a number of the major aspects requiring investigation are resolved. Research is being assisted by the Australian Apple & Pear Corporation, which body has injected funds into five research projects being undertaken by State Departments.

In 1985 the Victorian Nashi Fruit Association was formed to provide an industry forum to facilitate industry development. Two areas that the Association will become involved in are a review of packaging and marketing alternatives and consideration of means of quality control and its implementation. The Association provides a newsletter. Whilst the Association has been formed primarily for growers in Victoria membership is welcomed from interested people in other States.

Promotion

The need for this was foreshadowed earlier(1). A tangible effort would appear to be desirable just prior to and during the 1987 marketing period, in view of anticipated increased availability of fruit. The point has been echoed in Sydney markets is that consumers, with the exception of those with Asian background, don't know Nashi nor what to expect from them. It is suggested that cost effective promotion could be undertaken through market agents/merchants, retailers and the advisory services of the Department of Agriculture.

Potential for Nashi

The domestic potential cannot be adequately defined at present. The nature and potential quality of Nashi as a fresh dessert fruit commodity however are considered to warrant commercial optimism. Sales to date (1986) have substantially been on a "try out" basis by chains and retailers, with wholesale prices in February 1986 mainly between $15 and $20 per single layer tray (approximately 4 kg), for counts between 16 and 25. All fruit observed were Nijisseiki (Twentieth Century).

Some small fruit was observed (count 40), which understandably was difficult to clear. One would expect prices to come back appreciably in full supply situations. Many of the Nijisseiki observed were excessively russeted, some excessively skin marked from other causes and some fruit not sufficiently mature. A small number of excessively long counts were observed. There is thus scope for improvement which needs to be taken seriously in the longer term interests of the commodity.

Nashi fruit have attracted the attention of retailers servicing consumers of Asian background. There is thus a ready-made market amongst people who with their ethnic background are already aware of this fruit - a relatively small outlet but nevertheless significant. It is anticipated that Nashi fruit will find acceptance amongst the broader Australian community as the commodity becomes better known.

Since the Japanese cultivars are distinctly shaped, it is anticipated these will be readily discerned by consumers as something new. Perhaps not so the two Chinese cultivars, Tsu Li and Ya Li, which roughly resemble the shape of some European cultivars. Recognition of Nashi fruit by consumers and a knowledge of ripening habit, internal quality and shelf-life by both retailers and consumers will be areas in need of attention in the longer term interests of the community.

It is considered that the domestic potential of Nashi fruit will be partly influenced by the extent to which the commodity is effectively promoted. Other important factors are fruit quality and presentation. It has to be recognised that the peak availability of freshly harvested Nashi fruit also coincides with peak availability of Williams pear and a plentiful supply of other fruits, especially the stone fruits.

In the longer term, consumer demand will also be influenced by the availability of high quality cultivars. An excellent range of cultivar material has been introduced into Australia but much of it is currently held in quarantine. There is a need for some of these cultivars to be processed as speedily as possible, e.g. Hosui, which has been accorded high priority.

The experience being gained in production and marketing at the domestic level will be invaluable in learning to satisfy export market requirements, which will provide a logical extension of the domestic marketing phase.

Earlier information [1], based on marketing data in Singapore, Hong Kong and Malaysia for 1981 and 1982, focussed attention on potential markets for Nashi that appear to exist in these countries. More recent information extracted from the report of the Australian Horticultural

Officer, South East Asia 1984 [2] further draws attention to the significance of Singapore, Hong Kong, and to a lesser extent Malaysia, as potential outlets and provides other comments of interest.

There are two pear markets in Singapore, the same as in Hong Kong (Table 1). The Nashi market in Singapore is dominated by China, with small quantities from Korea and Japan, and the European pear market is dominated by Australia.

In 1983 the Nashi market in Singapore accounted for 69% of all imported pears. The principal cultivars are Ya Li and Tsu Li from China, the brown skinned, large Korean Nashi, and the well-known Nijisseiki from Japan.

Table 1. Import of Pears into Singapore (tonnes)

Main Suppliers	*1979*	*1980*	*1981*	*1982*	*1983*	*Up to 30.9.84*
Australia	13 445	6 677	8 178	6 136	7 597	6 023
China (Nashi)	16 106	15 080	13 531	12 521	7 044	8 481
France	62	170	114	317	437	-
Japan (Nashi)	67	576	1 238	2 037	2 073	847
Korea (Nashi)	935	902	840	1 065	1 281	1 436
U.S.A.	515	587	383	187	232	443
South Africa	-	-	535	743	613	536
Total:	31 199	24 006	24 946	23 512	29 391	17 883
Australia's Share:	43%	28%	33%	26%	26%	

The Singapore market will accept yellow Nashi fruit which remain quite firm as they ripen. Indeed the Ya Li pears from China were invariably bright yellow in colour and the Japanese Nijisseiki ranged from yellow through to green in ground colour. The final shipments of Japanese pears around May showed internal browning and importers suffered some severe losses. Interestingly, the Japanese were including ethylene-absorbing sachets in the cartons of Nijisseiki, which were packed with all fruit enclosed in a plastic bag.

There are also two distinct pear markets in Hong Kong. The Nashi market is supplied by China and Japan, and the European pear market is almost entirely supplied by Southern Hemisphere countries with Australia the most prominent. The Nashi market is very much larger, accounting for 91.6% of all imported pears in 1981 and 91.4% in 1982. The principal cultivars are Tsu Li and Ya Li and the well-known "Crystal" Nijisseiki from Japan. Korea also provides the rather large brown Nashi. Details of pear imports into Hong Kong are provided in Table 2.

Table 2. Import of Pears into Hong Kong (tonnes)

	1980	*1981*	*1982*	*1983*	*To July 1984*
Country of Supply					
South Korea	58	107	98	183	
Japan	4 303	6 571	9 892	5 089	
USA	430	560	644	191	140
China	36 671	44 091	41 056	39 156	10 405
Chile	183	-	78	-	1 037
South Africa	160	110	297	225	349
New Zealand	127	103	109	45	
Australia	5 818	3 876	3 641	4 741	3 608
Total	47 923	55 754	56 065	49 740	15 670
Australia's Share	12.1%	7.0%	6.5%	9.5%	

It is important to differentiate between these markets because not only is the Nashi fruit market ten times as large as that for European pears but the fruit quality criteria required are quite different.

For instance, the Chinese will accept yellow Nashi fruit. In fact, the Ya Li from China were always bright yellow in colour. However, when it comes to European cultivars such as the WBC and Packham pears, the market wants green, firm pears with several days shelf-life at ambient conditions.

Importers are particularly critical of russet and excessive blemish and limb rub. These were problems seldom seen in the Nashi fruit.

The consignments of Ya Li Nashi fruit from China were fully wrapped and packed in 18 kg cartons. The season for these pears would now seem to have been extended with the use of controlled atmosphere storage. The season would therefore extend from mid-August through to early June. The Ya Li at the end of the season were still firm and showing little shrivel, however the stems were brown and dry.

The Nijisseiki from Japan were externally perfect and free from blemish. The fruit was uniformly graded and beautifully presented with polystyrene foam-weave cups used to individually protect each fruit. These Nashi were packed in 15 kg cartons and the most common counts were 36-48. The extra care in fruit selection and presentation is reflected in the prices paid for Japanese Nashi (Table 3).

Table 3. Average CIF Values for Pear Imports into Hong Kong ($HK per kg)

Nashi Fruit	1981	1982	1983
China	1.85	2.11	2.67
Japan	7.19	6.39	7.04
European Pears			
Australia	4.89	5.11	5.27
USA	5.33	5.41	7.43
South Africa	4.93	5.15	5.65

The low prices for Chinese Nashi probably indicate why China dominates the pear market in Hong Kong. In Malaysia, Australian pears have become popular although the Nashi fruit from China dominate the market (Table 4).

In 1978 only 636 tonnes of pears were imported from Australia. However, by 1983 the total had climbed to in excess of 2,400 tonnes. During 1984 very much smaller quantities of pears were shipped and importers were greatly disappointed.

Table 4. Imports of Pears into Malaysia (tonnes)

	1980	1981	1982	1983
Main Suppliers				(to 30.9)
Australia	1 523	2 094	1 727	2 450
China	7 490	15 434	8 069	
Japan	274	504	760	
Korea	305	22	345	
South Africa	86	35	35	
USA	84	103	44	
Total:	9 775	18 464	10 941	
Australia's Share:	15%	11.3%	14.9%	

Malaysia prefers smaller pears as these are used on altars as offerings. It is not uncommon for devout Buddhists to visit and pray at several temples. At each temple an offering is made. The other major factor influencing this strong preference for smaller fruit is the fact that Malaysians have generally less spending power than the average Singaporean.

Although the heavily russeted Nashi from Korea are well-known in South East Asia there is a preference for clear skin cultivars. Whether this will always be so is difficult to say, bearing in mind the increasing production of russeted cultivars in Japan and the interest of that country in exporting into South East Asia.

Other possible export outlets for Nashi fruit are North America, West Germany, the U.K., and the Middle East. A trial consignment of New Zealand Nashi into Los Angeles, USA, in 1985 returned an average $US27 per tray.

A small pilot trial from Australia to West Germany in 1985 of clear skinned and russeted cultivars was well received. These rated high for eating quality but blemish marks did attract comment. The importer suggested there should be no problems in clearing 10 containers in 1986.

As with the domestic market there are sufficient encouraging signs at this stage to suggest that there will be viable markets to service overseas. Quality standards sought will be high. There is some comfort to be derived as a Southern Hemisphere producer as there will be periods for marketing when little if any competition is experienced from Northern Hemisphere producers though with improved cool storage technology being adopted by those producers these periods can be expected to shrink.

It should also be indicated that Australia will not have Southern Hemisphere production on its own. New Zealand was estimated to have about 75,000 trees in the ground prior to winter 1985 with the expectation that a similar number would be planted in that year. Not much interest in Nashi fruit appears to be evident in other Southern Hemisphere countries at this stage but it will be very surprising if that situation prevails.

Cultivar Situation

Commercial availability of introduced cultivars is confmed at present to the following (in order of maturity) - Shinsui, Nijisseiki, Chojuro and Tsu Li.

The release from quarantine of the highly sought Kosui was approved in February 1986. Also approved for release was Ya Li. It will be a few years before significant amounts of propagation material of these two become available.

The following 20 cultivars have been introduced from overseas and are currently (1986) held in quarantine:

From Japan: Choju, Yakumo, Tama, Hakko, Nittaka, Hosui, Shinseiki, Shinsetsu, Okusankichi, Shinko, Osanijisseiki (patented), Shinsei (patented). From Korea: Bong Ri, Dan Bae, Hwa Hong, Haeng Soo, Poong Soo, Sin Soo, Sin Go. From USA.: Kikusui.

These cultivars require virus indexing and dates of release cannot be anticipated at this stage with any certainty.

Suitable Growing Areas

It would appear that in general terms Nashi should grow and produce satisfactorily under conditions of similar climate suitable for European pears. There is a need for more information so that climatic suitability can be more adequately defined in terms of winter chilling requirements for a range of Nashi cultivars. This is of particular relevance in some parts of sub-tropical NSW where there is considerable commercial interest in this commodity. Trees which experience insufficient winter chilling to break their rest period have been observed [3] to exhibit the following symptoms - delayed and irregular opening of blossom and leaf buds, with the two types opening simultaneously; irregular opening of the individual blossoms within a cluster frequently accompanied by heavy flower drop; trees showing the effects of prolonged dormancy frequently have unexpanded flower and leaf buds, open flowers, fruit, leaves and new shoots all at the one time.

Insufficient winter chilling can impair cropping. Over time, trees will exhibit varying degrees of unthriftiness which may include limb dieback, and eventually death, depending on regularity and severity of the chilling hours deficiency.

Seike reports [4] that Japanese Nashi require about 900-1000 hours of chilling below 7°C (45°F) during winter in order to break dormancy. This is about 300 to 500 hours less than generally accepted as necessary for European pears. The cultivar Nijisseiki has been reported [5] to have a much longer chilling requirement than many European pear cultivars.

Observations were recorded in Mississippi, U.S.A. [3] on growth behaviour of the two Japanese Nashi cultivars, Chojuro and Nijisseiki, at the beginning of April following a mild winter and a total of 931 chilling hours. At that time Chojuro was very weakly leafed, Nijisseiki was still dormant, while the relatively low chill hybrid cultivars Keiffer and Le Conte were in full leaf. It was observed that cultivars of P. *pyrifolia* vary greatly in their chilling requirements.

There is evidence to show that at least some cultivars of Nashi will grow satisfactorily in areas with higher mean winter temperatures than needed by the main European cultivars. As with most fruit crops it can be anticipated that performance of cultivars may vary significantly between different areas.

Research in U.S.A. [6] has shown that the two Chinese Nashi, Tsu Li & Ya Li, have a minimum chilling requirement of 365-480 hours, and that two Nashi-European pear hybrids, Keiffer and Le Conte, have a higher minimum requirement of 600-800 hours.

Work in Taiwan [7] indicates that Japanese Nashi require an average annual temperature below 15°C, while a group of Chinese cultivars perform satisfactorily where average temperatures are less than 22°C. The method of calculating average annual temperature is unknown, and additionally there is difficulty in using the data in other environments. Using the data to make comparisons it is of interest to note that Shepparton, Victoria, where many Japanese Nashi are now cropping, has an annual mean temperature (based on average daily mean temperatures) of 15.5°C. Other centres of some interest in NSW are: Orange 12.8° C, Gosford 16.8° C, Taree 18.3° C, Glenugie 18.3°C, Lismore 19.3°C.

The existence of productive China pears in sub-tropical coastal NSW in situations comparable to those successfully used for production of 300 chill hour peaches provides hope that at least some of the introduced Nashi cultivars may perform satisfactorily in mild winter areas.

The information presented on chilling requirements should be used as a guide. Factors other than temperature such as choice of rootstock may have some influence.

Some cultivars may be rain sensitive under some conditions. At Orange, NSW in 1984 at least 40% of Nijisseiki fruit badly split following 60 mm of rain when fruit was about 75% developed. This may have been triggered by rapid moisture uptake following dry weather stress. However, similar damage, though of much less magnitude, was also reported by several growers in Victoria. At Orange in 1986 about 5% ofNijisseiki split. Moisture stress was not a factor. Under comparable conditions no similar damage occurred to Chojuro and Shinsui.

This phenomenon and the lack of information on chilling requirements illustrates the need for a careful approach to siting and choice of cultivars.

Soils and Rootstocks

Local experience at this stage is very limited and it is necessary to make judgments based largely on that from overseas.

Soils of at least reasonable fertility are needed with good depth and drainage. Those which are highly suitable for apples or European pears should also be found satisfactory for Nashi. Optimum soil pH will be slightly acid, pH 6.5.

In Japan a physiological disorder of the fruit known as Yuzuhada, which becomes evident as a roughening of skin, hardening of flesh near the calyx and sometimes malformation, appears to be associated with soils that become too wet or too dry, and where P. *pyrifolia* is used as a rootstock under these conditions.

In Japan P. *pyrifolia* is used very extensively in deep well drained soils, in which situations it is highly regarded. It is also being successfully used in some other countries. It produces a tree of moderate vigour. Seed of P. *pyrifolia* is not currently plentiful in Australia. The most expedient solution to this problem is importation of seed from overseas. Seed from China pear trees grown in isolation from other species, or cuttings of this pear, which are reported to root without difficulty, are a possible source of rootstock material, but suitability cannot be confirmed in the absence of trials. Seed of NSW China pears may be scarce because the fruit is sometimes parthenocarpic.

P. betulifolia is used overseas as a rootstock, especially in soils subject to excessive wetting and drying and unsuitable for P. *pyrifolia*. It produces a very vigorous tree. The seed is not plentifully available in Australia.

P. calleryana, used extensively in Australia as a very vigorous rootstock for European pears, does not appear to have been extensively evaluated overseas for Nashi. It is reported to have been successfully used in the USA, and to some extent in China. Although little used in Japan, verbal advice indicated it had been used successfully. Trees growing in New Zealand have been reported to be performing similarly to P. *pyrifolia*. No problems have been reported in Australia with propagation or with trees on *P. calleryana* during the establishment period.

P. calleryana has a fairly low chilling requirement. Investigations in USA [8] showed that trees made normal growth with 372 hours chilling. Its growth behaviour under conditions of less chilling was not examined. The investigators also found that the pear cultivar Bartlett (Williams) on its own roots made practically no growth following 1130 hours of chilling, but when propagated on *P. calleryana* made moderate growth following 648 to 744 hours of chilling and grew normally with 1130 hours of chilling. The investigators found that the rest influence in *Pyrus* seemed to reside primarily in the buds, but that also some translocation of the influence appeared to take place.

It might be concluded that *P. calleryana* when used as a rootstock for some Nashi cultivars may reduce the chilling requirements of those cultivars. Comparative growth behaviour of trees when propagated on *P. calleryana*, P. *pyrifolia* and *P. betulifolia* is not known.

P. communis has been used as the rootstock for most Nashi trees in California, USA, where growth has been described as fairly satisfactory but tending to lose vigour with maturity. New Zealand literature [9] suggests difficulty in attaining good fruit size at mature tree age and problems with biennial bearing. Many mature *P. communis* (Williams) trees have been reworked to Nashi cultivars in Victorian commercial orchards. The medium to long term performance of these trees will be of interest, especially those propagated initially on the very vigorous *P. calleryana* D6 selection.

The quince selection, Quince A, has been examined overseas and found to be incompatible with Nashi. The Department of Agriculture, Victoria is examining Quince A when used in association with a compatible intermediate stem piece of Beurre Hardy and Nashi cultivar. If found to be successful this combination will provide the basis for high density plantings.

In New Zealand the semi-dwarfing rootstock BA29 (Provence quince) is being examined as a possible rootstock for Nashi. As with the Victorian work, results will be some years away.

In the longer term results will become available from research at the Agricultural Research & Veterinary Centre, Orange, NSW, where a trial is to be planted which compares several Nashi cultivars propagated on *P. calleryana* and two strains each of *P. betulifolia* and P. *pyrifolia*.

Pending results of research and in consideration of the information available it is considered that preference should be given to the use of P. *pyrifolia*, *P. calleryana*, and *P. betulifolia* utilising the latter in soils considered less than desirable for the former two. It would seem desirable that until there are sufficient seed sources available of P. *pyrifolia* and *P. betulifolia* in Australia, arrangements should be made for their import from a reliable source.

Cultivars

Comments are largely confined to cultivars available and those recently released from quarantine.

Shinsui. Fruit is fully russeted, flat-oblate shape and tending to be small. Thinning of heavy crops will need to be meticulous in order to achieve good fruit size. Shinsui has good eating quality but reputedly a short life. Preliminary research in New Zealand suggests that Shinsui may have a useful storage life. Even so, being an early maturer, its advantage lies in early marketing rather than storage for anything other than very short term holding-over. It is the earliest to mature and may be ready for harvest under NSW coastal conditions in early January, and on the Tablelands about one month later. It may need to be handled more like some peach cultivars - frequent pick-overs and little delay in marketing.

Nijisseiki (Twentieth Century). Is the most widely grown cultivar in Japan and the USA. Greenish-yellow, clear skinned, medium sized fruit of round to oblate shape. The skin is very subject to abrasion and under certain conditions fruit loss may occur from splitting. Nijisseiki has good eating quality and a reputed cool storage life of up to six months. It matures about two to three weeks later than Shinsui. Some of the harvest period will overlap with Chojuro. It is well-known and highly regarded in a number of Asian markets.

Chojuro. Fully russeted medium oblate fruit. Very productive cultivar and easier to attain good size fruit. Has moderately good eating quality and a reputed storage life up to two months. Overseas it is reported to mature with or very slightly ahead of Nijeisseiki, but in Victoria and NSW Tablelands it follows Nijisseiki. There may, however, be some overlap between late picks of Nijeisseiki and early picks of Chojuro.

Whilst Chojuro has fulfilled a major role in the Japanese industry it is being replaced in younger plantings, particularly by Hosui and Kosui.

Tsu Li. This is of Chinese origin and unlike the three foregoing cultivars from Japan in shape more closely resembles a European pear; ovate-pyriform but tending to be variable. The fruit is light green to yellowish-green. Fruit is of medium size and reputedly of good eating quality. It is said to have a cool storage life of about 4.5 months. Tsu Li matures almost a month later than Chojuro or Nijisseiki. Young trial trees in NSW are exhibiting considerable vigour and are slower coming into production than the abovementioned cultivars. Only a few fruits have been observed to date. These have been misshapen and altogether uninspiring but some improvement can be anticipated as trees become more mature. The similarity in appearance between Tsu Li and some European cultivars highlights the need for retailers and consumers to be made aware of differences in flesh texture between the two commodities when ripe. Tsu Li will at least be well known to many Australians with Asian backgrounds. It is well known in South East Asian markets.

Ya Li. Also of Chinese origin and similar in shape to Tsu Li, though a little more 'necky', but also subject to variability. Fruit is greenish-yellow. Eating quality is described as good to excellent. The fruit of Ya Li is late maturing with anticipated harvesting dates similar to Tsu Li.

It was reported earlier [1] to cool-store for about 3.5 months, however consignments from China have been observed in Hong Kong markets as late as early June. It must be assumed, allowing for production to have originated in a late maturing area and given good storage practice, this cultivar has a life well beyond 3.5 months.

Ya Li was released from quarantine in February 1986, so small numbers of trees may become available in winter 1987. As with Tsu Li, it is considered there will be a need for retailer/consumer education.

Kosui. Fruit has not yet been observed in Australia hence comments are based on overseas experience. In Japan, where it originated, it is regarded very highly and is being extensively planted. Its quality has been confirmed in New Zealand. Fruit is oblate shaped, medium size, golden yellow and partially russeted. Flesh is very sweet. Fruit is anticipated to mature between Shinsui and Nijisseiki. No precise information is available on cool storage but up to two months has been suggested. Evaluation of Kosui will be undertaken as rapidly as possible. If its performance is comparable to that in Japan it will become a significant component in Australian plantings. Budwood was released simultaneously with Ya Li.

Hosui. A round medium-large, golden-brown russeted fruit, very sweet and of high quality. In Japan it is rated very highly and is being extensively planted - mainly as a replacement for Chojuro. Its quality has bee.n confirmed in New Zealand. It was examined by the author in Japan and U.S.A. and considered of excellent quality.

Of the many cultivars held in quarantine some are expected to find an important place in future Australian plantings. A number of these have been accorded high priority in virus indexing programmes and some may become available for release in 1987, though more likely in 1988 - should no problems arise. Amongst these is Hosui, singled out here because of its anticipated important role in future plantings.

Sources of Cultivar and Rootstock Material

A number of NSW and interstate nurseries are distributing and taking orders for Nashi cultivars propagated on *P. calleryana* rootstock.

Budwood is distributed by State Departments of Agriculture and equivalent bodies to commercial nurseries. Some also distribute *P. calleryana* seed. Many *P. calleryana* (D6 strain) trees have been distributed to nurseries in earlier years by the NSW Department of Agriculture and these are used as seed sources by some of those nurseries.

All propagation material including seed provided by the NSW Department of Agriculture is distributed through the NSW Horticultural Propagation Co-operative Society, P.O. Box 13, Rouse Hill, NSW, 2153.

Pollination

Provision should be made for cross-pollination. The important cultivars are generally regarded as commercially self-infertile though exceptions have been noted. In California, for instance, Nijisseiki is regarded as self-fertile. The point is worth making, however, that fully pollinated flowers usually develop larger fruit of more even shape.

In addition to having two or more compatible cultivars there must be an effective blossom overlap period between the cultivars. Additionally, the presence of pollen transfer agents is essential. With European pear cultivars the honey bee is by far the most important. Wild bees are not always plentiful, so it may be necessary for negotiation with a beekeeper to introduce bees onto the site for the duration of the blossom period. European pears are not a particularly attractive source of food for honey bees, the blossoms of which may not be effectively worked over when there are other much more attractive food sources available. The relative attractiveness of Nashi blossom has not been studied but is assumed to be little different from that of European cultivars for which the provision of three strong hives of bees per hectare are recommended.

Table 5. Blossoming Periods of Nashi & Two European Cultivars*

Cultivar	Year	First Bloom	Full Bloom	Last Bloom
Chojuro	1983	30.9	4.10	14.10
Nijisseiki	“	2.10	5.10	14.10
Packham’s Triumph	“	1.10	3.10	14.10
Williams	“	2.10	6.10	16.10
Tsu Li	1984	26.9	8.10	14.10
Chojuro	“	9.10	16.10	20.10
Shinsui	“	8.10	12.10	21.10
Nijisseiki	“	9.10	16.10	24.10
Packham’s Triumph	“	9.10	13.10	23.10
Williams	“	10.10	15.10	21.10
Tsu Li	1985	14.9	27.9	8.10
Chojuro	“	1.10	7.10	16.10
Shinsui	“	3.10	9.10	17.10
Nijisseiki	“	5.10	9.10	18.10
Packham’s Triumph	“	5.10	10.10	16.10
Williams	“	5.10	9.10	18.10

*Data collected at Orange - Mrs. J. Campbell, Senior Research Horticulturist.

Table 5 shows that at Orange there is good overlap between Chojuro, Shinsui and Nijisseiki. These are cross-compatible. Information in the table should be accepted as a guide only. The Department of Agriculture, Victoria for instance reports [10] there is a problem with Chojuro flowering too early for Shinsui and Nijisseiki in the Goulburn Valley of that state and suggest Packham’s Triumph as a better option.

In USA [11] Tsu Li and Ya Li are reported to blossom together and are early. They are cross-compatible. Whilst there is only a partial overlap of blossoming with these and some of the Japanese cultivars, e.g. Nijisseiki, Chojuro, they are reported in USA to set good crops when planted amongst Japanese cultivars.

The USA experience also indicates that Williams is an effective pollinator for Chojuro and Nijisseiki, the blossom overlap periods for which are illustrated in Table 5.

Kosui is pollinated by Chojuro and Hosui - and probably others. It is considered as a good pollen source and would be very satisfactory for pollinating Nijisseiki and Hosui [9]. Kosui is however cross-incompatible with Shinsui.

Layout for Pollination

The effective pollinating influence of a cultivar frequently does not extend more than two rows so the layout of major and pollinating cultivars is important. Where a great majority of one cultivar is desired the 1 in 9 layout provides a good working system (Fig. 1).

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+ + + + + +	p p + + + + P P	+ + P P P P + + + + P P
Suitable when minimum number of pollinators are required - an 8: 1 ratio.	Main cultivar and pollinator in a 2:1 ratio	Two cultivars in equal proportions

Figure 1. Distribution of Pollinators in Standard Plantings

With this, commencing with the second tree in the second row, every third tree in every third row is a pollinator. There are eight trees of the main cultivar to every one tree of the pollinating cultivar and yet every main cultivar tree is immediately adjacent to a pollinator. If a 2: 1 ratio is required, the main cultivar can be planted in units of two or four rows and the pollinators in units of one or two rows respectively. Where equal numbers are required, plant cultivars in blocks no more than four rows wide, providing pollinators on either side.

Some overseas research has indicated that bees mainly work along closely planted hedgerows, rather than across rows, to the detriment of cross-pollination. This was not confirmed in a trial at Orange, where bee movement was investigated in a moderately dense hedgerow of apples, in this adequate across-rows movement occurred. However, it may be a wise precaution in hedgerow or trellised plantings which are likely to become very dense to locate pollinators within each row, especially in cool areas, to approximate the design shown in Fig. 2.

In both standard and hedgerow/trellised plantings where a minimum number of a pollinator is planted amongst a single main cultivar there may be some advantage at harvest time if one is a clear skin and the other a russeted cultivar.

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Figure 2. Distribution of Pollinators in Hedgerow/ Trellised Plantings

Planting

Bare rooted trees should be planted whilst dormant. Roots commence to grow before new above-ground growth is evident. Some new training systems now aim to make maximum use of growth produced in the nursery rather than removal of much of it at planting time. Where light levels of pruning or nil pruning are adopted at planting time, late planting can lead to very poor establishment - particularly where soil has not been adequately prepared and where irrigation is unavailable.

Systems and Planting Distances

It has not been possible to fully exploit high density plantings as it has been with apples because of the scarcity of suitable size-controlling rootstocks. However, promising tree training research currently being undertaken with Nashi by the Department of Agriculture, Victoria at Tatura is showing that a complete break from traditional tree forms, using the Tatura trellis, may go a long way towards overcoming restricted availability of size-controlling rootstocks.

On the Central Tablelands of NSW, at Orange, a trial has been initiated to compare Central Leader, Lincoln Canopy, and MIA Trellis planting/training systems. In the north of NSW, at Wollongbar, it is proposed that a trial will compare Central Leader, Tatura Trellis, and Lincoln Canopy systems.

It will obviously be some years before the optimum system(s) become evident. In the meantime it will be necessary to base suggestions on limited domestic experience and observations here and overseas.

One important feature to become evident is the susceptibility of Nashi fruit to wind damage, particularly the clear skinned Nijisseiki. Limb, lateral and even excessive leaf movement can result in unsightly blemishes. Windbreak protection is required, with trees or other vegetative growth set in place before the Nashi are planted in all but the very best protected sites. Experience indicates that on sites sufficiently protected for, say, apple production, significant skin abrasions can become evident on fruit of free-standing central-leader Nashi trees. Under

these circumstances it is suggested that a trellised form of culture in which the growth canopy consists of less moving parts will be more desirable than free standing trees. Tatura trellis or a modification of this system or palmetted trees on a vertical trellis appear to be preferred options.

The stylistic Tanashitate trellis system, very widely adopted in typhoon-liable parts of Japan, features a horizontal growth canopy that may cover an entire orchard area. It provides testimony to the effectiveness of a system that considerably reduces limb and lateral movement and thus keeps mechanical damage of fruit to an absolute minimum.

In wind prone situations less pre-harvest fruit drop is likely to occur on trellised trees. In any situation Tatura or palmette trained trees can be anticipated to commence cropping earlier and provide a higher percentage of unblemished fruit than central leader or vase trained trees. The big immediate disadvantage of trellised systems is the appreciably higher establishment costs.

Kosui and Hosui are both lateral fruiting cultivars inclined to produce laterals with narrow angles of attachment to vertical stems. Narrow angles of attachments lead to structural weaknesses. These cultivars would therefore appear to be more suited to trellis culture than a central leader system.

The following planting distances are suggested where *P. calleryana* is the rootstock:

System	*Distances*	*Trees/ha*
Tatura Trellis (standard)	5 m x 1.5 m	1 333
Palmette Trellis	5 m x 3.0 m	666
Central Leader	5 m x 3.0 m	666

Crop Regulation - Fruit Thinning

Experience of the past few years has reinforced earlier advice that adequate fruit thinning would invariably become an integral part of management. Where cross-pollination is adequate, and notwithstanding favourable growing conditions, there is little or no chance of the crop making up to good commercial sizes without removal of surplus fruit. The Nashi cultivars examined, especially Nijisseiki and Chojuro, are very prolific, setting up to five fruits to each bud cluster.

Insufficient research has been undertaken to date to relate crop load to planting distance and fruit size for mature trees. On an assumption that a good central-leader planting at 5 m x 3 m will produce about 45 t/ha, this will represent 3.75 'bushels' or 16.8 x 4 kg trays (gross production that does not allow for inferior grade or wastage) per tree. With the aim of producing fruit that will pack out mainly between 16 and 23 pieces of fruit per tray (av. 250- 175 g/fruit), a tree should carry about 270-390 pieces of fruit at maturity. These figures are rather hypothetical, but bring into focus the need for removal of excess numbers if good commercial sizes are to be attained and for promotion of good cropping in the following year. It may well happen that as market prices adjust downwards in response to increasing production, average fruit size sought will become larger than at present, making the need for heavier thinning.

Various guides for thinning are available, for example in Japan 1 fruit may be retained for each 20 to 30 well developed leaves, or 15 fruit per square metre of trellised canopy. However, Japanese growers aim to produce large fruit - 300-350 g. NSW Tableland experience points to the need for thinning clusters to a single fruit, and the complete removal of fruit from some clusters, where these will result in fruit being retained closer than about 15 cm apart. The opportunity should be taken during thinning to remove lopsided fruit which results from inadequate pollination, and any that are blemished.

In Japan thinning commences very early - when the fruit is about 15 mm in diameter when only one fruit in any cluster is retained. Normally fruit resulting from set of the King bloom and the last or youngest to set are removed. Fruit of the former tend to be flattish in shape and the latter too tall. One fruit, set from the 2nd, 3rd or 4th flower is retained. This preliminary thinning is followed up later to adjust crop load and remove blemished or misshapen fruit.

At present chemical thinning cannot be recommended. Hand thinning is labour intensive, and for mature trees will probably require inputs between 300 and 600 hours of labour per hectare annually.

Irrigation

On the assumption that production of Nashi will not be a low cost enterprise the availability of adequate soil moisture will fulfil an important role in maximising production, quality and returns.

Rainfall and crop requirements are such that even in the most reliable and better watered areas, horticultural crops generally provide economic response to provision of irrigation - more so now with adoption of higher density planting technology, where it should more appropriately be regarded as essential.

Regular heavy crops of fruit within size ranges sought by the market will largely provide the key to profitability. There is already evidence in the market place that consumer demand for Nashi will be little different from most other fruit types where there is a preference for larger fruit rather than smaller.

Irrespective of adopted system or scheduling, the aim should be to provide adequate moisture to promote fruit set and its development without checks. Growth development without disruption has particular significance with early maturing cultivars and those in which average fruit size tends towards smallness, e.g. Shinsui.

Disease and Pest Problems

The significance of various disease and insect pests on this crop is not sufficiently clear at this stage. There are some grounds for suggesting that a more relaxed programme of fungicides than for European pears may be appropriate. However, some cultivars of Nashi are susceptible to powdery mildew, a problem not normally encountered with European pears. This is not a problem at present but it has been observed. Scab, the most important disease of European pears has not been observed on Nashi trees in NSW so far.

It is anticipated that measures will need to be taken annually - some on a programme basis, e.g. for control of codling moth and fruit fly, while others will probably require control on a more sporadic basis, e.g. mites, pear and cherry slug, San Jose scale, plant damaging bugs and chewing insects. While it can be anticipated that regular spray applications will be needed for control of codling moth in NSW Tableland and Inland situations this pest may not be of similar significance under coastal conditions. San Jose scale is likely to be a lesser problem on the coast than inland. Coastal growers can anticipate the need for control measures for Queensland fruit fly during the two months preceding and perhaps during harvest.

No specific instances of phytotoxicity have been noted in NSW but New Zealand literature [9] indicates that considerable care should be exercised in choice of chemicals for which no previous experience exists. It has been reported in that country that emulsifiable concentrates (ECs) have a devastating effect on foliage. Reference is specifically made to triforine and maldison as chemicals that will drop leaves. Personal communications also implicated chlorpyrifos amongst the ECs that have caused damage.

Propagite and calcium salts were also reported to have caused damage. The foliage of Kosui and Hosui is reported to be particularly sensitive to spray injury. It would appear that not all ECs are damaging or that some are not damaging under certain conditions, e.g. endosulfan and fenarimol have been safely used in NSW.

Birds and Flying Foxes

In some areas damage by birds can be anticipated. They are a problem in Japan and have already appeared as a potential problem in New Zealand. Hosui and Kosui are two cultivars reported to be particularly attractive to birds - perhaps because of their sweetness. Isolated plantings surrounded by considerable timber would appear to be most vulnerable. Applications of methiocarb will discourage smaller birds.

Flying foxes, which are now a protected animal, loom as a potential problem in areas frequented by this pest. A permit is required for their destruction.

Harvesting and Storage

Fruit should be handled very carefully and picked into rigid plastic or metal containers. In

Japan foam liners are frequently used at the bottom and at intermediate levels of containers to protect fruit. Picking bags frequently used for European pears will invite scuff marks and bruising.

It remains to be learned which types of sorting/grading equipment are most suitable for handling Nashi fruit. The skin of fruit which is too advanced in maturity will most likely become discoloured with unsightly scuff marks during normal mechanical grading and sizing. For some equipment this may mean harvesting and sorting a little before optimum maturity resulting in some loss of fruit size and flavour.

Where relatively small areas are grown with the objective of providing a high quality, premium pack, hand sorting may be found a sound proposition particularly since a significant increase of fruit size can be anticipated during the run-up period to harvest and during prolonged harvest periods. As Nashi fruit becomes mature the ground colour becomes yellow, soluble solids increase and flesh firmness decreases. The relationship between these factors has been little studied in Australia so far. Fruit maturity and storage research of Nashi fruit is currently being undertaken by the Horticultural Research Institute, Knoxfield, Victoria.

In Japan colour charts and the ease with which the fruit stem can be separated from the spur by an upward twist are two techniques used widely to provide a guide to harvesting maturity. Preliminary research at Knoxfield(12) suggested the following guides for determining harvest maturity of Nijisseiki intended for cool storage. Change in skin colour - some green colouration still evident. Flesh firmness, 4-5 kg, as measured with a penetrometer using the standard pear plunger, and soluble solids between 10 and 12%.

A number of consignments of Nashi fruit were examined in Sydney markets during the second half of February 1986. Harvesting of these was said to have been based mainly on skin colour, though some growers were said to have also aimed for soluble solids of 12%. Exhaustive canvassing was not conducted but opinions more generally suggested the desirability of a less green skin colour and more sweetness. A few specimens examined tested 10% soluble solids. Notwithstanding these comments, the fruit observed, excepting for some very long counts (approx. 100 g fruit) sold at very attractive rates.

Overseas, fruit intended for direct marketing is generally more mature at harvest time. In California, for instance, fruit of Nijisseiki when considered suitable has average values of 3.2 kg pressure, 12.3% soluble solids and a greenish-yellow ground colour [11]. Field observations in Japan indicated a fairly well advanced greenish-yellow ground colour at harvest.

Preliminary New Zealand research [13] indicates that Nashi grown in that country may have higher soluble solids than equivalent fruit in Japan. Based on New Zealand taste preferences, optimum eating quality of Shinsui, Kosui, Hosui and Nijisseiki corresponded to soluble solids of 14%, 14%, 14% and 12% respectively.

The New Zealand work has also shown with the above cultivars that once harvested, there is no marked increase in the soluble solids content of Nashi fruit. The research at Knoxfield is showing that some cultivars continue to ripen markedly after harvesting, e.g. Shinsui.

The preliminary research in New Zealand also shows that storage life of some cultivars may be considerably better than indicated in Japan. Shinsui for instance was successfully stored for 24 weeks. However, the New Zealand work suggested that at O°C, Shinsui, Kosui, Hosui and Nijisseiki can be stored for 10 weeks, as after 12 weeks there is some risk of disorders.

The research at Knoxfield suggests that Nijisseiki may be air-stored for 12-16 weeks and up to 24 weeks in CA using similar atmospheres as those used for Packham's Triumph. The Knoxfield work, however, noted skin blackening which was assumed to be associated with chilling injury. Rapid cooling to O°C was suspect, the preferred treatment being to cool rapidly to 5°C then reduce slowly to O°C.

Packaging and Grade Standards

In Japan [1] most generally a 15 kg net (3 layer) carton is used, with the exception that softer textured cultivars such as Kosui and Hosui are packed into 10 kg (2 layer) cartons. A thick polypad is usually placed at the bottom of the carton under the lower tray. Between each layer of fruit is placed a thin polypad. Above the top tray of fruit is placed a thin perforated polypad, and above this and below the carton lid a thick pad of the same type as used on the bottom. Occasionally polybag liners are also used. Some use is also made of single layer trays. The methods of handling described illustrate the careful measures taken to present a top quality commodity.

So far as can be ascertained, all Nashi fruit marketed in NSW and Victoria to date have been packaged in single layer trays and have been well received. At present this method of presentation would appear to be the most appropriate. It is considered however that a colour other than green could more appropriately be chosen for carton tray inserts in order to better highlight the fruit of Nijisseiki.

As a new commodity and in the absence of grade standards every effort should be made to provide the market with well presented fruit of high quality. With current production quite inadequate to satisfy local demand it may not be difficult to sell all that is produced quite profitably for a period. However, long term viability will only be secured if market/consumer requirements are identified and those requirements met.

Acknowledgements

The author is appreciative of assistance provided by colleagues in the N.S.W. Department of Agriculture, Officers of the Department of Agriculture, Victoria and the Victorian Nashi Fruit Association. He is particularly indebted to District Horticulturists, Mr P. O'Brien and Mr B. Valentine of Bathurst and Orange respectively, who developed the Economics of Establishment and Production.

Also to Mrs J. Campbell, Senior Research Horticulturist, Agricultural Research & Veterinary Centre, Orange for provision of blossoming data.

References

1. Johnson, J.F. 1983. *A Study of Asian Pears in Japan*. Miscellaneous Bulletin No.8. 4,41-43 & 34,4.
2. Minnis, D. 1984. *Australian Fresh Fruit, Vegetables and Flowers Exported.to South East Asia and Japan in 1984*. Report to Department of Primary Industry.
3. Overcash, J.P. and N.H. Loomis 1959. *Prolonged Dormancy of Pear Varieties following Mild Winters in Mississippi*. Proc. Amer. Soc. Hort. Sci. 73:91-98.
4. Seike, K. 1973. *Japanese Pear Culture*. Farming in Japan Vol. 7, (3) 27-30.
5. Westwood, N.M. 1978. *Temperate Zone Pomology* 25.
6. Sherman, W.B. and T. Crocker 1982. *Low Chilling Pears. The Pear - Cultivars to Marketing* 130-136.

7. Hsing-Fang, L. 1979. *Fruit Growing in Taiwan* Vol. 2.
8. Westwood, M.N. and N.E. Chestnut 1964. *Rest Period Chilling Requirements of Bartlett Pear as related to P. calleryana and P. communis Rootstocks*. Proc. Amer. Soc. Hort. Sci. 84:82-87.
9. Van Workum, M.B. 1985. *Nashi - Culture & Management* 6, 17 & 23.
10. Jerie, P. & L. Van Heek. 1985. *Nashi Fruit Growing in Northern Victoria - Field Day Notes*.
11. Griggs, W. & B. Iwakiri. 1977. *Asian Pears in California*. 4-6.
12. Little, C. 1985. *Nashi Notes* (Supplement to Northern Victorian Fruitgrower). Vol. 9 No.5 - and personal comrnunications.
13. Lallu, N. 1985. *Nashi News* (New Zealand Nashi Growers Assoc. Inc. Vol. 1 No.1).

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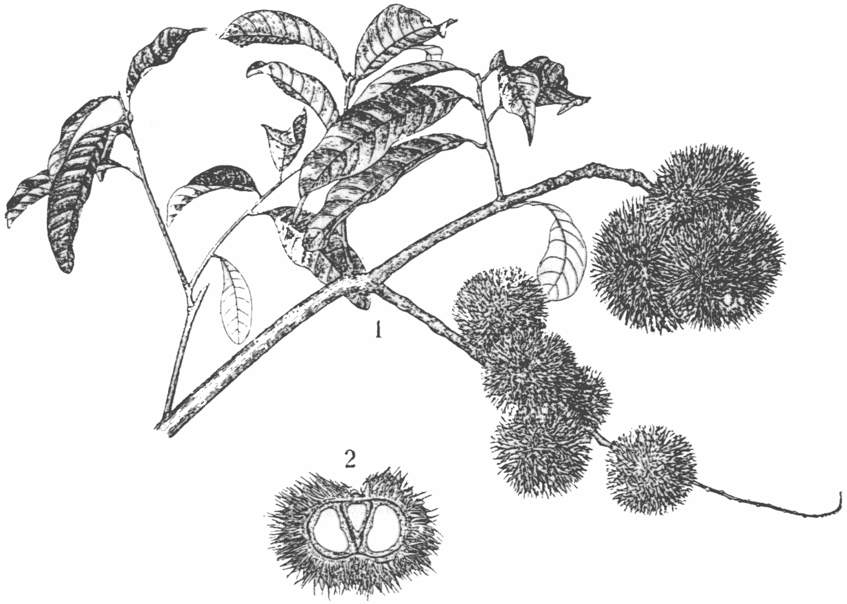
[Based on a report compiled in the Department of Agriculture. New South Wales].



Indonesian chestnut, *Castanopsis argentea*

JUJUBE GRAFTING

ROGER MEYER
16531 Mt Shelly
Fountain Valley. CA 92708, USA

Jujube trees readily send out sprouts from the roots. If allowed to grow during the year, they may be harvested the next winter and transplanted to pots or other locations. Then grafting or budding can be done so that you will have a known varietal plant.

The question keeps coming up - "why do I need to graft these sprouts when they come from a known plant?" The reason is that, at least for the two major varieties, Li and Lang, your plant was grafted onto seedling rootstock. Hence, it will not produce true rootsprouts to your named variety. For some reason, propagators apparently haven't yet been successful to get the named varieties to root from cuttings. This presents a challenge and a chance for the backyard grower to somehow get the Li or other variety on its own roots.

One exception to the above may be the Sherwood variety. However, I would like to wait another season or so to see how well it really does with a good fruiting variety.

COLLECTING AND SAVING SCIONWOOD. Dormant scionwood can be collected during the winter months and stored under refrigeration until needed. When collecting the wood, I look for branches that grew vigorously last season. This wood usually has a deep brown colour instead of the older wood which is definitely grey. I get far better success when using this year old brown wood. Clip sufficient scions into six to twelve inch lengths and snip off the spines which are on each side of each bud.

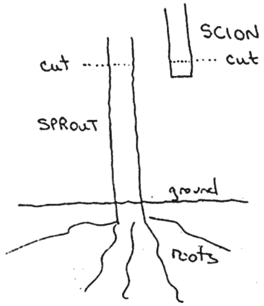
Wrap the scions in newspaper and soak in water a few seconds. Let drain and squeeze off excess moisture. Seal in plastic bags (such as bread bags) and store in the refrigerator. Wood stored properly (kept moist and cool) will still be good in July.

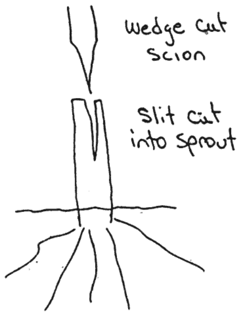
GRAFTING. When you're ready to graft, you'll need the following items: 1. Grafting knife or simply a well-sharpened steak knife (non-serrated). 2. Grafting tape or a light to medium weight green stretch tape commonly available at nurseries, hardware, or larger discount stores. 3. Hand clippers.

First, find a scion which has the same diameter as a straight portion of the sprout. With the hand clippers, snip off the upper portion of the sprout above this point. Then, cut off the last 6 mm of the scion stick to renew the scion. Make two wedge cuts about 25-30 mm long on each side of the scion so that it comes to a point. Slice down the centre of the sprout an equal distance to that of the wedge. Slide the scion wedge into the slit and make sure at least one side of the barks align exactly.

With a 0.5 m or so length of the stretch tape, begin below the lowest wedge point and wind the tape around the graft to completely cover the cut areas. With the last 10 cm or so of the tape, make a loop, insert tape end, and tighten so that the tape remains covering the graft. You've got it! See the drawings which are included.

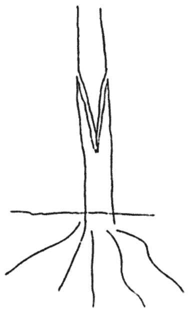
JUJUBE GRAFTING

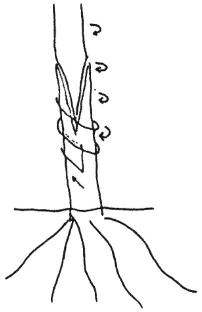




a) Find scion with diameter the same as plant.
b) Cut sprout and lower 6 mm off the scion.

c) Wedge-cut Scion on two sides.
d) Make slit cut into sprout.





e) Slide wedge into slit.

f) Begin tape to seal and protect graft.
Wrap snugly.

SOME HINTS

1. When possible, I like to watch the mother tree before I take the scionwood. I watch for the very first signs of the buds greening and when that occurs I take the scion sticks for immediate grafting.

2. By waiting for the above, you may find that the sprouts have already sent out green leaves. Go ahead and graft. The plants do not bleed too much and I get the best takes at this tIme.

3. For reasons unknown to me, most plants I've grafted send out their leaflets and fruiting spurs but generally no major trunk the first season. The trunk is sent out from a bud the next year. Anyone out there know why this occurs?

4. I put a Band-Aid on my grafting thumb to protect it from all the little slices I used to get from the grafting knife.

5. Be sure to remove the stretch tape next year. It will strangle the tree unless it's removed.

6. When digging out the root sprouts, I find it far easier to completely clip off all side branches, leaving only a whip. Then cut off all spines before digging out the plant. Those spines can be brutal.

[Based on an article in *Pomona* (North American Fruit Explorers), 22(3), Summer '89].

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, PO Box 445, Caboolture, QLD 4150.
Department of Primary Industries, PO Box 46, Brisbane, QLD. 4001.
Rare Fruit Council of Australia, PO Box 707, Cairns, QLD 4870.
Sunshine Coast Avocado Grower's Association, PO Box 822, Nambour QLD 4560

South Australia
CSIRO Division of Horticultural Research, GPO Box 350, Adelaide SA 5001.
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.

Victoria
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, GPO Box 2196T, Melbourne, VIC 3677.

Western Australia
CSIRO Division of Tropical Crops, Kimberley Research Station, Kununurra WA 6743
Department of Agriculture, Baron-Hay Court, 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.
Tree Crops Centre, PO Box 27, Subiaco WA 6008
Western Australian Nut and Tree Crop Association (Inc.), PO Box 565, Subiaco, WA, 6008.

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

Chile
Instituto de Investigaciones Agropecuarias, Casilla 439/3, Santiago.

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

Israel
Department of Subtropical Horticulture, Volcani Centre, PO Box 6, Bet Dagan, Israel.

Italy
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.

United States of America
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.
Connecticut Nut Growers Association, 27 Baldwin Rd, Manchester, Connecticut 06040.
Friends of the Trees Association, PO Box 567, Moyie Springs, Idaho 83845, USA.
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.
Iowa Nut Growers Association, Stewart Road, RR 6, Iowa City, Iowa 52240, USA.
Kansas Nut Growers Association, PO Box 247, Chetopa, Kansas. 67336
Michigan Nut Growers Association, 199 Strongwood, Battle Creek, Michigan 49017.
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.

Venezuela
Foundation para el Desarrollo de la Region Centro Occidental de Venezuela, Apartado 523, Borquisimeto.

Addresses of Nurseries and Commercial Sources

Please notify the Editor of any omissions or errors.
Entries in bold type are associated with members of WANATCA

WESTERN AUSTRALIA

Blossoms Garden Centre, 2311 Albany Hwy, Gosnells 6110. Retail and wholesale, large range of tropical, exotic and temperate fruit and nut trees.

Dawsons Nursery, Hale Rd, Forrestfield 6058. General garden centre with range of traditional fruits and nuts.

Granny Smith's Bookshop, PO Box 27, Subiaco 6008. Specialists in books on nuts, fruits, and useful trees. Efficient mail-order service, free catalogues. Phone (09) 386 8093, Fax 386 7676.

Kelmscott Azalea Gardens, 41 Roberts Rd, Kelmscott 6111. Retail garden centre. Avocado, blueberry, mango, persimmon, pistachio, macadamia, etc.

Nutland Nursery, 97 Carabooda Rd, Wanneroo 6065. West Australian producers of nut and fruit trees Avocado, pecn, macaamia, chestnut, pistachio and others. Contract Growing. (09) 407 5474

Nut Tree and Conifer Nursery, 52 Croydon Rd, Roleystone 6111. Order in advance.

Nut & Tree Crop Consultants, PO Box 27, Subiaco, 6008. Consultancy services for commercial applications. Phone (09) 386 8093 Fax 386 7676.

Olea Nurseries, RMB 44, West Manjimup 6258. W.A.'s largest producer of temperate fruit and nut trees. Wholesale only.

Pecan Industries, PO Box 68, West Perth 6005. Wholesale suppliers of pecans, jojobas, pistachios, chestnuts. Planting and management services.

Richards, A., 1349 Albany Hwy, Cannington 6107. Propagation and nursery seeds.

Waldeck Nurseries, Russell Rd, Wanneroo 6065. Large Perth chain of garden centres, stock more popular fruits and nuts.

Zamia Nursery, 1 Coppin Road, Mundaring, 6073. Propagators of stone and pome fruit, grapes and other temperate fruits. Rootstocks and contract growing.

VICTORIA

Australian Blueberry Nurseries, Boundary Rd West, Narre Warren East 3804.

Bloms Seeds, P.O. Box 335 Dandenong 3175. Extensive listings of trees, shrubs, palms, flowers and vegetables.

Blueberry Hill Nursery, R.S.D E655, Ballarat. Blueberries, feijoa.

Botanic Ark Nursery, Copelands Rd, Warragul 3820. Wide range of unusual and useful plants.

Flemings Monbulk Nurseries, Macclesfield Rd, Monbulk 3793. Temperate fruit tree wholesaler.

Goodman, C.J., Box 47, Bairnsdale 3875. Temperate deciduous fruit and flowering fruit trees. Wholesale and retail.

High Grove Nursry, Mt. Stanley Rd., Stanley 3747. Propagators of grafted chestnuts, walnuts, and layered hazelnuts.

John Brunnung & Sons, Somerville 3912. Fruit tree wholesaler with large traditional range.

Lucas Liners, PO Box 81, Olinda 3788. Mass producers of 1-year seedling trees, including some nuts.

W A Shepherd & Sons, Moorooduc, 3933. Good range of temperate fruits and berries.

SOUTH AUSTRALIA

Balhannah Nurseries, Balhannah, 5242. Traditional fruits.

Freshford Nursery. Highbury, 5089. Grafted walnuts, persimmons, and pecans. (08) 389 2343.

Perry Nurseries, Kangarilla Rd, McLaren Flat 5171. Avocado, pistachio, quandong, carob, guava tamarillo, chestnut.

Tolleys Nurseries, PO Box 2, Renmark 5341. Citrus specialists, supply trees, seeds, and budwood.

TASMANIA

Hazelbrook Farm Nurseries, R.S.D. 1600 Pine Rd, Penguin 7316. All stone fruit, hazelnut, chestnut, deciduous ornamentals. (004) 37 2072.

Phoenix Seeds, PO Box 9, Stanley 7331 (004) 58 1105. Good range of unusual 'permaculture' seeds, many exotic fruits, some nuts.

NEW SOUTH WALES

Blue Hills Blueberry Farm and Nursery, Tilba Tilba 2546. Chestnuts and N.S.W, waratahs.

East Coast Blueberries/Sector (Nurseries) Pty. Ltd.. P.O.Box 7, Gosford East, 2250.

Fruit Spirit, Research Nursery and Gardens, Dorroughby 2480. Paul Recher, Wide range exotic, useful tree crop seeds. (006) 89 5129

Gilbert's Wholesale Nursery, Pacific Highway, Moorland 2443. Nick Gilbert (065) 56 3148. Shahtoot King White Mulberry originators; grafted macadamias, kiwi, cherimoya, persimmon, nashi, avocado, casimiroa, low-chill peaches.

Hunter pecans, P.O. Box 217, Muswellbrook 2333.

H.G. Kershaw, PO Box 84, Terry Hills 2084. Wide range of tree, shrub, and palm seeds.

Mountain Blue Nursery, Walton Rd, Federal via Lismore 2480. Blueberry specialists.

Premier Nurseries, PO Box 400, Griffith 2680. Wholesale and retail supplier of fruit trees.

Riverina Nurseries, PO Box 400, Griffith 2680. Range of fruit trees.

Sunraysia Nurseries, Sturt Highway, Gol Gol 2739. Grapes, olives, citrus and avocados.

Yarrahapinni Fruit Trees, A. & K. Seccombe, c/-P.O. Stuarts Point 2441. Large range grafted fruit and nut trees, vines, blueberries.

QUEENSLAND

Avondale Nursery, PO Box 30, Smithfield, Cairns 4870. Lychees. (070) 55 6395.

Birdwood Nursery, Blackall Range Rd, Woombye 4559. Avocado, custard apple, lychee, mango, kiwifruit.

B W Whoesale & Exotic Nurseries, PO Box 125, Childers 4660. Avocados, lychees, custard apples, pecans.

Fitzroy Nurseries, PO Box 859, Rockhampton 4700. Very good range of tropical fruits and nuts, pecans, macadamias.

Flower's Tropical Nursery, Rosemount Rd, Nambour 4560. Specialists in carambola, sapote, abiu and over 100 varieties of tropical fruit trees.

Honnef's Fruit & Nut Tree Nursery, Callaghan Rd, Narangba 4504. Rare and traditional fruit trees for Brisbane area. (07) 888 1223.

Huonbrook Nursery, Mullumbimby 2482. Over 100 varieties grafted subtropical fruits and nuts.

Langbecker Nurseries, PO Box 381, Bundaberg, 4670. Avocadoes, pecans, custard apples.

Limberlost Nurseries, Freshwater, Cairns 4870. Range of tropical trees, including some fruits and nuts.

Peninsular Plants. 93 Mason St, Mareeba 4880. Large range of tropical and subtropical fruit trees. (070) 92 2797.

Pioneer Valley Nursery, P.O.Box 43, Marian 4741. Tropical fruit tree nursery.

Rainforest Nursery, 23 Reynolds St., Mareeba 4880. Grafted avocado, mango, citrus, lychee etc. (070)92 1018.

Sippy Farm Lychee Nursery, Eudlo 4554. Wholesale growers of all lychee varieties, including No Mai Chee.

Tablelands Nursery, Cooran 4569. Organic growers of exotic subtropical fruit trees. (071) 85 1522.

Turner Horticultural, PO Box 109, Spring Hill 400. Grafted macadamia, grape, tropical fruit.

OVERSEAS

CHILE

Jan Correa, Casilla 53027, Correo Central, Santiago 1, Chile. Supplier of seeds of fruits, nuts and other useful trees from Chile.

PHILIPPINES

Edwin L. Belem, Km 73, Maharilka Highway, Alaminos, Laguna 4001, Philippines. Suppliers of range of tropical fruit seeds, including marang, pulasan, pili, mabolo, bulala.

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Alcoa Tree Coordinator [D Redreau] PO Box 172 Pinjarra 6208
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Allan (Andrew) PO Box 40 Carnarvon 6701
APACE Western Australia Winter House Johanna St North Fremantle 6159
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ARS Scoresby [Librarian] PO Box 174 Ferntree Gully Vic. 3156
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Australian Macadamia Society [Ted Davenport] 146 Virginia Ave Hawthorne, QLD. 4519
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Blight (J M) RMB 237 Beverley 6304
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Boucaut (W) Kelmscott Azalea Gdns 41 Roberts Rd Kelmscott 6111
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Brenkley (D J) Tenindewa 6632
Brew (Peter) Stringybark Nursery via Cathcart NSW 2632
Brinsden (Mr P F) 21/23 Hammond Rd Claremont 6010
British Library, Serial Acquisitions 14799642 SWETS Boston Spa Yorks LS23 7BQ UK
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Brookman (G) RAC Roseworthy SA 5371
Brown (D H) 61 Charles St Northam 6401
Bruce (David) 22 Packer Cres Paradise SA 5075
Bruce (Mr J) 35 Boulevard Dr Park Ridge 6210
Bruce (R) 112 Marine Tce Busselton 6280
Bruekers (M) 25 Glen Rd Lesmurdie 6076
Bryant (A V) PO Box 45 Balingup 6253
Burton (Edmund D F) 10 Row Place Noranda 6062
Butcher (Robin & Peggy) 145 Great Eastern Hwy Glen Forrest 6071

(C)
California Rare Fruit Growers State University Fullerton Fullerton Ca. 92634 USA
Campbell (Mr R S) Tiaro Park Tiaro QLD 4650
Cardwell/Johnstone Brnch RFCA PO Box 51 El Arish QLD 4855
Cargill (R D) 60 McKenzie St Wembley 6014
Carlan Nursery 1062 Grand Jnctn Rd Holden Hill SA 5088
Carroll (Hugh & Louise) 1325 S Kihei Rd Suite 114-1114, Kihei Hawaii 96753 USA
Chauhan (Dr K D) Amerbharat Library PO Unjha 384170 North Gujarat India
Child (Mr & Mrs F H) RMB 477 Lot 9 Cumming Rd Oakford 6113
Chislett (Mr W R) PO Box 743 Orange NSW 2800
Christensen (Dr P & Mrs H) Post Office Balingup 6253
Clarke (Michael) 33 Valley Rd Epping NSW 2121
Clements (Mrs E) 7 Warton St Mosman Park 6012
Clifford (H L) Pearce's Creek Rd Alstonville NSW 2477
Clover (Bill) PO Box 624 Manjimup 6258
Collins (Mr N C) PO Cudlee Creek SA 5232
Commonwealth Development Bank [Chief Rural Officer] GPO Box A32 Perth 6001
Constantine (E P) RMB 9020A Albany 6330
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