ISSN 0312-8997

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Price $25.00

WANATCA YEARBOOK • Volume 22 • 1998

WANATCA Yearbook 1998

The Limmonik, *Schizandra chinensis* (see page 38)

West Australian Nut and Tree Crop Association (Inc.)

Yearbook 22 • 1998

Registered by Australia Post: Publications WBH 0868 ISSN 0312-8997

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WANATCA Yearbook

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References to the ATCROS Directory

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

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

West Australian Nut and Tree Crops Association (Inc.)

P0 Box 565, Subiaco, WA 6008

Publications
The Association publishes a quarterly magazine 'Quandong' and the *WANATCA Yearbook*. Members receive these publications as part of their current year subscription.

Membership
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For further details of the Association see Inside Back Cover

WANATCA Yearbook: ISSN 0312-8997; Supplement to Quandong: ISSN 0312-8989

Typesetting and design: Tree Crops Centre, PO Box 27, Subiaco, WA 6008
Printed in Australia by Optima Press, Perth

ELECTRIC-GANTRY HORTICULTURE:
A Whole-Game Rethink for Tree Cropping

DAVID NOEL §
Tree Crops Centre PO Box 27, Subiaco, WfA 6008, Australia
<davidn@AOI.com.au>

Abstract

Tree Crops, meaning the production of fruits, nuts, beverages, other foods, pharmaceuticals, and industrial and construction raw materials from perennial plants, is the Third Component of rational land use. Unlike the first two components, Stock Raising and Field Crops, it is immensely diverse with thousands of different products, and contains the potential for a huge range of new industries, from major national export items down to small-operator niche markets.

For these reasons, the required investments of information, labour, equipment, and money are more concentrated and on smaller land areas than traditional rural industries, and far more diverse. Major factors affecting economic production of tree crops include skilled labour costs, proportion of available land used effectively, equipment availability and cost, and cost return ratios for pest control and harvesting methods.

Working from a broad analysis of the fundamental factors in this area, a new basic approach to operating tree crop industries has been devised, which has the possibility of substantially reducing costs and raising output, and at the same time would be very quickly adaptable to new crops and new methods of growing traditional tree crops. Labour costs should be reduced by 50% in the first phase, perhaps by 90% later, yields per area should increase by 50%, and quality of produce should increase.

One possible implementation method is described, based on low-cost electrically driven gantries running on a cheap and simple track system, and the potential of this method for extensive automation and remote control is described.

Factors constraining tree crop profits

A great many cost, yield, and profit factors impinge on the growing of tree crops. Here I will pick out some of the major ones, and show how their impact could be favourably altered through a reorganization of the ways in which tree crops are grown.

Land use. Recommendations on tree spacings and planting patterns have altered considerably over the years, in many crops the currently favoured methods involve high tree dens-

§ Member, WANATCA

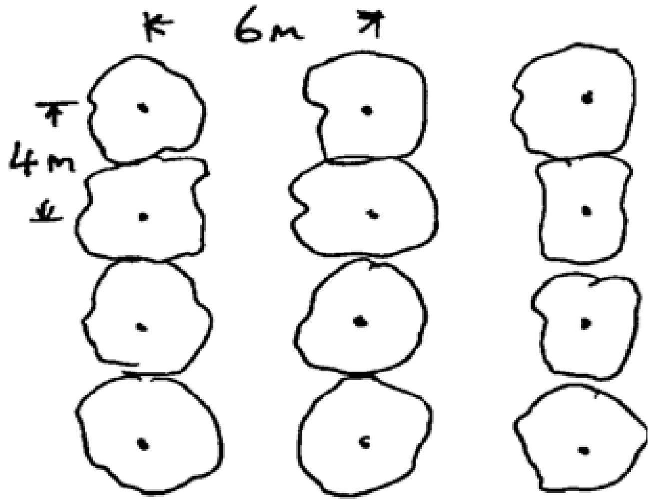

Fig. 1. Tree layouts and land use

ities. Trees may be closely planted in hedgerows or on trellis or wire supports, and the rows are separated by the minimum necessary to allow machines to pass between the rows.

Take as an example a macadamia orchard (Fig. 1), planted at. a spacing of 4m within the rows, 6m between the rows. In this layout., 33% of the land is set aside for machinery. As you go even closer, the amount. of 'unused' land is higher still. In macadamias, around 3 x 5 m is reckoned the densest practical spacing, this has 40% - two-fifths - unused land.

All forms of useful horticulture are based on turning light falling on plants into food or other products. If the two-fifths unused could be converted into macadamia-producing area, in theory yields could increase by a factor of 1.6 - say going from 5 to 8 tonnes to the hectare.

Labour Costs. It will be no news to practical tree crop growers that shortage of their own skilled time, or the labour costs of skilled help, are a huge limiting factor in what can be done in practice with tree crops. And of course this limits profits.

So anything which could substantially reduce time or labour inputs into tree crop production should be of major interest. This is true for harvesting, for pruning, for spraying, and often for weed control and irrigation monitoring.

Other factors. The two factors just mentioned are perhaps the big ones. There are many others, such as:

- *Soil compaction by machinery*
- *Blocking of irrigation lines*
- *Fertilizer application*
- *Safery in using chemicals*

Present Harvesting - Man Plus

In Fig. 2 is a schematic of a common harvesting device -- a fruit picker. The same model

Fig. 2. Standard Orchard Device - The Fruit Picker

can be used for other orchard operations, such as pruning. Let's have a quick look at the essential parts of this device.

Part A is an organic computer assembly weighing about 1.6 to 1.8 kg (less for women). This essential component controls the whole device.

Part B is an organic leverage and activation component which weighs around 3 - 5 kg, this is the part which actually picks the fruit.

Part C is a common transport mechanism typically weighing around 10- 15 kg. Other parts of the whole device perform ancillary functions, such as energy storage and conversion.

Present: Machinery - Tractors Plus

The typical machinery found in orchards consists of a tractor plus attachments, for spraying, mowing, spreading fertilizers and chemicals, as a harvesting aid, and sometimes for mechanical pruning.

Tractor assemblies are a way of mechanizing Part C of the standard orchard device. They can also go part of the way towards mechanizing Part B, but only for crops which do not need careful handling, and they are not much use for skilled operations such as pruning.

Part A of the device, the organic computer control, is very much harder to replace with a non-living component. Australian broad-acre farmers were advised years ago to 'Get Big or Get Out'. And so they typically invested sums of around a million dollars each in big equipment, able to sow or reap many, many rows of wheat or whatever in one pass of the tractor. When you think about it, you can see that their basic strategy is to hook as much mechanics

Fig. 3. Tractor plus sprayer

as possible onto the one component which could not be mechanized - the man behind the tractor wheel.

Tractors used in orchards have many limitations:

• *They cannot have the wide coverage of a field-crop tractor;*

• *This means their labour cost per crop unit is high;*

• *Required access ways for them lead to a big loss in land used for growing;*

• *They are heavy (perhaps 1 tonne), and can compact the soil;*

• *They represent a high capital input;*

• *They are quite expensive to run.*

The Electric Gantry proposal

The main idea put forward here is to use self-levelling, simply-assembled, electrically driven gantries, running above the growing trees on cheap tracks, as devices to deliver all the required services to the trees. Here is one such implementation which could be put into practice (Fig. 4)

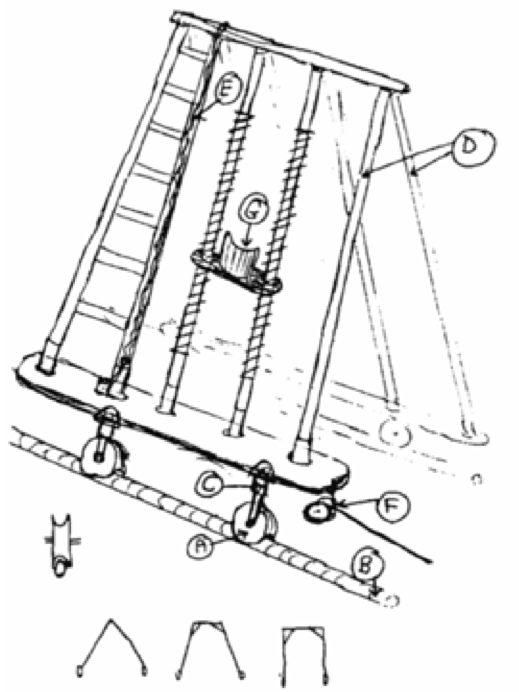

Fig. 4. Basic electric-gantry assembly

The main parts include:

• *twin wheel assemblies (A), driven by electric motors, which run on:*

• *cheap 'rails' (B) which might typically be water-filled, 50 mm black plastic agricultural pipe;*

• *self-levelling legs (C), controlled by hydraulic fluid pumped between them;*

• *frame components (D), similar to meccano pieces, added in to suit the tree height;*

• *utility harness (E) to carry electric cable, hydraulics, and possibly water hoses and electronic control lines from one side of the gantry to the other.*

The utility cables and hoses would be connected to fixed plug-in supply points at the end of tree rows via:

• *powered reels (F), either on the gantry or on the supply points*

To provide ease of working, most installations might also include:

• *power seat (G) to carry occupant, able to rise in frame.*

The normal implementation in an actual orchard would probably see gantries movable along tree rows on row rails as described, and movable between rows on cross rails (Fig. 5).

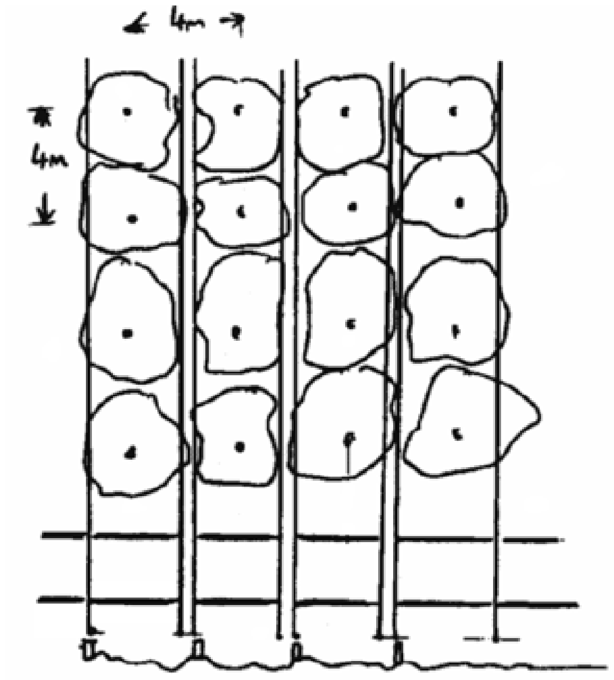

Fig. 5. Orchard layout with gantry servicing

The immediate advantages of such a setup will be apparent:

- No tractor capital cost;
- Equipment is light, could be assembled and moved by one person;
- Lightness means lower energy/fuel costs to run;
- Lightness means no soil compaction;
- No cropping land lost to tractor roads;
- Power seats give ease and speed of work.
- Power seats should reduce labour costs.

The main disadvantages would be:

- Cost of installing service points to ends of rows;
- Improved land-use factor not obtained unless trees re-planted closer.

Where to from here?

Even this basic setup should lead to significant cost savings for orchardists. But the really interesting possibilities lie in extensions of this method in two directions, which we can call 'Waldos' and 'Automation'.

Waldos

Waldos are remote-control devices, artificial 'hands and arms' operated by a human, but remotely. They were developed in the 1950s, firstly to handle radioactive and other dangerous substances, and have also been used to de-fuse bombs, and to obtain samples with very-deep sea submarines.

Waldos do not replace a human operator, but they can make operations much more convenient. Also, the power-operated remote 'hands' can be enhanced and adapted for special purposes.

Some orchard operations would be better if they could be done very early in the day - say picking fruit at 5 am, in the dark, while still cool, and perhaps raining. Chances of getting staff to operate then would be poor. But getting people to operate gantry-mounted, electrically-lit waldos remotely, from a warm and comfortable workroom, would be much more realistic.

For pruning, the waldo 'hands' might be very large and powerful, with 'secateur blades' between finger and thumb, able to cut off a branch with a simple finger-thumb motion. For intricate top-working to a new variety, the hands might be tiny and precise, operating with a screen which magnified the view, and with specialist bud-cutting templates built into particular fingers.

Electric gantries, with their triangular section, lightness, and relatively low centre of gravity, ought to be pretty safe for a human to operate in. But for difficult situations - say detail spraying high in a 30 m pecan tree, or 'hand' -pollinating tall date palms, just send in the waldo. Equipment preservation is a matter of economics, human safety the realm of a mass of laws, ethics, and regulations.

Automation

The second EG development route is to run the gantries using automatic control programs, infinitely variable for every task, and needing no regular training and explanation with staff changes. As with the waldos, the control computers might be in the air-conditioned centre, linked to the gantries by electrical signals.

Take **Irrigation**. Orchardists have considerable investments in irrigation systems, and may spend a lot of time checking and clearing nozzles and jets and balancing outputs to individual trees to achieve optimum water use. A person with a hose walking along the tree rows, and checking leaf colour and droop, could give a better result for the tree, but at prohibitive cost.

Mount your computer-controlled water outlets on the gantries, and you can do away with all your tree-based irrigation pipes and nozzles. Get feedback from moisture sensors in the soil or foliage, and you can tailor water delivery to exact tree-needs. And you can set your program to work two hours after dusk, or to supplement light rain, even though the dusk time or rainfall varies each day.

Take **Nutrition**. Trials have shown that applying trace elements and dilute fertilizer to tree foliage is hugely more efficient [Noel, 1996] than applying it to the ground, where it is likely to feed your weeds instead of your trees. Gantry-mounted foliar sprays could deliver just the right amount - even spectroscopically checking leaf colour to adjust trace elements delivered.

Take **Pest Control**. Obviously automated EGs can deliver conventional spray treatments without worries about harm to the operator, but they can do much more. Suitably programmed gantries could do things like run up and down, vacuuming pests from leaves, or shooting water bullets at marauding birds.

Finally

This article is intended to suggest a basic re-think of how we grow tree crops and how we might grow tree crops in the future. The main thrust is that the realities of the situation will force us to look at ways at getting more output from the same input. I believe that the way to do that in orchards is to work the land more intensively, putting more capital and infrastructure to work per hectare.

The Electric Gantry implementation outlined here is one approach, there are probably others equally valid. The main benefit of the EG approach is to put a lid on the cost of human labour in orchards, by replacing labour with capable infrastructure devices.

Vladimir Lenin made Electrification one of the main pillars of his political plan to bring Russia up to speed as a modern world power. While I am not Lenin, or even a Leninist, there is a lot to be said for the view that Electricity can give Power, and can give Control, whether in Society or in the Orchard.

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1. Noël, David (1996). *The Bird's Message - commercial crops with minimum input*. WANATCA Yearbook/Vol 20: 3-12.

[Based on a paper presented at the ACOTANC-98 Conference, Nelson, New Zealand, May 1998]

Tree Crops Centre: <A 1561>

PITAYA (*HYLOCEREUS UNDATUS*), A POTENTIAL NEW CROP FOR AUSTRALIA

DIMITRI JACOBS
Department of Agronomy
Wageningen Agricultural University
Wageningen, The Netherlands
<Dimitri.Jacobs @94.student. wau.nl>

Background

The author, a final year student at Wageningen Agricultural University, Netherlands, spent his practical period (May to September 1997) at the New Crops Program, University of Queensland Gatton College, Lawes, Queensland.

Part of the period was dedicated to a literature review and an evaluation of pitaya in Australia, with the cooperation of WANATCA, DPI&F (Department of Primary Industry & Fisheries, Northern Territory), Ben Gurion University (Israel), and growers in Australia.

Pitaya was present in a list of forty plants compiled by the organisers of a Tropical Fruit Planning Workshop held in Cairns in July 1997. Primary producers at the Workshop put pitaya in the top ten of crops worth further research and commercialisation. The fresh fruit was identified and targeted as potential product.

A preliminary search on pitaya, by means of amount of published papers worldwide indicated it was among crops with recent increasing attention. This attention has been limited to its appearance in foreign literature and the presence of the crop in developing countries.

Recent research carried out in Israel towards drought resistant crops for the Negev Desert has drawn attention to this cactus grouping.

Historical production of the fruits could indicate a promising market and production potential. Its distribution, and geographic and political characteristics may have favoured development of local markets .

Growing attention towards drought resistant plants, and expansion of production areas under possible global warming, are factors of relevance in Australian agriculture.

Introduction

Pitaya is a common name applied to a broad variety of warm-climate cacti fruit (Table 1), from different species and genera. It represents an interesting group of underexploited crops with potential for human consumption.

Table 1. Botanical and common names of some species and genera of cacti, known as pitaya or pitahaya.

Acanthocereus occidentalis	pitaya
Acanthocereus pentagonus	pitahaya, naranjada
Acanthocereus tetragonus	pitaya, acanthocereus
Cereus peruvianus	pitaya, apple cactus
Cereus thurberi	pithaya
Echinocereus conglomeratus	pithaya de agosto
Echinocereus stramineus	Mexican strawberry, pitahaya
Escontria chiotilla	pitaya, jiotilla
Hylocereus costaricensis	pitaya, pitahaya
Hylocereus guatemalensis	pitaya, pitahaya
Hylocereus ocamponis	pitaya roja
Hylocereus polyrhizus	pitaya, pitahaya
Hylocereus undatus	pitahaya oregona, red pitaya, strawberry pear, dragon fruit, dragon pearl fruit, thang loy, pitaya roja
Myrtillocactus geometrizans	pitaya
Selenicereus megalanthus	pitaya amarilla, yellow pitaya
Stenocereus griseus	pitaya de mayo
Stenocereus gummosus	pitaya agria
Stenocereus queretaroensis	pitaya de queretaro
Stenocereus stellatus	pitaya de augusto
Stenocereus thurberi	pitaya dulce
Stenocereus thurberi var *litoralis*	pitaya dulce

Sources: Fletcher, 1997; Nerd et al., 1997; Mizrahi et al., 1996a; Janick, 1996.

Taxonomy

Various crops are referred to as producing pitayas, a variety of columnar and climbing cacti bear these delicious, medium to large fruits. *Hylocereus guatemalensis*, referred to at the Tropical Fruit Crops workshop, probably originates from Kamerunga. Unfortunately, no trials were carried out as far as is known, and no data are available on pitaya from the research station. A yellow fruiting species originating from this station is present at the DPI&F in the Northern Territory.

Early imports in North Queensland from Colombia are recorded as *Hylocereus ocampensis*, red pitaya, and *Cereus triangularis*, yellow pitaya. Probably the yellow pitaya was *Selenicereus megalanthus*, and the red pitaya, *Hylocereus ocamponis* or *Hylocereus undatus*. *Cereus triangularis* is a synonym of *Hylocereus undatus* (Table 1).

Hylocereus species have been widely distributed in the past. This genus is commercially grown in the Americas, originally, and in Vietnam, where it was imported by the French and is locally recognised as native species by now. Recent research and development in Israel provides a rich source of information.

Closely related species may have importance in breeding. The small group of crawling cacti comprising *Hylocereus*, *Selenicereus*, and *Mediocactus* species should be given attention. They are assigned to the tribe Cereeae, subtribe Hylocereeae. *Mediocactus* is intermediate between the others, according to Britton & Rose.

Similar production and cultural conditions are required for these species, which permits some comparison between the species. Cullmann et al. mention 24 and 25 species of *Hylocereus* and *Selenicereus* species respectively. Distribution of the species occurs roughly from Mexico and Texas to Peru and Argentina.

Performance in Australia, its commercial production in Latin America, Vietnam and Israel, and availability of literature have broadened and restricted further research to crawling cacti. An analysis of the most important species is given in Table 1.

Production

The pitayas described are fruit from segmented, vine-like crawling cacti. They have aerial roots, and originally lived an epiphytic life. The roots are used to attach themselves to supports. They are shade tolerant and flower at night.

The large white flowers gave them their popularity as ornamentals, named Moonflower, Lady of the Night or Queen of the Night. Fruits are brightly coloured, and have an unique, attractive appearance. The red pitaya bears large fruits, which are pink, red, or mauve in colour, weighing around 150-600 g and containing many, small edible seeds. Their pulp varies from white to various hues of red.

The yellow pitaya (*Selenicereus megalanthus*) is a smaller fruit, and is covered with many small clusters of spines, which are easily brushed off the fully ripe fruit. It is commercially grown in Colombia, has white pulp with higher sugar levels. Fruits of the climbing cacti are harvested when changing colour, and tend to hold for at least one week. Cooling (10-12 degrees C) does not seem to affect the fruit adversely.

Fruit set takes 30-50 days after flowering, and 5-6 fruit crop cycles (between May and November) a year are seen in Nicaragua, yielding 10-12 t/ha in the fifth year. Orchards of the same species yield 30 t fruit/ha/yr in Vietnam. The yellow pitaya differs remarkably in fruit characteristics and fruit development, with a fruit development time of about five months.

The crawling cacti, particularly *Hylocereus*, have gained popularity in ornamental production in greenhouses in Europe and the United States as rootstock for other, slow growing ornamental cacti. According to Backeberg, all species bear red fruits, except for a very few *Selenicereus* species.

The pitaya is a species of dry tropical climates. Maximum temperatures of 38-40 degrees C, and minor short frosts (0 degrees C) are survived without major damage.

Rainfall requirements are modest (600-1300 mm), while excessive rain leads to flower drop and fruit rot. Due to their epiphytic life in the areas of origin, these cacti formed aerial roots to find nutrients in cracks where organic material concentrates. There is a positive response in growth to the amount of organic matter in the soil, but highest number of roots and greatest bud number are obtained in sand.

Cultural practices employ a trellis, or, traditionally, old tree stumps or living tree posts. As the plants have high tolerance to sulphurous gases, commercial production in Nicaragua is found on the slopes of the Mount Santiago volcano. In Nicaraguan plantings, propagation is done by stem cuttings, placed at 3 x 5 m on living tree posts. Nutrients can be applied by foliar spraying, or through fertilizer spreading.

Some pests and diseases are recorded on pitaya. Problems in Australia are most likely to involve birds, possums, rats, or bats feeding on the fruit. Observations in Australia indicated similar effects to those caused in Central America by the bacterium *Xanthomonas campestris*, causing rot in the stem flesh, leaving the main veins intact. Except for local insect attack, a fungus (*Dothiorella*), causing brown spots, is mentioned as one of the important problems in Nicaragua.

Table 2. Some species of Cereeae and Hylocereeae, important for fruit potential.

Name	Synonyms	Common Names
Selenicereus megalanthus	*Cereus megalanthus*, *Mediocactus megalanthus* (Some References Made From: *Hylocereus triangularis*, *Cereus triangularis*, *Mediocactus coccineus* *Hylocereus* sp. Katom Yellow	pitaya pitaya amarilla
Hylocereus undatus	*Cereus undatus*, *Cereus triangularis*, *Cactus triangularis*, *Cactus trigonus*	pitahaya, pitaya roja, red pitaya, dragon fruit, dragon pearl fruit, thang loy
Hylocereus costaricensis		pitaya, pitahaya, pitaya silvestre, wild pitaya
Hylocereus polyrhizus		pitaya, pitahaya

Sources: Barbeau, 1990; Weiss et al., 1995; Mizrahi et al. 1997; Jorge et al., 1989.

Freshly cut stems and flowers of *Selenicereus* grandiflorus, in particular, are used in the preparation of drugs with a spasmolytic effect on the coronary vessels, and to promote blood circulation. For this purpose, cuttings are cultivated in hot-houses. S. *megalanthus* contains the heart tonic captine. The *H. undatus* fruit is noted to be useful in combating anaemia. Stems of the species are sold in homeopathy.

Some germplasm is already available in Australia. A few growers in the Northern Territories and Queensland have some species. The DPI&F in Darwin recently addressed attention to pitaya. Since Israeli research and breeding has been carried out, imports of this material, supported by local plant improvement, should yield good commercial varieties and hybrids.

Experience in growing this crop in Australia shows low yields. Two fruiting cycles, one in May, and a smaller one in August, have been recorded in the Brisbane area. Enquiries from growers in north Australia indicate difficulties with fruit set. Growth and performance in Australia are so far not very promising. Although good yields are obtained, sunburning, insufficient pollination, and unknown nutritional requirements can be identified as causing this poor performance.

A limited production in California, grown on a small scale by a few producers, has led to occasionally selling in Farmers Markets on a individual basis.

Marketing

Although considerable investments seem to be necessary in commercial production of pitayas, Israeli observations show relatively cheap trellising could be sufficient. If providing shade, however, proves to be necessary in commercial production, extra costs will be incurred. Solutions such as netting will protect as well against possible bird attack.

Rare, attractive fruits will draw attention at the market place in the first phase. Customer demand at the moment is fragile and very low because the fruit is unknown at the markets. The market size for exotic fruit is limited, but growing. Consumer acceptance, measured in the Brisbane markets, gave an indication of good performance for yellow pitaya, and moderate for red pitaya, as fresh fruit. Musky smell and taste of the red variety might explain limited enthusiasm.

In August, market prices of $7-8 per kg in Barcelona and $40 per 8-12 pieces were observed. Local Californian produce was sold at $8-10/ kg through 1996. Due to its novelty and small amounts traded, no more reports were made. Barbeau however made notice of several consignments exported to Europe, and Utopia Pty Ltd is successfully importing Colombian pitayas into Europe.

One species is grown in Vietnam. Pitayas are commercially produced and sold as dragon fruit, dragon pearl fruit or thang loy. Production takes place along the coast from Nga Trang to Ho Chi Ming City. Very little information, however, seems to be available from Vietnam. Some articles are being translated from Vietnamese at the DPI&F.

Vietnamese exports to other Asian markets show potential markets in Hong Kong, China, and Japan for high quality fruit. Twenty two tons of pitaya were imported in Japan in 1988. Specimens of the Vietnamese fruit have been imported into the Northern Territory.

The variability in size, taste and colour of the fruits indicates the strong need for coordination in commercialisation. In respect to potential future export, attention should be addressed towards the characteristics of the Vietnamese *H. undatus* and exported varieties from Israel. The red pitaya (*H. undatus*) as referred to by Barbeau, grown in Nicaragua, is red fleshed.

Evaluation

Fruits are picked when most Australian grown tropical fruits are finished. Fruits are widely appreciated, especially chilled or served with lemon. Compared to prickly pear, these fruits are easier to handle due to the thornless skin (or thorns are easily removed before entering the market, in the case of *Selenicereus*). Their very small, black seeds are similar to the seeds of the kiwi.

There is an organised tropical fruit industry present in the northern regions of Australia. Transport and handling of a new fruit, if information is provided to concerned parties, should be carried out relatively easily. With regard to infrastructure, specific knowledge of cultural practices and problems in picking the fruit, have been gained in Israeli production.

Profitability is expected to be high in the first phase. The attractive and unique fruit fits into the Australian market, regarded as willing to try out new products. There is a growing trend in demand for tropical fruit and prices are high. Additionally, export to Asian countries, where the fruits are already known, is a market for high quality produce.

Weaknesses are seen in the lack of any experience in Australian markets. No commercial growers or plantings have been made in Australia as yet. Consumer awareness will demand education and time before the product might be widely accepted. Lack of resources is a general constraint, arguing for good communication between those involved. Prices are likely to fall if higher production levels are obtained. To succeed in providing future export markets, identification and coordination between growers and industry are likely to be keys to success.

The diversity of varieties present under one name is likely to cause difficulties for consumers in recognising of the product. Pitaya, dragon fruit, or other brand names could be applied to different varieties, and be a solution to problems with interpretation of the product name.

Better varieties and current research in Israel create opportunities for commercialising pitaya in Australia. Import of germplasm to be able to carry out breeding programs or to introduce Israeli hybrids are options. Pitayas have a relatively fast return, for tropical fruits, starting to bear in the second year, reaching full production in five years.

Low inputs of water, fertiliser and pesticides, could make organic production a good opportunity, still producing high quality fruit. To maintain high prices and demand in new exotic fruits, high quality has proven to be very successful.

Quarantine to import plant material from overseas, and particularly phytosanitary regulation limiting export of fruits to the Asian markets, could be seen as threats to the developing pitaya market. Cheap commercial production in Vietnam, Central America and other countries could be serious competitors in providing export markets to Australian producers. Pitayas act as hosts for fruitfly, but the Japanese Plant Quarantine can provide certificates if proper disinfestation is undertaken. Import of germplasm into Australia takes time.

Further Research

Industrial processing of the red fruits, for ice-cream, juice, wine, fruit salads and recipes should be further researched and published. Markets are currently restricted to fresh fruit due to lack of information for other uses. A restaurant supplier in Brisbane showed enthusiasm both to process and consume fruits.

A Nicaraguan study has shown that the pulp contains 84.4% water, 0.4% fats, 1.4% protein, 11.8% carbohydrates, 1.4% cellulose, and 0.6% ash. Red varieties contain anthocyanins, giving a strong red colour. Increasing sugar levels would increase consumer acceptance.

Novelty and lack of experience in Australia should warn producers to continuously evaluate markets. To secure future markets, coordination is important from the beginning. Consumer education, and analysis are important to respond to unexpected occurring problems.

So far, no records in Australia are known of production levels comparable with data from its region of origin. We. might assume higher production will be obtained when providing shade. Bleaching and death occurs at photon flux up to 2000 to 2200 moll photons/m/s in *S. megalanthus* and will cause reduction in yields for most areas.

Research on environmental factors influencing induction of buds in order to manipulate

them is lacking. Flowering is initiated at the end of the dry season in Central America, and continues throughout the wet season. Barbeau notes this might be a dependence on day length. Fruiting occurred in two to three waves in experimental production in Israel, from June to November, possibly temperature related.

However their adaptability and performance in the field are much less than that of opuntia, where drought resistance and high seed production favour distribution in the wild. Spread was found minimal of *H. undatus*, and not seen as threat, because of low fruit set.

Several pitaya species planted in the Negev Desert in Israel are being examined. At present, the cytogenetic make-up of *Selenicereus megalanthus* is being studied with the aim of understanding its low seed set and consequently low fruit weight. Cross pollination between *Hylocereus* species yield heavier fruit. As well, crop improvement in *Cereus* peruvianus, with similar fruit, could act as competition for crawling cacti. These latter columnar cacti don't require any support and are also characterised by high growth rates. Their good performance in high salinity and lower susceptibility to sun burning could be advantages in the same potential production areas.

Pollination problems are often met with in Australian grown pitaya. Moths and bats are the native pollinators. However, their short individual flower opening period - one night - requires high presence of pollinators. Ants are observed pollinating flowers, honey bees visit flowers, but are low effective in pollination. The effect of pollination was researched by Weiss et al., and showed higher fruit weight for cross-pollination between *Hylocereus* species. Some of the species were self-sterile.

Disinfection measures and other postharvest treatments have to be developed. Australia is exporting mangoes to Japan, and this market, together with Hong Kong and Taiwan for fresh tropical fruit as imports, is growing.

Notes

In selecting pitaya as a crop and product, some selectivity has been inevitable. I have attempted to give an indication of factors that were used here, however this was difficult and is not complete. Potential growers should define markets and product themselves and make a business plan according to the specified target.

A lot of plants from the Americas, tropical and subtropical species, have been cultivated, but never become well known. Their richness in semi-arid crops is likely to be a promising resource for relatively dry regions. Climate change and increasing CO_2 levels should open eyes and make us aware to treat our planet with more respect. At the same time, CAM plants and species from arid zones should get more attention if present trends continue.

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[Based on an article in the March-April 1998 issue of The Exotics, magazine of the Rare Fruit Council of Australia.]

Rare Fruit Council of Australia: <A1473>

The Exotics: <A2767>

Wageningen Agricultural University: <A1591>

SITUATION OF THE CAROB TREE IN AUSTRALIA

JUAN TOUS
San Antonio 44-2, Vilaseca
Tarragona, Spain

Australia is an important agricultural and livestock producing country that is growing quickly into one of the most aggressive on the world market. The agricultural sector provides 4% of the Gross Domestic Product (GOP), emphasising wool production, meats, cereals, seed oils, sugar, and fruit. In the last few years, Australians have cultivated crops such as the almond, grape, pistachio, macadamia, and citrus. These have increased in cultivation area and, more recently, others such as the olive and the carob are beginning to be considered as new alternatives for some states of the country.

The cultivation of the carob in Australia is still of minor importance although some orchards have been planted, basically in the states of Western Australia and South Australia. The history of this leguminous crop in this continent dates only from the past century.

The first trees were planted around the year 1850, with seeds imported by Afghan, Italian, Greek and Spanish immigrants. The carob was to be used as food for fattening animals which were used for the pulling of cultivation and harvesting implements. The carob is found very scattered in this country, normally in the form of isolated trees in streets, gardens and agricultural developments.

The first commercial orchards were planted in the 1980s and are found in the localities of Burra, Gawler and Loxton (South Australia), and later extending to other areas such as Geraldton, Nabawa, York, etc. in the state of Western Australia. At present there exists some 30,000 widely separated trees, of which half are productive plants with female flowers, and some 170 ha in young orchards, basically in four states of Australia (Table 1); Western Australia with some 110 ha, South Australia with 50 ha, and New South Wales and Victoria with 5 ha each. The principal cultivation zones are located between latitudes 20° and 38° S.

Livestock raising has great importance in Australia, mainly sheep and cattle. This accounts for the interest in the carob as an ingredient of stock fodder. Also it is being increasingly used in the human consumption of some foods, when some components of the fruit are used, such as the “toasted flour of the pulp” in chocolates, biscuits, fruit coating, etc. The ‘locust bean gum’ that is used as a thickener and a natural stabiliser (E-410) is of great importance in different products (ice cream, sauces, creams, mayonnaise, etc.). The agroforestry utilisation of this species is another aspect being studied, emphasising the extensive sheltering of stock, providing fruit, shade and its association with some herbaceous cultivation (grass, cereals etc.); and land restoration of warmer zones to reduce erosion problems and desertification of the soil.

Table 1. Area of orchard trees, isolated trees, and approximate production of the carob in Australia.

State	Area (ha)	Isolated adult trees (number)	Carob bean production (tonnes)
Western Australia	110	12,000	300
South Australia	50	10,000	250
New South Wales	5	5,000	125
Victoria	5	3,000	75
Total	170	30,000	750

* Some 15,000 trees are female and therefore productive.

Recently some non-governmental organisations, such as the International Tree Crops Institute (ITCI), Men of the Trees, Land Management Society, etc. and government centres, such as the South Australian Department of Primary Industries in Loxton, and a private organisation of producers (Carob Growers Association in Western Australia) have shown an outstanding interest in encouraging the cultivation of the carob, its processing, and the consumption of carob pulp, for human nourishment as well as for stock fodder.

Production, marketing and industrialisation

The production of carob in Australia is estimated to be 750 tonnes annually and is located mainly in the states of Western Australia and South Australia. The greater part of the crop is destined for stock feed (sheep, cattle, goats, etc.), located in the same cultivated zones. Australia is an importer of the dried fruit, especially the toasted carob-bean flour (carob powder) and the locust bean gum. In the last few years an average of 100 tonnes of toasted carob-bean flour were imported, mainly from Spain and Italy, for an approximate value of AUD$150,000. Annual imports of locust bean gum vary around 800 - 1,000 tonnes, with a purchase price in 1993 of AUD$ 5.06 / kg. This corresponds to a total value of some AUD$5 million (Esbenshade, 1994). Spain dominates this market, with more than 50% of the exports.

The distribution chain of carob products is relatively short and generally it directly links the importer, who uses it in the food industry (ice cream, chocolates, etc.) with the retailer. There are some exceptions in the use of distributors that act in the food chains of the different states, and of wholesalers specialised in supplying health food shops and local supermarkets. There do not exist industries of carob-bean traders. However it is anticipated that in the next few years, at least two will be established in the principal producing states. There exists, however, several food industries that use the toasted carob flour as a substitute for cocoa in chocolates and bakery products, and others that employ locust bean gum for the manufacture of ice cream, pet food and microwave fast foods.

Ecology

The zones in Australia where the carob is cultivated are characterised by a Mediterranean climate, with high temperatures in summer months, low annual rainfall (250 - 450 mm), mild winters and rare frosts. The lack of water, in critical periods of the productive vegetative cycle of the carob, and the frost risk, for example at Burra in South Australia, are perhaps the principal limiting factors in obtaining good crops in some potential cultivation zones. Table 2 shows the two climatological zones of the states of South Australia (Loxton) and Western Australia (Geraldton) where. there exist orchards compared with two in Spain (Tortosa, Catalonia), located in the northern hemisphere.

The temperatures of Tortosa compare well with those of the Australian zones producers, with a difference of 6 months because of the southern hemisphere location. The plantations located in the states of South Australia (Loxton, Burra, etc) and Western Australia (Geraldton, Perth, York, etc.) are characterised by a climate similar to the temperate Mediterranean and subtropical Mediterranean types respectively, according to the ecological classification of Papadakis.

The temperatures of Tortosa and Loxton are similar, however, the annual rainfall of Tortosa (576 mm) is double that of Loxton (275 mm) and evapotranspiration (ETP) is almost half. The climate of some of the cultivated areas of Western Australia (Geraldton, York, etc.) is warmer, with greater evaporation and somewhat less rain than that of Tortosa (Tarragona). In both Spain and Australia the carob orchards normally are therefore found in drylands, though some of them also exist in irrigated areas. In regions with very low rainfall, the carob subsists by using the water of the subsoil, thanks to its strong tap-root system.

Soils of the cultivation zones (South-West Australia) are, as a rule, low in fertility, most are of poor texture and can be cultivated only with difficulty. The carob orchards are found in better soils - clayey, brown or reddish - of neutral pH or alkaline and usually low in phosphorus.

Some non-governmental organisations show interest by encouraging the cultivation of the carob, its industrial trade, and the consumption of the carob fruit for human nourishment, as well as for that of stock.

Varieties

The carob trees that exist in Australia are produced largely from seed. Therefore there exists a great heterogeneity. At the beginning of the 1980s the ITCI imported 12 foreign varieties originating in Europe and California to introduce them to different states of the country (Esbenshade and Wilson, 1986). They originated from a varietal collection, now disappeared, that was located in Vista (California).

Also, at this time, some farmers began to select interesting local types for the good size of the fruit and high content in flesh and sugar. This means that there does not exist systematic studies on the behaviour of carob varieties in the different cultivation zones. There is, however, four recent cases concerning collections, mainly with foreign clonal plant material, that produce fruit with high flesh content. Three of them are found in the state of South Australia (Loxton, Burra and Gawler).

The most important is located in the Loxton Research Centre, where, in the ninth year, the cultivars 'Laguna', 'Santa Fe' and 'Clifford' (USA), Tylliria' (Cyprus), 'Sfax' (Tunisia) and 'Amele' (Italy) had all achieved good production levels. Some farmers of Mediterranean ancestry have introduced, in the course of the years, varieties of their respective original homes. Most of these have not been tested.

The varieties cultivated in Australia are characterised by having a high flesh content, the production being destined for animal food. Spain, in contrast, currently recommends varieties with a high content of seed. The gum is then extracted and is used as a food additive (Tous, 1994), to satisfy the demand of the European market for this product. Also they are using some male trees to pollinate the female varieties in the commercial orchards. Emphasis is placed on the following foreign and local varieties:

Local: In the state of South Australia emphasis is on the female cultivar 'Bath', 'Irlam', 'Maitland' and 'Paxton'. In Western Australia there are varieties produced called 'King's Park No.1', 'Princess', 'Marshall No.1 and 5', 'Collins', and 'Banks No.2, 3 and 4'. The cultivar 'Princess' is given significance since it has a high sugar content in its flesh (almost 60%). The clones of the series 'Banks', selected by the author in the area of Perth, are characterised by producing fruit with good yields of seeds.

Foreign: In new orchards they have begun to graft the female varieties 'Tylliria', originating in Cyprus, 'Amele' of Italy, 'Casuda' of Spain, 'Sfax' of Tunisia, and the hermaphrodites 'Santa Fe' and 'Clifford' of the USA.

In the last few years in New Zealand, where there exist some 20 ha of carobs, the farmers have emphasised the introduction of the Australian varieties 'KP-1' and 'Marshal No. 1'.

In summary it could be said that at this time there are several varieties for new orchards. There do not exist clear evaluation criteria in this regard, due to the fact that the trials are very recent and incomplete. Not all of the potential local plant material has been selected yet. Furthermore, there does not exist much experience in cultivation. Agronomic and commercial criteria (flesh and/or seed) are the most important in this regard, as well as selection of the clonal material. The zones where the carob is cultivated are characterised by their high temperatures in the summer months, low annual rainfall, and mild and infrequent winter frosts.

Characteristic of typical orchards

The carob orchards in Australia are recent, the oldest being dated at the beginning the 1980s. Currently these have begun to produce the first commercial crops. In this section will be described some characteristic of interest of these same orchards.

Size of plantations. Areas of the carob plantations tend to be small, between 1 and 5 ha, though there also exist two large plantations, each one of them having some 40 ha, located in the localities of Burra (South Australia) and York (Western Australia).

Propagation. The method mainly used in the orchards has been by direct seeding or by planting seedlings with subsequent grafting of the variety selected in the field at two to four years old. Currently some nurseries are experimenting with the technique of top grafting and also propagation by cuttings rooted under mist. This is quite recent in this country. Perhaps because of the shortage of commercial nurseries, and large distances, farmers set up their own nurseries to produce the necessary free graft wood to cover their needs.

Planting densities. The densities used vary between 100 - 200 trees / ha, with spacing of 10 x 10m, 9 x 9 m, or 6 x 8 m. On some developments the carob is also used as a species for hedges, in association with other cultivation.

Techniques of cultivation. The orchards, as a rule, receive little cultural care, due basically to the fact that it is considered a new crop in this country. They do, however, emphasise, among others the following:

The system of 'no tillage soil maintenance' is used, mainly to eliminate weeds and reduce competition, by application of herbicides under the crown of the tree, and leaving the natural green cover between the tree rows.

'Branch pruning' is quite light or absent with respect to the interior of the crown. The branches at the base of the trunk are pruned to leave the height of the cross of the tree at about 1 metre to help with future mechanical harvesting of the fruit with trunk vibrators.

Pests and diseases. The carob in Australia does not have excessive plant disease problems. One might emphasise, however, in young orchards, the damage done by birds that destroy the soft shoots of the young trees. Animals (rabbits, kangaroos, etc.) also gnaw the bark of the trunk and eat the leaves, mainly in the drought years when there is little food.

Final considerations

The cultivation of the carob tree in Australia is relatively new. In given areas of some States of this country, mainly in Western Australia, there is a considerable interest to encourage this cultivation. It is anticipated that increases in planted areas in the next years will occur for agroforestry uses and to satisfy the potential internal demand of carob-bean flesh, largely for animal nourishment.

The Australian consumer seems to know the beneficial characteristics for human health of this typically Mediterranean dried fruit.

It is accepted also, that in the last years there has been a growing trend in imports of toasted carob-bean flour, as well as in locust bean gum, for its use in the food industry. The Australian consumer seems to know the beneficial characteristics for human health of the carob flesh, and the natural thickener uses of the locust bean gum, of this typically Mediterranean dried fruit.

Current cultivation technology is little developed. The same is true for the study of the existing clonal plant material. This situation could be improved with the beginning of investigation activities and/or experiment (R & D) in this regard on the part of the competent Australian organisations.

Acknowledgments

These results are the fruit of a technical visit to Australia in the month of April 1994 accomplished by the author. My thanks for the financial support of the International Tree Crops Institute (ITCI), the University of Adelaide, and the Deputy of Tarragona. Also I desire to express my gratefulness to Dr. Henry Esbenshade (ITCI), Mr Farnell Hobman (Loxton Research Centre) and Mr Graham Brookman (University of Adelaide), for helping me gather information on the cultivation of the carob in Australia.

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Translation by A. Murphy from the Spanish article of Dr Joan Tous Marti, *"Situacion del algoarrobo en Australia"* (Boletin Agropecuario de la Caixa, vol. 35, Jan-Mar 1995). Dr Tous is attached to an Arboricultural Research Centre in Tarragona, Spain.

[Based on an article serialized in 'Algarrobo', newsletter of Carobs Australia, 1997-98].

Carobs Australia: <A1623>

THE FLORAL SITUATION OF THE CAROB IN CALIFORNIA

C. A. SCHROEDER
33 Haldeman Road, Santa Monica
CA 90402USA <persea@ucla.edu>

The carob, *Ceratonia siliqua*, a leguminous subtropical tree, has been grown in California for many decades, primarily as an ornamental plant (1,2). Recent demands for the fruit and its products and by-products have stimulated inquiry concerning the potential value of the carob as a commercial tree crop in California (1). Information on the floral situation in the species and its varieties may be of value for an understanding of the field behaviour of the plant. It is hoped that this report, which is concerned with the floral situation and sex condition in a large number of varieties, will be of value in the development of future commercial plantings.

The observations reported here were made on a collection of carob varieties assembled by J. E. Coit and maintained near Vista, California, under an endowment provided by Dr Walter Rittenhouse of San Diego. This collection consists of 59 clones which include some of the finest varieties of the Mediterranean Basin introduced during the past decade from Spain, Italy, Israel, Yugoslavia, Portugal, Cyprus, Greece, Tunisia and Algeria. Also included in the collection are a number of selections from seedling trees in southern and central California, several of which have been under propagation for years past. The observations were made over a five-year period by examination of the trees periodically during the blossoming season.

The carob is generally described as polygamo-dioecious, a condition which implies that the flowers are either pistillate, staminate or perfect. These sexual forms may occur singly or in any combination in any given tree in a seedling population.

The inflorescence and flowers

The carob inflorescence consists of a short raceme or cluster of racemes usually borne on older branches or occasionally along the trunk (Fig. 1A). The flower is without petals and the calyx tube bears a disk on which is borne the single pistil. Stamens when present are five in number. The two pollen chambers at the tip of each stamen discharge by longitudinal splitting, releasing the yellow pollen. The fruit is an elongated, compressed leathery indehiscent pod.

The pistillate flower consists of a short stalk which is expanded slightly toward the apex to form the calyx lobes. Surmounting this expanded receptacle is a broad, flattened, somewhat fleshy five-lobed disk upon which the pistil is inserted. The latter is 6-12 mm in length and terminated by a broad expanded stigma (Fig. 1F). Occasionally abortive or partially developed stamens may develop in the lobes at the base of the disk

The staminate flower also is without petals. It bears five well developed stamens attached at the base of the central disk (Fig. 10).

Hermaphroditic or perfect flowers contain both a pistil and a complement of five stamens (Fig 1C).

Usually the flowers of a given inflorescence do not develop simultaneously. Maturation of the individual blossom normally progresses in an acropetal direction, hence the basal flowers may have attained maturity, dried and dropped prior to the complete development of the apical flowers in a given inflorescence. Under some conditions, however, all the flowers of an inflorescence may mature at approximately the same time.

The floral situation and sexual expression of a given clone appear approximately constant, though some variability in quantity of the stamens or pistils may be observed during the season. The clone Feminello, for example, has been observed over a long period, both in Europe and California, and has been reported as pure pistillate type at all times. Some of the hermaphroditic clones exhibit a tendency toward the failure of pistil development late in the season; hence the flowers may become completely staminate in function.

Groups with respect to floral situation

The floral indexing of the clonal collection established in California indicates that the varieties can be grouped into five classes based on the expression of the sex condition throughout the season. These groups are pistillate, pistillate with occasional perfect flowers, pistillate with occasional staminate flowers, perfect and staminate. While the older established clones have continued to maintain their floral types, some of the younger clones have exhibited variation in the development of stamens, especially during their first few years in the orchard. It has been noted that in varieties normally hermaphroditic early in the season there is some tendency toward the failure of pistil development later in the season, such that late flowers are essentially staminate in structure and function.

Sex conditions and pollination requirements

Group I. The pistillate clones appear to be highly constant in their sexual behaviour. Little evidence of staminate structures has been noted among these varieties. Occasionally very slight protuberances will develop at the point of normal stamen insertions, but normally these aberrant structures fail to develop beyond a primordial stage and never attain the pollen formation stage.

Group II. The group, pistillate with occasional perfect flowers or stamens, is essentially and functionally a pure pistillate type, as the exceptionally few perfect flowers provide a very limited amount of pollen, probably insufficient for adequate commercial fruit set. The staminal structures, though evidently developed to various degrees, might be questioned as to their effectiveness in provision of viable pollen. Some stamens are completely developed with apparently normal pollen while others reach full development but contain little or no pollen. A wide range of intermediate stages of staminal development is found in this group. The effectiveness of pollen from such flowers with few or partially developed stamens was not tested.

Group III. A third group, perfect with staminate flowers in the same cluster, probably results from the pistil abortion of otherwise perfect flowers. This condition may be seasonal and in all probability is related to the physiological condition of the plant. Perfect flowers predominate in the floral structure in these varieties, the staminate flowers being borne in small numbers and irregularly throughout the several inflorescences.

Group IV. Perfect flowered clones have been noted and designated as a separate group in the present study. Such clones have a strong tendency toward the development of both stamens and pistil with very little evidence of suppression of either structure throughout the several seasons of observations.

Group V. Staminate clones such as Holmes and Grantham, selected for their abundance of pollen, have not been observed to develop the pistillate structure to any degree on any occasion.

Adequate pollination must be provided for the pure pistillate clones to ensure fruit set by interplanting with perfect or staminate varieties. Those clones which are normally pistillate with occasional perfect flowers or stamens will also require adequate sources of pollen from other clones. Perfect flowered clones frequently have flowers with aborted pistils; hence these are staminate in function and are well supplied with pollen. The problem of requirement for cross-pollination and aspects of self-sterility among hermaphroditic clones has not been investigated. Casual observations indicate that isolated perfect flowered seedling trees set adequate crops and that cross-pollination, except in the pure pistillate forms, probably will not be a major limiting factor in fruit set. Specific male clones such as Holmes and Grantham have been selected both for the abundance of pollen and the amount of flowers they produce. Holmes also blooms early, whereas Grantham matures its flowers over a long period, especially in the mid and late season.

An indexing of the clones now under investigation in California shows distinctive groups into which all the varieties can be placed.

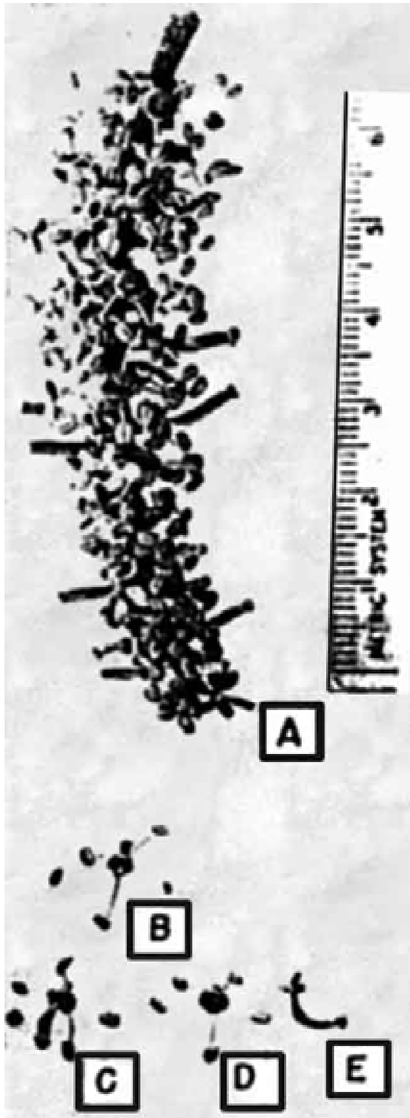

Fig. 1. Inflorescence and flower types of carob, ceratonia siliqua. A--polygamous inflorescence. Floral types, B--staminate with aborted pistil, C--perfect, D--staminate, E--pistillate.

A classification of the clones with respect to sex expression is as follows:

Group I. Pistillate

Ancho	Diego	Francisco	Regardo
Antonio	Domaci Krupni	Hall	Sandalawi
Apex	Eggers	Kinncloa	Sipanski
Arlington	Excelsior	Laguna	Soboba
Castaludes	Fargo	Matherwos	Sobrante
Collin	Feminello	Mekis	Southard
Corona	Formay	Mockingbird	Sykea

Group II. Pistillate with occasional perfect flowers or stamens

Amele	Sfax	Tunis
Gabriel	Tylliria	White

Group III. Perfect with staminate flowers in some clusters

Bolser	Dickerson	Nichols
Gamino	Horne	Sante Fe
Conejo	Lorna	Uhland

Group IV. Perfect

Islay	Nedra	Molino

Group V. Staminate

Holmes	Grantham

In summary it appears that the several carob clones selected for trial in California can be indexed in respect to sexual condition into five general groups based on the development of the sexual structures.

These groups are: 1- Pistillate, II - Pistillate with occasional perfect flowers or stamens, III - Perfect, with staminate flowers in some clusters, IV - Perfect. V - Staminate. The provision of pollinators will probably prove to be essential for those clones in groups I, II and III in order to insure adequate commercial fruit set.

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[Based on a 1959 article in *American Society for Horticultural Science*, Vol. 74. Almost 40 years on, Art Schroeder, now aged 85, and Emeritus Professor at the University of California: Los Angeles, is still active in Californian tree crops matters. Article sourced by Joe Traynor.]

CHESTNUT VARIETIES AND CULTURE IN VICTORIA

JENNIFER WILKINSON
Australian Nutgrower
PO Box 1, Dargo, Vic 3862

What chestnut tree should I plant? This is the million dollar question for chestnut growers and Bill O'Kane of Ardern and O'Kane Chestnuts in North East Victoria faces the problem on a daily basis. For sixteen years Ardern & O'Kane Chestnuts (Don Ardern, Bill O'Kane, and Bill's son Peter) have propagated about 50,000 chestnut trees for their grove and the commercial market.

In 1982 when Bill and Don began propagating chestnuts, they concentrated on the varieties that they wanted to plant in their own orchard at the foothills of Mt Buffalo near Myrtleford. Buffalo Queen, Early Marone, Sword, Late Marone and Wandiligong Wonder were chosen because the nut maturity of these varieties ranged from very early to very late and this spread the workload at harvest time. These varieties also produced nuts of mainly large and standard grades.

How things have changed. Buffalo Queen, a variety that was selected from Ian Wallace's chestnut orchard near Myrtleford, still remains an excellent variety for Ardern & O'Kane Chestnuts because it drops early, has a good appearance, produces large nuts consistently and is good to eat and peel. Also, being early, it returns the highest price. Bill says that it's no surprise to see in the latest chestnut tree census that there are currently 6000 Buffalo Queen trees in cultivation, making it the leading variety.

The next variety to drop at Ardern & O'Kane Chestnuts is Early Marone. This is a beautiful variety to eat and it peels very easily. The only drawback is that in a wet cool summer it is very prone to Phomopsis and during a dry year it falls too slowly and can suffer size reduction. So Bill and Don are now grafting their Early Marone trees over to Red Spanish, a variety that produces mainly Large or Special nuts (L2, L3 and L4 on the overseas market).

Fortunately chestnut trees are easy to top graft in situ and trees that are topworked at Ardern & O'Kane Chestnuts are back to the original yield in three years. Bill and Don gather the scion wood in July, seal the ends with wax or paint, wrap the labelled bundles in damp hessian and plastic, and store them in the cool room at 0 - 1°C. Bill said that if the scion is not kept near freeze point, it bursts bud too early and the graft shrivels and dies.

During winter Bill and Don get out with the chainsaw and cut back all the branches of the trees to be top-worked to about head height. They then paint the sunny side of the trunks with white paint to prevent sunburn. Budburst is grafting time and Bill and Don get the scion sticks from the cool room, trim off the ends, and don their carpenters-bag-cum-grafting-kit.

Each scion stick is sliced off diagonally at the bottom, a slit is cut in the bark of the branch to be grafted, and the scion is slipped in with the flat side to the branch cambium. The graft is then taped in position and the top of the sawn-off branch is sealed with mastic and a daub also seals the top of the scion stick. The leader branch is grafted with four scions and side branches receive two scions (on the sides, not top and bottom).

In ten days the new varieties are growing. Bill says that Purton's Pride will produce nuts the first year, while Red Spanish may take two or three years. Any variety can be topworked but if both the tree and the scion are the same type, that is 'crenata' type is grafted with 'crenata' type, compatibility is assured.

The variety harvested immediately after Buffalo Queen at Ardern & O'Kane Chestnuts is Red Spanish, and because the nuts are so big, they command top dollar on the shop shelves. Bill says that if and when the domestic market is oversupplied with large nuts and the price falls, there is an option to sell on the Japanese market because the Japanese love big chestnuts.

Bill on the right and Don stand beside one of the many trees they topworked in 1977.

The next variety of nut to fall in the orchard is Sword. This variety is out of favour at present because it is difficult to peel. Bill explained that there are three variations of Sword and they call the one they grow the 'good' Sword. The other two, Bill said, drop terrible nuts that are "black in colour and smell like rotten wine".

Bill and Don have grafted 300 Sword trees over to Red Spanish and have another 1000 Sword trees earmarked for Morena, an early good eating and good peeling variety from Western Australia. This variety also drops large nuts that grade Large and Special. Bill doesn't know what they will graft on to the next 1000 Sword trees. Maybe Di Coppi Maroni, who knows.

Late Marone follows Sword at harvest time and Bill believes it is an excellent eating nut, perhaps one of the best. But Late Marone is unreliable. Bill and Don have found that in a very wet year it doesn't pollinate well and consequently yield is low. and in a very dry year nut size is down, which means prices are also down.

So what should Bill and Don do with their Late Marone? Should they continue grafting back to early large "not so good to roast" chestnuts? Or should they hang on to the good eating varieties like Late Marone and hope that the market trends reverse? Bill believes that Late Marone is such a good eating nut, it must have a ready market among chestnut connoisseurs.

The last variety to mature at Ardern & O'Kane Chestnuts is Wandiligong Wonder and Don and Bill have decided to continue with this variety. It is good eating, good peeling, it drops late in the season (mid May), and brings good prices. The one drawback Bill and Don find with Wandiligong Wonder is that it is a shy bearer. However, they have been told that when the trees reach about 15 to 20 years production improves!

Disease resistance has become increasingly important in the selection of chestnut varieties. Bill and Don are constantly looking for good Phytophthora resistant rootstocks. While tree loss from Phytophthora root rot at the Ardern & O'Kane orchard is low at present (about 0.5%), in other areas growers have lost a high percentage of trees. The most Phytophthora resistant rootstock that Bill and Don have found is Menzies, and when a tree dies in their orchard, they plant a Menzies seedling in its place, and if it is doing well in a few years, they graft it to whatever the variety is in the particular block.

According to Bill, several Phytophthora resistant varieties have been identified in Spain and the French have bred a hybrid that is resistant to both Phytophthora and Chestnut Blight. He hopes that in the near future they will have the opportunity to compare these with Menzies under Australian conditions.

Susceptibility to Phomopsis has also become an important factor in chestnut variety selection. Problems with this nut rot disease have escalated in recent years and while Bill and Don have not found a variety that shows complete resistance to Phomopsis, they say some varieties are more susceptible than others. Bill said that the severity of the Phomopsis problem depends on the weather. He believes that in a hot dry summer with day temperatures exceeding 38o C the incidence of Phomopsis is less, but in a cool wet summer, infection is widespread.

Cleaning up pruned branches from topworked trees

Phomopsis-affected nuts are inedible. Bill explained that badly affected nuts are chalky and lighter in weight than sound nuts and can be floated off in the wash tank during processing.

All chestnut varieties planted at Ardern & O'Kane Chestnuts fall free of the burr and all are harvested by hand. Currently the crop weighs in at 65 tonnes but when trees are in full production, it should peak at around 300 t. Bill said that at present it takes about 50 pickers to do the job. He explained that they tried harvesting mechanically but it was too slow. There are so many trees to harvest that they'd need ten harvesters and ten tractors, and more importantly ten skilled operators to do the job. These, he said, would be impossible to find.

Of course Ardern & O'Kane Chestnuts is not your usual gentle sloping or flat nut orchard. Typical of many chestnut properties, trees are planted on steep hillsides and tractor work is for skilled operators only. The 10,000 trees cover some 120 ha of hillside and thrive without irrigation in red skeletal soil and a rainfall of 1300 mm.

As far as the Ardern & O'Kane chestnut tree nursery is concerned, the varieties grown are the varieties demanded by growers, primarily Red Spanish, Purton's Pride and Di Coppi Maroni, and Buffalo Queen grafted on Menzies rootstock. Bill says "Who knows what will take over as the flavour of the month. We'll leave that to the marketplace and just go with the flow."

The order of disease resistance as Bill O'Kane sees it:

Phytophthora resistance

Menzies, Buffalo Queen, Knox Early, Batlow, and other *Castanea crenata* types.

Phomopsis resistance

Di Coppi Marone, Purton's Pride and Red Spanish, Luciente and Late Marone, Menzies.

Varietal characteristics as Bill O'Kane sees them:

Buffalo Queen - very early season nut and the first nut on the market so commands good prices, doesn't need pollinator, good looking nut, good peeler, good keeper and not very susceptible to Phomopsis, produces good size nuts even in drought years, reasonably Phytophthora resistant.

Di Coppi Marone - variety least susceptible to Phomopsis, good keeper, good flavour, good peeler, large to medium size nuts except in dry years when nut set is heavy and nut size is reduced.

Early Marone - Good eating and peels very easily but is prone to Phomopsis in cool wet seasons, nuts are small in dry years.

Late Marone - excellent eating nut, perhaps one of the best, but in a wet year it doesn't pollinate well and yield is low and in a dry year size is down, nuts drop in the peak of the season so price is not tops.

Luciente - precocious bearer but grows into large tree and sets too many nuts so needs pruning regularly to keep nut size up, mid to late season nuts of large to medium size depending on severity of pruning, excellent flavour, very easy to peel but poor producer in dry season.

Menzies - variety least susceptible to Phytophthora in Australia so good rootstock, good nut but a bit dull, not too prone to Phomopsis.

Morena - early good eating and good peeling nut which grades Large and Special.

Purlon's Pride - also called Emerald Gem, doesn't need pollinator, huge dark-coloured nut but will overbear so has to be pruned off about one third of new wood to keep nut size up, good for Japanese market if pruned back.

Red Spanish - also called Wandenberg, shy bearer so no pruning, huge nut that brings top dollar and good for Japanese market, falls early after Buffalo Queen, drought resistant.

Sword - difficult to peel so not suitable for fresh market, large size dark-coloured nut that falls mid season, vigorous growing trees.

Wandiligong Wonder - prone to Phomopsis but good eating, good peeling and late bearer (May) so gets good price, shy bearer so no need to prune but slow to come into full production.

[Based on an article in Australian Nutgrower, September-November, 1998]

Australian Nutgrower: <A1058>

CHINESE LIMONNIK - *SCHIZANDRA CHINENSIS*

LEONID A BURMISTROV §

N I Vavilov All-Russian Research Institute of Plant Industry

44 Bolshaya Morskaya Street

St Petersburg 190000, Russia <vir@glas.apc.org>

Limonnik is the Russian name of the species *Schizandra chinensis*, it means similar to lemons.

Description and distribution

Limonnik is a climbing plant with a woody stem, large deciduous leaves and fleshy fruits. In the modern taxonomy of flowering plants (Takhtajan, 1966) it is attributed to the family Schizandraceae and the genus *Schizandra*. This genus, according to Smith (1947), includes 25 species. The majority of species belong to subtropical regions of Eastern and South-Eastern Asia: China, Korea, Vietnam, Malaysia, Eastern Thailand, Cambodia, Nepal, north Burma and India, Sumatra and Java in Indonesia, Japan, and Taiwan. In Russia it is found in forests (taiga) of the Far East (the Amur Region, Khabarovsk and Primorye Territories) (Fig I).

The genus is divided into four sections, based on the structure of androecium. To one of them (Maximowiszia's section) the single species *Schizandra chinensis* Baill. is attributed. It is found in the northern section of the range of the genus.

The Limmonik that grows in Korea has two varieties: "Omide" or *Schizandra chinenis* Baill. var. *glabrata* Nakai, and "Keomide" - a literal translation is "Dog's Schizandra" - *Schizandra chinensis* var. *glabrata* Nakai). They are distinguished by the leaf shape ("Keomide" has sharper ones) and by the growing sites ("Omide" grows higher in the mountains than "Keomide").

The Limmonik growing in Russia occupies the northernmost location of all woody vines. The furthest north it is found is in the valley of the Zeya river, and as far west as the valley of the Amur river (near the village of Kumara). Downstream from here Limmonik grows and bears fruits throughout the territory of the Amur river valley and adjoining flood plains of the rivers that empty into the Amur (Fig. 2).

Limmonik also grows on Sakhalin Island and on the southern islands of the Kuril ridge (Moneron, Kunashir, Shikotan and Iturup).

This ancient plant is a remnant of a tertiary flora that at one time was in the Far East and

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has survived through the glacial period and global climate change. Now the main habitat of Limmonik can be found at an altitude of 200-500 m above sea level. Sometimes it is possible to find this plant lower down, and very rarely at an altitude of 900m. Mainly it grows in the coniferous-broadleaf forest zone, that occupies part of the territory of the Far East from the Amur river valley in the North up to the Ussury river valley in the South, and to the coast of the Japan sea in the East. Its favourite place is the lower parts of slopes near the beds of small rivers and springs. The optimal conditions for Limmonik are within cedar-broadleaf forests, where it is a typical part of the understorey.

It is a plant undemanding as to warmth, growing successfully given a frost-free 100-105 days with average daily temperature above 10° C. The sum of temperatures for this period must be near 1500 - 1600° C. If the duration of a frost-free period is less than 100 days, Limmonik can grow, but shoots are damaged by frosts and yield drops.

As a rule, in the forest, Limmonik vines grow on northern, north eastern and north-western slopes of hills. On south-eastern and south-western slopes it occurs rarely, and almost never on southern slopes. Limmonik needs an abundant water supply with high air moisture content.

In the Russian Far East, Limmonik grows on shallow, well-drained soils, mainly on brown mountain-forest soils with a humus horizon of about 15-20 cm and close to neutral (pH 6.5).

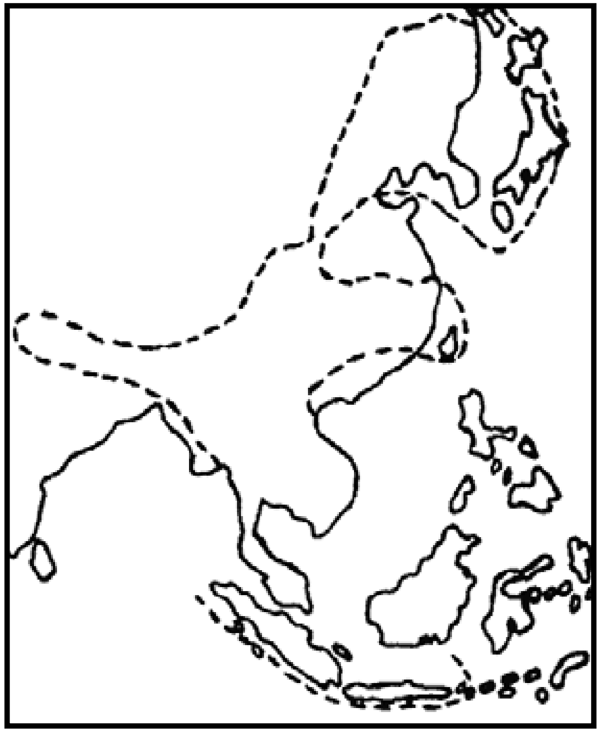

Fig. 1. The northern distribution of the genus Schizandra (A. Smith)

Limmonik is known to grow and bear fruit well on a wide range of soils: red earth, chernozem (black soil) and typical podzol. So the soil type does not limit growth as long as it is possible to provide this plant with water and nutrients.

Limmonik is one of the more elegant vines. The length of the main stem is about 10 m and its diameter near the ground is about 20 mm. It climbs on high bushes and trees clockwise. In Sakhalin and the other islands it grows on open slopes of hills in a bush-like form.

The leaves are simple, entire, sharply-elliptic or inversely egg-shaped, length 5-10cm, width 3- 5 cm, light- or dark-green

Flowers are unisexual. Under normal conditions Limmonik is monoecious, but as well as plants

with flowers of both sexes, some plants possessing only male (staminate) flowers can be found (See Cover illustration).

In culture the seedlings of Limmonik produce plants that can be divided into the following groups, according to L.M. Shilova (1966). The plants with constantly only male or female flowers fall into the first group, the plants with flowers of both sexes fall into the second group, and the plants which possess flowers with sexes one year male and female flowers and the other year female fall into the third group.

The flowers are single, hanging down on thin stems and form groups with 2-3 flowers. The flowers have up to 8 white or cream-coloured petals. Male flowers carry 3-7 stamens and female, 30-40 free pistils. The pistils in buds and just opened female-type flowers form a small greenish ‘pine cone’. By this characteristic it is easy to distinguish them from male ones. Besides that a male flower is larger (up to 20 mm), its interior is more intensely coloured and it possesses a number of broader petals.

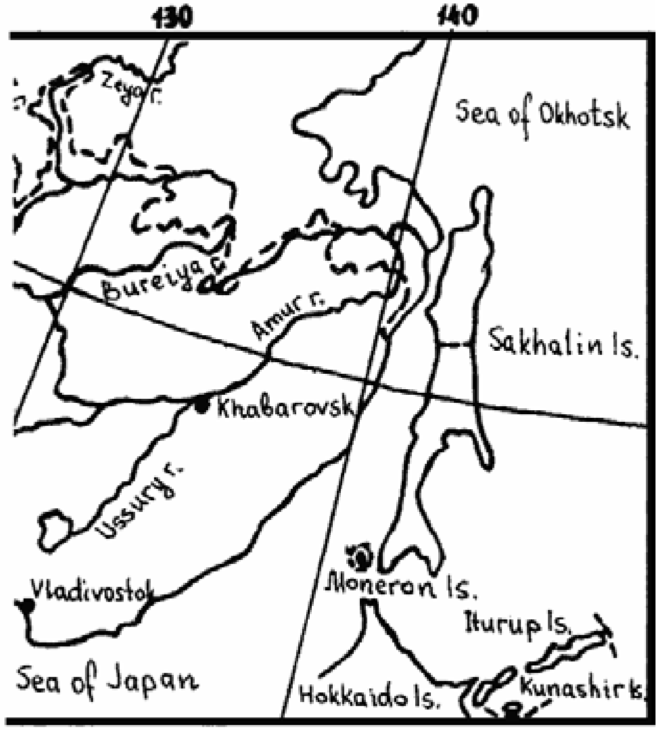

Fig. 2. The Northern area of distribution of Schizandra chinensis in the Far East (A. P. Nechaev)

There are no nectaries in the flowers of Limmonik, but they generate a sweetish liquid that discharges on the stigma of the pistil. Moreover the flowers give out a rather strong aroma of lemon. Limmonik is a cross-pollinated plant.

Fruits

The fruit is a fleshy aggregate with indehiscent small fruits. In appearance these fruits appear as big, sessile, almost globular berries, sometimes to 10 mm in diameter. Each collective fruit consists of 15-20 small fruits which resemble a cylindrical “cluster” about 10 cm in length with weight 6-7 g. In the taiga (jungle), one vine produces 0.2-3.0 kg of berries and 1 ha of plants, 340-1640 kg.

The ripe berries of Limmonik are very delicate. They have thin skin, juicy flesh and 1-2 rather large and hard seeds. The berries have colours with varying shades of red, from crimson to orange-red. The weight of 1000 seeds is 20 g.

In spring the sap movement of Limmonik begins in the middle of April and depends upon the date of the beginning of snow melting and the sum of temperatures above 0° C. Usually blooming begins in the first part of May. The flowers do not open simultaneously.

The beginning of fruit formation is recorded 40 days after blooming, at the end of July. This process takes 3 months. The maturation period lasts 2 weeks and ends in late September.

It is possible to begin fruit harvest before full maturity (5-7 days earlier) while the fruit is hard. Fruits easily and quickly ripen after harvest.

The duration of the period from beginning of bud opening to full maturity of berries (10% berries are full ripe) lasts 133 days. The duration of a vegetative period from the beginning of sap movement to end of leaf fall lasts 180 days.

Medicinal Uses

Limmonik is of primary interest as a medicinal plant.

In the East the berries are even more highly valued than they were a thousand years ago. In China the fruits are named "u-wey-tzy", in Japan "tesengomisi", in Korea - "tomido". Literally translated in all those languages this means fruit with five different tastes. Su Qung (VII century AD) explained the name "u-wey" in his manuscript and wrote that the skin and flesh of the fruits are sour and sweet, seeds are bitter and astringent, but after chewing a whole berry you can taste a saltish aftertaste. All parts of Limmonik - berries, leaves and bark - have an odour of lemons (Titlyanov, 1969).

In the Chinese Pharmcopoeia (1956), Limmonik is classified among the first category of medicines recommended as a tonic remedy. It is very useful for treatment of dysentery, colds, seasickness, bronchitis and bronchial asthma, whooping-cough, exhaustion, weakness and emaciation of the body. For curing neurasthenia and impotence, berries are recommended with other remedies.

In Korea the juice from fruits of Limmonik mixed with honey is used as a medicine in cases of stomach-intestinal and pulmonary diseases, and for treatment of patients with poor sight and hearing.

In the Russian Far East, the local population brews a tea with shoots of Limmonik. This tea becomes dark yellow in 4-5 hours. It has a pleasant taste and the aroma of lemon.

In the Soviet Union pharmacological studies were carried out for the first time in the Khabarovsk Medical Institute (Drake, 1942, 1949), when from its seeds, leaves and stem bark the substance 'schizandrin' was extracted. This produces a moderate stimulative action on the nervous system, similar to the action of the cola nut, but less harmful.

It has been shown that Limmonik is almost nontoxic. It intensifies respiration sharply and reduces blood pressure. It stimulates the activity of the womb, suppresses peristalsis of bowels, enlarges peripheral vessels and increases wall firmness of capillary blood vessels.

It has been established by Sorokhtin and Minut-Sorokhtina (1958), that the seeds of Limmonik have a stimulative action. The substances contained in them influence the reflex reactions of the central nervous system.

Pharmacological studies showed (Rossyiskyi, 1945, 1952) that Limmonik tones up the cardiovascular system, increases the strength of heart systolic action, regulates circulation of the blood, increases frequency and amplitude of respiratory excursions, and stimulates reflex excitability.

Fig. 3. Limmonik, Schizandra chinensis Baill. (See also illustration on cover)

A number of investigators have underlined the importance of Limmonik for stimulating the central nervous system, especially when treating nervous-mental diseases, due to the fact that it doesn't lead to the exhaustion of nerve cells, doesn't cause changes in urine and blood, doesn't increase blood pressure and has no side effects. It may be used for treatment of elderly people in those cases when other stimulators, for example, phenatin-type, are contraindicated. It appears that Limmonik possesses more effective action than pantocrine. but is inferior to ginseng.

Limmonik is a stimulator of birth throes in cases of secondary birth weakness. The application of Limmonik does not lead to raised blood pressure and does not produce harmful effects on the foetus.

It produces a positive effect in the treatment of gastric diseases. The powder from ground berries and seeds or its decoction increases acid reduction in gastric juices.

Definite positive results have been registered when Limmonik was used medicinally. It increases the sensitivity of the eye under normal and pathological conditions. Powder from the seeds increases light sensitivity, expands the field of vision, and accelerates the process of adaptation to the dark. Treatment of patients with different anomalies of refraction complicated by progressive myopia (more than 0.6 dioptric) by Golovin's method (electrophoresis), used since 1959, increased keenness of vision approximately by 1.5 times.

Preparations from Limmonik have appeared to be active remedies. The effect of this medicinal influence depends not only on the characteristics of the disease, but also on the type of plant raw material (seeds, fruits, leaves, bark), form of utilisation (infusion, decoction, powder), dose, and typological features of the nervous system of the patient. Therefore the treatment needs to be carried out under the strict control of a physician.

It has been determined that if the preparations are used by healthy people, their muscular activity increases as a result of physical action, fatigue reduces, capacity for work increases; as for intellectual action, attention becomes stronger, and speed and accuracy increase.

In medical practice an infusion from the seeds is used more often than berries ground to powder.

Edible uses

The fruits of Limmonik are also used in the food industry. The pasteurised juice is sold for manufacturing wines and bracing soft drinks.

The juice and flesh of fruits after extraction of seeds may be used for the manufacture of sweets.

Recipes for an assortment of food produced from Limmonik fruits have been worked out, including an extract from natural berries rubbed through a sieve as well as mixed juices.

Limmonik is widely used by local people. Hunters consider that its berries give strength and endurance, especially when hunting in winter. Fishermen, when going to sea, try to provide themselves with juice, since it cheers them up, reduces lethargy, and helps seasickness.

Fresh juice from the berries can be kept in a tightly closed bottle and in a dark cool room for years without loss of freshness.

Under home conditions it is possible to prepare the kvass (Russian national soft drink) from juice and kissel (a jelly+like preparation) and "dry" jam (juice with sugar). Sometimes entire berries are covered with sugar, but in this case the syrup acquires bitterness and a resinous taste.

Jam prepared from berries without seeds has a dense consistency and distinctive aroma.

Composition

In fresh berries the dry matter content is 15% and moisture content is 85%. Dry matter consists of 27-32% organic acids (40% citric, 20% malic, the rest tartaric and succinic acids), up to 20% of sugars (90% of them invert), up to 40% pectins, about 1% tannins, 0.8% substances with -vitamin activities, 0.25% ascorbic acid.

Ash forms 1.15% of dry matter and is rich in potassium (53%), magnesium (11-12%), calcium (7.9%), and phosphorus (6.7%). Of the trace elements, Mn, Cu, Ni, Ti, Mo, Pb, Sn, Zn are always present.

Alkaloids, glucosides and carotenoids are not found.

The following substances have been found in Limmonik seeds: "raw fat" - 30-33% (90% of fatty oil consists of oleic and linolic acids). Essential oil reaches 2%. Sesquiterpene series hydrocarbons and their acids are found (23.3%). The seeds also have schizandrin and its derivatives as well as water-soluble free oxycarbonic acids.

Propagation and culture

In the forests the natural seedlings of Limmonik are found only very rarely - less than 3% and only on open plots free from grasses, grassy turf and fallen leaves. This plant is propagated mainly vegetatively.

In culture both seed and vegetative propagation are practised.

Limmonik is fairly easily propagated by seeds, but disadvantages are the presence of a great number of empty seeds, as well as slow growth of the embryo and non-simultaneous emergence of seedlings. The immersion of seeds in water does not produce a good effect because the hollow seeds rise to the surface together with the normal seeds that have a large aerial cavity under the shell. As a rule not only the normal seeds sink in water, but also incompletely filled seeds and seeds with abnormal endosperm. Therefore it is impossible to separate seeds completely.

Only fresh, filled seeds extracted from berries just after harvest and kept under dry-air conditions for not more than 4 months are suitable for sowing.

The soaked, swollen seeds are placed into sand with sawdust (1: 1), preferably under good aeration and regular but moderate irrigation. These seeds are kept at a temperature of 15-20° C for one month. After that they are stratified at a temperature of 0-5° C (optimal 3-5 C). Then the seeds are grown at a temperature of 8-10° C (Burmistrov, 1972).

If this method is followed strictly the seedlings emerge in 2-2.5 months. Seeds of Limmonik are sown in furrows of beds at a separation of 20 cm. Within the furrows the seeds are sown at a distance of 5 cm from each other. The depth of sowing must be not more than 3 cm. After sowing the seeds are covered with peat and irrigated.

In the first year the seedlings in beds grow slowly (5-6 cm) and possess few leaves. It is necessary to protect them from hot sun since they can perish due to overheating. Therefore they need to be grown in semi-shade - under trees or shaded with special shadecloth. It is necessary to irrigate plants abundantly, especially in early summer. Fertilisers are applied 3- 4 times in summer combined with irrigation. For this purpose it is necessary 10 dissolve 25- 30 g of nitrogen, 40-80 g of phosphorus, and 20-40 g of potassium in 10 litres of water, depending upon the content of these nutrients in the fertiliser. The solution is applied at the rate of 1 litre per square metre.

In the first summer fertilization NPK is used, in the second, N is excluded, since it delays maturation of shoots.

Seedlings are transplanted into their permanent positions at the age of 3-5 years, preferably in early spring. Cuttings must be 5-8 cm in length with 2-3 nodes, from shoots growing in the middle or top part of a vine. The lower cut is done 4-5 mm below the bud and the upper cut 2-4 mm above it.

Treatment with solution of IBA (25 mg/l for 18-24 h) or GA (100 mg/l at the same exposure) accelerates root formation and improves root system formation.

Layering is generally done in autumn. For this the shoots are bent down, pinned at a distance of 20-30 cm, abundantly irrigated, and covered with soil. Rooting begins in spring.

In autumn of the second year, layers are sectioned and shoots with roots are transplanted into hot-beds for forcing and planting the following year in the field.

In the third year the vegetatively propagated plants are transplanted to their permanent position. The best time is early spring.

They should not be planted deeply, the upper part above the cotyledonary node of the seedlings should always be above the surface of the soil. This is necessary in order to prevent the formation of rhizomes, which can spread out and suppress the growth of the main stem. If this is not done a bush, rather than a vine is formed. In such cases a plant of Limmonik begins to bear fruit 3-4 years later and the yield will be lower.

When choosing the site for a commercial orchard it is necessary to take into account water level and light requirements. In summer vines require continuous irrigation, but boggy plots and plots without drainage are not suitable. The plants need direct sun. It is necessary to protect a plot against cold, and especially against dry winds. The most suitable sites are lower parts of southern, south-eastern and south-western slopes (northern hemisphere) with well-drained, but sufficiently moist soils. Both light sandy and heavy silty soils are of little use.

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N I Vavilov All-Russian Research Institute of Plant Industry: <A 1575>

LIMMONIK (SCHISANDRA CHINENSIS) IN CHINESE FOLK MEDICINE

NOBORU MOTOHASHI §
Department of Medicinal Chemistry, Meiji College of Pharmacy
1·22·1 Yato-machi, Tanashi-shi
Tokyo 188, Japan <BYA15662@niftyserve.or.jp>

GUO-WEN ZHANG
Institute of Botany, Academia Sinica, Laboratory of Phytochemistry
141, Xi Wai Da Jie, Beijing China

DAVID NOEL§
Tree Crops Centre
PO Box 27, Subiaco, WA 6008, Australia <davidn@AOI.com.au>

Introduction

Right from ancient times, the aims of good health and balanced nutrition have led people to look for natural plant products which contain plant chemicals and minerals able to support these aims.

In particular, many fruits, nuts. and vegetables contain substances both of nutritional value and of medicinal value, useful in maintaining health and curing sickness. Among such fruits is Limmonik (*Schisandra chinensis*), little known in the west, but used in Chinese folk medicine for centuries. This fruit, a sweet berry resembling blueberry in taste, has many unusual and useful properties.

The plant

Limmonik, *Schisandra chinensis* (Turcz.) Baill., is in the family Magnoliaceae. Chinese common names of the plant are Wu wei zi, Mian teng and Shan hua jiao.

The plant (Figure 1) is a deciduous woody climber, reaching 8 metres long, with brown bark featuring clear lenticels.

Leaves are alternate, with a long, thin petiole. The leaf is thin and membranous, ovate or broadly elliptical, 5-10cm long, 3-7cm wide, acuminate in front, cuneate at the base, dentate.

Plants are dioecious, with fragrant unisexual flowers. Male flowers have a long stem, 6-9 perianths, elliptical, stamens 5; the female flower, has 6-9 perianths and a syncarpous pistil,

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§ Member, WANATCA

spirally arranged on the receptacle. The ovary is obovate, there is no style. The flowering period is May-July.

The fruit is a spheroidal berry of diameter 5-7 mm, dark red when ripe, with 1-2 seeds. Fruiting period is August-November. The plant grows in forests exposed to the sun, twining on other plants. Distributed in northeast and north China, and Hubei, Hunan, Jiangxi, Sichuan provinces.

Harvest

The fruits are picked in October and dried in the sun in dry, ventilated conditions to prevent mildew, rot and insect attack.

Fruits

The dry fruits are orbicular or elliptical, 5-8 mm in diameter, red or purplish-red or dark red exocarp, glossy and wrinkly, with soft pulp, 1-2 brownish-yellow reniform seeds, and a hard white kernel. Fruits have a distinctive smell and a tart taste. Newly-crushed fruit smells sweet, and the taste is hot and bitter. The best fruits are purplish-red, with thick pulp, and glossy (Figure 2).

Limmonik is produced mainly in Liaoning, Jilin, Heilongjiang, and Hebei provinces, where it is called "Bei wu wei zi". Another variety, with red fruit, thin pulp, of not such good quality, is produced in Sichunan, Hubei, Shanxi, Yunnan provinces.

Composition

The fruits contain volatile oil 3%, mainly sesquicarene, alpha-bisabolene, beta-chamigrene, and alpha-ylangene [1- 3]. Citric acid content is 12%, malic acid 10%, with a small amount of tartaric acid, also monose, and resin etc. [4].

The seed contains fatty acid oil 33%, the non-saponification part of which contains various tonic schizandrins totalling 0.12% [4,5,6]. Volatile oil content is 1.6%, mainly citral. Also present are chlorophyll, sterol, vitamin C, resin, tannin, and a small amount of carbohydrates [4, 7J.

Figure 1. Limonnik, Schisandra chinensis

Medical effects

Figure 2. Dried fruit of Schisandra chinensis

Limmonik extracts can benefit the central nervous system, and act as a tonic. It appears to improve human thought action and working efficiency [4]. Tests indicate improved ability to perform such tasks as threading a needle or evaluating music with schizandrin [4]. Conditioned reflex or electroencephalogram trials indicate that it can help balance competing nerve processes and improve the regulatory action of the cerebral cortex.

Schizandrin has been found of value in treating drug overdoses and poisoning, sleeplessness, and breathing difficulties. Trials on dogs showed it could counter the effects of radiation poisoning [4].

Schizandrin is said to be superior to ginseng in some actions [4]. Oral administration or injection of a petroleum extract (containing 10-80% schizandrin) showed beneficial effects on the nervous systems of mice affected by nicotine or fungal alkaloids, based on electroencephalogram (EEG) trials [4].

Schizandrin also improves breathing action and has relevance in anaesthesia of animals. It counters the action of morphine, which can cause breathing inhibition [4].

Extracts affect the cardiovascular system, raising blood pressure (hypertension) [4]. Trials show cardiac stimulation action in animals [4, 9] and regulatory effects on blood pressure. An extract is very effective for raising the blood pressure in cases of poor circulation [4].

Extracts also improve the action of uterine muscles during pregnancy and childbirth, and benefits systolic action (heartbeat), without any notable side effect. Its action is different from that of ergot [4].

As regards metabolic processes, schizandrin extract can improve sugar metabolism, glycogen allobiosis, and catabolism of the liver. Beneficial effects are noted in the interaction of phosphoric acid and fructose and glucose with the brain, liver and muscle tissue. An extract can improve working of intestines which assimilate via the enzyme P32, and also increase and accumulate the P32 in liver, kidney, lungs, heart, spleen, pancreas and brain. [t may improve the function of the adrenal gland cortex [4].

Schizandrin extracts can improve eyesight and broaden one's field of vision, and improve hearing and skin sensitivity. The extract has a regulatory action on the secretion of gastric juice and improves bile secretion. The extract has antibiotic properties and an inhibitory action on coughs. There is no effect on blood pressure, breathing, or heart rhythm when the healthy people take orally 2-3 g doses [4].

Some actions of Limmonik are the same as ginseng [4]. Although its action is weaker than "Ci wu jia" [*Acanthopanax senticosus* (Rupr. et Maxim.) Harms] and ginseng, its toxicity is less too. Extracts counter the weight loss in adrenal glands caused by testicle ketone, and prevent the decrease of vitamin C inside adrenal glands caused by hydrocortisone [13 J. Extracts can also alleviate the effects of burns [4].

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Tree Crops Centre: <A 1561>

ALMOND GROWING IN CALIFORNIA

WARREN C. MICKE

Pomology Department, University of California

One Shields Avenue, Davis

CA 95616, USA <wcmicke@ucdavis.edu>

Almonds [*Prunus dulcis* (Mill) D.A. Webb] apparently originated from one or more of the wild species that evolved in the deserts and lower mountain slopes of central and southwestern Asia. Beginning about 450 BC, almond cultivation spread into the Mediterranean coastal areas. Almonds were brought to the United States with the early colonists in the 1700s but were only successful in California where they thrived in the Central Valley's Mediterranean climate of mild, wet winters and dry, warm summers. Although some almond trees were grown at the Spanish missions, the earliest significant plantings were made in Central California in the mid 1800s. This crop has been grown commercially in California for over 100 years.

The growth of the almond industry has followed more or less classic trends, in that the initial start was made with either imported European cultivars or seedlings. Most of the European cultivars were not adapted so that before long local selections arising as chance seedlings were found that were more adapted to the California environment. The original basic list of cultivars selected prior to 1900 included 'Nonpareil', Texas Prolific' (now 'Mission'), 'Ne Plus Ultra', 'Peerless', 'Drake' and 'IXL'. The first four are still important in the California industry.

Currently there are over 165,000 hectares of almonds bearing and possibly 40,000 hectares or more non-bearing in California. This acreage is almost entirely located in the Sacramento and San Joaquin Valleys (the Central Valley of California). In recent years production has ranged from 165 to over 310 thousand tonnes. This fluctuation has been largely due to the effects of varying late winter and spring weather conditions, with lower production primarily the result of rain and cool temperatures. The farm value of almonds recently reached one billion dollars.

The California almond industry is under a federal marketing order known as The Almond Board of California. Through this order the industry compiles statistics, funds production and nutrition research, and provides generic advertising and promotion efforts. There are over a hundred handler/processors of almonds in California.

During the past 30 years the production of California almonds has increased greatly, not only in total volume but also in production per hectare. Since the early 1960s the acreage of almonds in California has approximately tripled. However, production per hectare has also significantly increased during this period. The increase in production per hectare has been related to cultivar selection, improved pollination, updated irrigation practices, better site selection for new orchards and superior disease and pest control.

The ideal climatic conditions for almond production include a long, rainless spring, summer and fall. Rain occurring during these times can hinder pollination (at bloom), increase disease pressure, and/or interfere with harvest when occurring in late summer and fall. While almonds require a certain amount of winter chilling to break dormancy, they require less chilling than most deciduous fruit and nut tree species. Depending upon cultivar, almonds need between 300 and 600 hours below 7 degrees C during the dormant period to adequately break dormancy.

Freedom from frost is also important. Almonds bloom early in California, often during February and into early March and should be grown in a frost-free climate from that time on. In areas where frost is likely to occur, water has become the primary means of frost protection in recent years.

Over the years it was found that almonds could grow in shallow, marginal soils with limited water. However, trees grew and yielded so well in deep, well drained, light to medium textured soils with adequate irrigation, that now they are mostly planted under these more-intensive conditions. Yields of over 2.5 tonnes of edible kernels (meats) per hectare are now relatively common. However, in recent years there have been some successful plantings in what were once considered less productive sites using new cultural procedures and better adapted rootstocks.

Current Production and Growing Practices

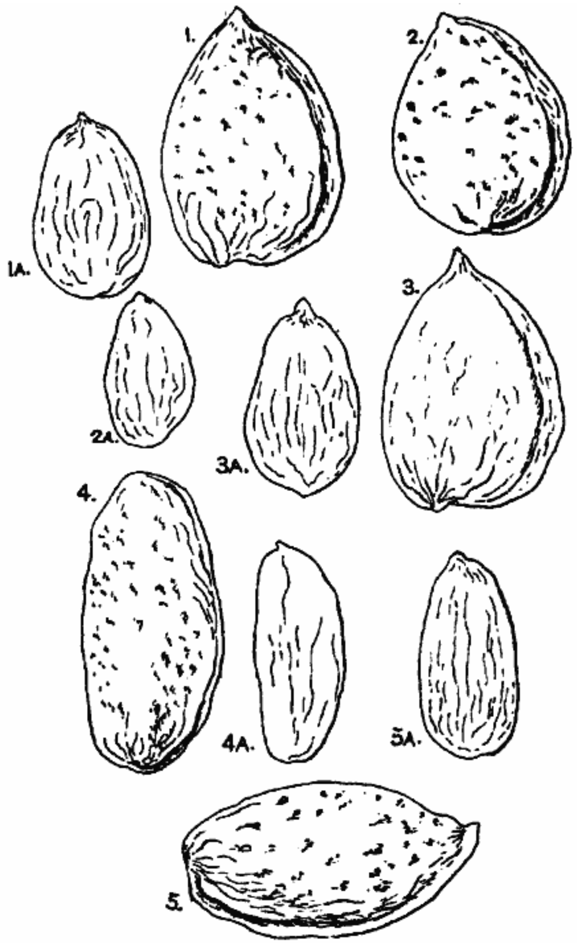
Cultivar Selection

Today the California grower has many cultivars available; in 1995 over 40 cultivars were commercially grown. However, eight cultivars make up almost 90% of the present acreage. 'Nonpareil' which has been grown for over 100 years still accounts for nearly 50% of today's acreage. The other seven most widely planted cultivars are 'Cannel', 'Mission', 'Price', 'Butte', 'Merced', 'Ne Plus Ultra' and 'Peerless'.

Because of self-sterility in all of the important California cultivars, almonds are planted in combinations of two or more cultivars. In selecting combinations, time of bloom and harvest should be considered. Bloom combinations may be made by planting two or three cultivars whose bloom times coincide or a combination of a main cultivar with a somewhat earlier and another slightly later blooming pollenizing cultivar. For best pollination and yield, single rows of a cultivar should be planted with pollenizer(s) on either side. In relation to harvest, cultivars should give a sequential harvest in order to extend the harvest period and utilize equipment and facilities more efficiently. Mixing of cultivars should be avoided at harvest in most case, and sequential harvest can help avoid this situation.

Pollination

Highest yields are a result of setting as many flowers as possible, with typical nut sets ranging from 20 to 40% of the flowers. In addition to planting single rows of cultivars with pollenizers on each side that have good coincidence of bloom with the main cultivar, honey bees are brought in as the agent to transfer pollen between cultivars. Typically 4 to 10 strong hives (colonies) per hectare are brought into the orchard at the beginning of bloom. Hives are usually placed in small groups around the periphery of smaller orchards and around the periphery and throughout larger plantings.



Early almond varieties in Western Australia, from The Handbook of Horticulture and Viticulture (Despeissis, 1921). Nuts and kernels: 1 - IXL; 2 - Languedoc; 3 - Nonpareil; 4 - Jordan; 5 - Ne Plus Ultra.

Rootstocks

Five rootstocks are commonly used in California, although most plantings are on peach rootstock. At one time almond seedling was the most common rootstock used in California. However, today it is seldom planted. Almond rootstock grows satisfactory on deep, well-drained soil and can resist drought conditions. However, trees on almond rootstock are particularly susceptible to crown gall and Phytophthora root rot as well as root knot nematodes (*Meloidogyne* spp.). In addition, trees on this rootstock tend to be less precocious than when grown on other rootstocks and have not been completely satisfactory under irrigated conditions.

Lovell peach seedling has been extensively used, particularly in the Sacramento Valley. Trees on this rootstock come into bearing early and do well under irrigated conditions. However, Lovell does not tolerate drought and is susceptible to root knot nematode, crown gall and Phytophthora root rot. Nemaguard peach seedling rootstock has been widely used in the San Joaquin Valley due to its resistance to root knot nematodes which are prevalent in much of this area. Other than its resistance to root knot nematode, Nemaguard is very similar to Lovell.

Hybrid rootstocks, particularly hybrids of peach and almond, have become relatively widely planted in recent years. These rootstocks, whether propagated from seed (Bright's hybrid or Titan hybrid) or vegetatively (Hansen hybrid), produce vigorous, deep-rooted trees that withstand drought conditions and blow-over by wind. Trees on hybrid rootstocks tend to be quite large and may be suited for weaker growing cultivars or perhaps on shallow or marginal soils which are well drained. These rootstocks are susceptible to *Phytophthora* root rot.

Marianna 2624 plum is sometimes used in areas were *armillaria* root rot is present because of its tolerance to this disease. It may also be used in heavier and poorly drained soils. Trees on this rootstock are significantly smaller and must be planted closer together and well managed in order to produce good, per acre, yields. 'Nonpareil' and some other cultivars are not compatible on this rootstock, unless an interstock of Havens 2B plum is placed between the Marianna 2624 and the scion cultivar.

Planting

Most growers plant nursery budded trees of the desired cultivar on the selected rootstock. Trees are normally planted in late winter to early spring, depending upon soil conditions. Most orchards are planted in a square pattern using spacings of 20-30 feet between trees within the row and between rows. The actual spacing depends on soil conditions and the cultivar and rootstock selected. Recently, some hedgerow plantings, where trees are planted somewhat closer in the row than between rows, have been tried with some success, although this technique has not been well researched at this time.

Irrigation

Because almonds are grown in areas of California that receive very little summer rain, irrigation is critical to good tree performance and production. Irrigation systems used in California include flood, sprinkler, microsprinkler and drip. Sufficient water should be applied to prevent tree stress from before bloom through harvest. The amount of water applied depends on the amount of winter rainfall, water use during the growing season and irrigation efficiency, with between 2 1/2 and 5 acre feet per acre frequently applied.

Tree Nutrition

Fertilization in almond orchards consists primarily of applications of nitrogen. Almond kernels are high in protein of which nitrogen is a major component. High-yielding orchards often remove a hundred pounds or more nitrogen per acre from the orchard. Such orchards often require the application of 200-250 pounds of actual nitrogen per acre each year to replace that removed by the crop, used in tree growth, etc. Orchards with reduced yield potential (for reasons other than fertilization) generally should be given lesser amounts of nitrogen. In addition to nitrogen, other nutrients sometimes found deficient and needing correction in almond orchards are zinc, potassium, boron and copper. Excess boron, sodium and chloride can be problems in certain areas of California.

Orchard Floor Management

At one time most orchards were cultivated and then smoothed for harvest with floats, rollers and land planes. This method was primarily used in flood or furrow irrigated orchards. However, non-tillage is the preferred method by most growers today. particularly those using sprinkler irrigation, low-volume irrigation systems, or flood irrigation with permanent berms

down the tree rows. With non-tillage, herbicides are usually used in the tree row; the weeds or cover crops in the row middles are mowed throughout the season and either flailed very close or treated with an herbicide late in the season to provide a smooth, clean orchard floor for harvest.

Tree Training and Pruning

Almond trees are trained to an open centre or vase shape, with usually three primary scaffolds similar to many stone fruit trees. At planting trees are headed at 30-40 inches above the ground so that at least 24 inches are left between the ground and the lowest scaffold to facilitate mechanical harvest. Primary branches are allowed to branch into secondary and then into tertiary limbs. Almond trees branch readily and require less heading cuts than most other fruit tree species.

Bearing trees should be pruned annually by removing 10-15% of the older less-productive fruiting wood to encourage new growth. However, less detailed pruning is needed than with many other fruit tree species. In many cases the removal of a few older limbs, 3/4" to 1 1/2" in diameter, will give the desired amount of regrowth from pruning.

Pests and Diseases

Navel Orangeworm (*Amyelois transitella*) and Peach Twig Borer (*Anarsia lineatella*) are the primary insect pests of almonds. These insects cause worm damage to the nuts and Peach Twig Borer can also kill the tips of shoots on young trees. In addition, ants can attack the nuts when they are drying on the ground. Various species of mites and San Jose scale (*Quadraspidiotus perniciosus*) can also be problems under some conditions. In controlling pests in almonds, integrated pest management procedures have been widely adopted by growers. These procedures include sanitation, prompt harvest, and biological control with chemical insecticide applications only when necessary.

Diseases of almonds can be broken into two types. First those that affect the roots, trunk and major limbs, including *Phytophthora* root and crown rot caused by several species of *Phytophthora*, oak root fungus (*Armillaria mellea*), bacterial canker (*Pseudomonas syringae*), ceratocystis canker (*Cerarocystis fimbriata*), and crown gall (*Agrobacterium tumefaciens*).

The other group of diseases consists of those that affect the blossoms, nuts, foliage and fruiting wood. This group includes brown rot (*Monilinia laxa*), shot hole (*Wilsonomyces carpophilus*), scab (*Cladosporium carpophilum*), bacterial blast (*Pseudomonas syringae*), and hull rot (*Rhizopus stolonifer* or *Monilinia* spp.). A relatively new disease, anthracnose, has recently been found in California almond orchards.

Other pests that can be a problem in almond orchards include several species of nematodes, birds, ground squirrels and pocket gophers.

Noninfectious Bud Failure

A genetic disorder, Noninfectious Bud Failure (BF), can be serious in some cultivars. This disorder tends to be worse in the hottest growing areas. BF causes the death of some vegetative buds: those buds that are not killed show vigorous growth often occurring at right angles to the originating branch. This growth pattern gives BF one of its common names, "Crazy Top". Fruit buds are not directly affected. However, after several years loss of vegetative buds, the amount of fruit wood in the tree is reduced, and thus, production eventually declines on affected trees. The more severe the BF symptoms, the more yield can be reduced over time. At this time it appears that bud wood source selection and clone testing are the best ways to cope with this disorder. Low BF potential selections of major cultivars affected with this disorder are now available. Nurseries are moving toward using such selections as well as certified stock.

Harvesting

Essentially all orchards in California are mechanically harvested. Mechanical harvesting consists of knocking the nuts to the ground with mechanical shakers, sometimes followed by hand poling to knock off nuts not removed by the shaker. The nuts are allowed to dry on the ground for 5-10 days until they are completely dry (below 7% moisture). They are then swept into windrows, picked up by machines into nut trailers and transported to the huller where the hulls are mechanically removed. Many growers have their own harvesting equipment and some have their own hullers, while others rely on custom operators or cooperative hulling plants. Nuts are usually shelled by the handler/processor, but in recent years some shelling has been done on the farm or by commercial hulling/shelling plants and then delivered to the handler/processor as shelled product.

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EDIBLE NUT PINES IN CANADA

CHARLES & LINA RHORA

Rhora's Nut Farm

RR#1 Wainfleet, 32983 Willis Road,

Wainfleet, Ontario L0S 1V0, Canada <rhora@valueweb.net>

Our original planting of nut pines were from seed obtained from Europe, and Asia. Specifically from the Countries of Denmark, Sweden, Russia (formerly USSR), Mongolia, Eastern Siberia, and North Korea. We had picked these countries because we were looking for the most hardiest of the nut pines to grow here. The seeds obtained were from areas classified as Zones 1 and 2.

Starting in 1975, we corresponded with many individuals, experimental stations, and arboretums. Over the next five years we were able to obtain our requirements from these sources. The seeds we obtained ranged from a few ounces upwards to 15 pounds. They were locally collected from individual trees growing in their natural terrain. Most were at highest altitude which exposed them to extreme weather conditions.

After the seeds were received, they were stored very carefully at controlled temperatures. Later they were given the proper stratifications. All of the seeds from our sources required two different types of stratification to ensure proper germination.

We prepare the seed beds the year before the planting, working the inoculant into the soil so the germinated seedling will be able to use it immediately. A 6 mm wire mesh is made to cover the seed bed with it being buried 10 cm in the ground. Enough height above the seed bed is allowed for the seedlings to grow for one year. This is very essential ! as protection from birds and rodents which will destroy the seeds or seedlings as they germinate.

The seeds are planted in the first week of June and in two weeks the first seeds were observed germinating. This continued for another two weeks. The final germination count varied from 85 - 90 percent.

The seed bed was covered with partial shade to prevent the heat of the sun burning the seedlings off for the next four weeks. After this time had elapsed the shading was removed and no damage occurred to the seedlings,

At first the seedlings looked very healthy, but they did not grow. Soon some started to turn brown and a few died, the rest remained at the same height as they were when they germinated.

We looked for help from various sources, but were surprised that in North America no one could offer us any help, as apparently few had tried to grow these two species.

We remembered some correspondence from a retired chemist from one of the European countries who had, as a hobby, grown some of the Korean pine. He had mentioned that adding a certain natural type of material to the soil would benefit the trees. We immediately gathered some of this material and sprinkled them over the seedlings, this showed immediate results in the seedlings returned to their natural bluish colour and actually put on some growth (approx 3 mm growth) for the first year. This was a start, but we knew that if we were going to bring this experiment to a successful conclusion, more work had to be done in this area.

Upon further studies, we found that all pine trees benefit from an inoculant (Mycorrhizal fungi). For instance with the Korean, Siberian, Swiss stone, and Siberian stone pines, the seed will germinate, but will not survive without this special inoculant.

Over the next 7 years, we experimented with natural ingredients and adding these to the other natural ingredient and we were able to obtain growth of from 25 to 45 cm each year.

From this start we now have developed inoculants that are essential, or will greatly help, the edible nut pines to grow at their maximum growth rate and the trees will produce cones and nuts at a much earlier age than had previously been reported. Also we found that each species required different ingredients in their inoculum.

Weeding of the seed bed must be carried out by hand. Herbicides are not used as they will destroy the fungi. The protective wire mesh cover is removed and the necessary maintenance is carried out. Then the cover is returned. In the third week of August this same procedure is carried out again for the last time for this season. The weeds are allowed to grow as the seedlings are very shallow rooted and this helps in preventing frost heaving. In early December the seedlings are also given a mulch of pine needles as an added precaution and the protective wire mesh is returned to cover the seedlings for the winter.

The wire mesh protective cover remains over the seed bed until the following year as added protection through the winter and then removed in the month of June. All weeding is still carried out manually. Seedlings remain in the seedbed until the start of the third year, then they are transplanted as lined out seedlings. We space the trees one foot between the trees in the row. The inoculant is placed around the roots at the time of transplanting. They are allowed to grow here for 2 years before they are transplanted to their permanent location.

The Korean pine to date is the only pine that has had a crop. One tree started bearing cones at the age of eight years from seed. This was unusual, as we found that they take an average of 10 years before they start to bear. They produce male cone pollen as early as 5 years, but the female cone does not start until they reach the average age. The cones at first are borne only on the main leader in groups of 3 to 5 cones. The cones take two years to mature, in the first year the cones develop to the size of about 2.5 cm in diameter. In the second year, the cones start to grow and fill the cones very rapidly. They are full size by the end of June, but the seeds continue to develop through the summer and ripen by mid October to the first week of November. They will withstand frosts as they continue to ripen. At first we thought we would only have a crop every second year, but the following spring, we found first cones starting on trees that had produced cones from last year. Thus we harvest a crop every year from these trees. Each year they produce more cones till finally they reach the age of approximately 17 years, they then start to produce cones on lateral branches. At approximately 20 years of age they should be producing a quarter bushel of cones. This translates to approximately 1.5 to 2 kg of nuts.

The nuts produced per cones varies. We had one cone that produced 165 nuts per cone, but on the average, they produce approximately 90 nuts to a cone.

Up until now we hand harvest the cones. The cones are covered with a very sticky resin. One should wear gloves when harvesting the cones. The cones ripen in middle October to first week of November, and are easily recognized when they are ready for harvest. While maturing they are a medium green, but upon ripening they turn to a brown colour. One can easily tell when they are ripe. Just grasp the cone and give it a light twist and if it is ripe it will separate from the tree.

The cones are air dried for 3 to 5 days. In this period the pitch or resin dries, but most importantly the cones open and by shaking it the nuts fall free from the cone. Some nuts need a little coaching but they are quite readily removed.

As the trees mature, it is our intention to use a modified cherry tree shaker to harvest the cones. Also the cones would be easily dried in a kiln as the harvest grows in size.

All of our crop to date is sold from our farm. Once the general public learned that we had fresh pine nuts, we could not keep up with the demand. Each year we have a list, the first person contacting us, is of course at the top, and has first choice. After our supply are depleted, we notify the remaining customers, and their names are put on next year's list. We also set aside a good portion of the nut seeds for our own use in our nursery. We receive $7.00 per kg for eating purposes, and those that are sold as nut seeds to our mail-order customers we receive from $9.00 to $12.00 for planting purposes. The reason for the difference in prices is because nuts for seed require more care in their handling and storage.

We also have a demand for the cones, in fact, the cones are in as much of a demand as the pine nuts. The resin on the cones last for up to 3 years, even although it is dry, and the aroma is one of the most pleasant fragrances. We sell all our cones to craft stores for this reason. The demand is so high, that we have a waiting list up to 3 years for back orders.

A few years ago there was an article on edible nut pines in a well known magazine distributed in North America and after the write up, we were overwhelmed by the request for nuts. We received orders or requests from large chain restaurants for up to 250 kg of nuts in the shell every month. Unfortunately we had to decline because we could not meet these demands, nor will we be able to for several years.

As our harvest increases, it is our intention to invest in a cracking machine that will enable us to start selling the kernels, candied nuts, etc. Such machines are now available at a reasonable cost.

To date, we have not encountered at our location any pests, or diseases that have affected these trees. We carefully inspect the orchard at least once a week.

In our early experiments, as mentioned above, we have concentrated on reproducing the pines by seed only. We had tried several grafted seedlings in this trial period, but as time progressed we realized that the grafting method was not profitable. We also had tried several seedlings grafted onto the rootstock of the Eastern White pine. The trees grew reasonably well, but at the production stage, they only produced filled nuts in the 50 to 60 percent range.

We tried several other grafted trees of other varieties, but the results were so disappointing - e.g. stunted growth, graft failure, etc.

We had of course tried these experiments because others had suggested that this might eliminate the need for the inoculant. but these experiments proved out our first thoughts, that these trees will do better on their own roots. Our seedlings were producing filled nuts between 90 and 95 percent, while those grafted on the Eastern white pine were only produced a lower percentage of filled nuts. Also the first production of nuts from our seedlings, showed that the nuts were at least one-third larger in size than what we had originally planted. We have test trees planted from the second generation of seed, and in a few years we eagerly await what type of seed they will produce, and the percentage of filled nuts. Before leaving the subject of reproducing trees from grafting, we would like to mention that we have selected some superior trees from our original planting of trees based on their production of cones, filled nuts, and lastly on their ornamental value for landscaping. Several trees produce needles that are a very bluish colour (similar to some named Colorado Blue Spruce) and they retain this colour all year round. We will be releasing some of these in the near future as named cultivars. We will be grafting these onto Korean pine rootstock.

We have several hectares planted out to orchards of many of the varieties of edible nut pines. In monetary return per hectare on these trees it is best to plant the trees in rows 6 m apart with a spacing of 3 m between trees in the row. By using this spacing we have found that they produce the most return per acre, especially during their early producing age to obtain the most nuts. After they reach the age of between 20 to 25 years, they tend to start to crowd in the row. At this time we use a tree spade and remove every other tree to a new location. We are able to double the size of the orchard, and the trees moved in this manner will only lose one year's production. Also this gives us the final spacing of 6 m between the trees in the row of our orchard. The trees easily reestablish themselves, as they are shallow rooted. If the use of a tree spade will not be feasible, then one would have to cull every other tree out of the row in the orchard to prevent overcrowding.

We use several methods to protect the trees and crop from rodents. After the seedlings are transferred from the nursery to lined out seedlings, we apply in the fall a treated mouse bait containing zinc phosphide. This bait is coated with wax, and will protect the trees for one year from mice. Where rabbits and deer are a problem we recommend a tree guard.

Once the trees start producing cones and nuts, squirrels and chipmunks can be a problem. Although to date we have not had any problems with these, due to the fact that we have many owls, hawks, and other natural predators which keep these away from our trees. If there were a problem with squirrels, etc. we recommend a planting of another crop (possibly hazelnuts or filberts) a good distance from the pines to attract their attention away from the pine nuts. Another option is to live trap these pests.

In later years. after we had obtained the most hardy seed available, we obtained some seed from Japan and South Korea of the Korean Pine, but we found after several growing seasons that they were only hardy to Zone 4. Although we still have these growing, we do not sell or recommend these as they produce a much smaller pine nut, slower growing, and the time of their first crop is much longer.

In conclusion, the Korean pine is the only one producing pine nuts, due to the difficulties in obtaining the most cold hardy seeds available, plus the many years in developing the correct inoculant for the Korean pine to grow satisfactorily and produce at an earlier age. As we were developing our inoculant, we tried several other inoculants from different regions of North America. but found that none of these worked in our area. We were given information that these inoculants were developed for their own areas. In other words, they worked where they were developed, but met with failure when tried in other regions. Once the proper inoculant was developed for the Korean pine, we were able to turn our attention to developing inoculants for each variety of the other edible nut pines. We would report from replies and personal observations, our inoculants work all across Canada, in the United States, and also have helped these trees grow at a better growth rate in Europe, Asia, and other countries.

In the next few years, many of the other varieties of the edible nut pines will start producing crops. and information on these will be released at that time.

Listed below is a brief description of all the edible nut pines that we have experimented with. Some are in orchards, others are still in test plots, while others failed to survive our winters because of lack of hardiness (those in Zone 7a and up). The germination ranged between 80 to 95 percent. All have the potential as a commercial crop planting with the added benefit as an ornamental and for landscape settings.

Description of edible nut pine trees

Korean Pine (*Pinus koraiensis*)

Zone 2. A tall growing tree, very similar in appearance to the Eastern white pine in appearance. The needles are in fascicles of 5. Colour of needles ranges from a light green to bluish green in colour. Height range from 30 - 50m. Bearing age from 10 to 150 years plus. Number of nuts per kg 1430.

Siberian Pine (*Pinus siberica*)

Zone 1. Somewhat similar in appearance to the Korean pine reaching a maximum height of 30 m at maturity. Bearing age from 12 to 150 years plus. Very ornamental in appearance, somewhat similar to Korean pine. In their native habitat they usually grow in a wet bog-like area. Another outstanding feature of these trees are the seed coats of the nuts. They are thin enough to break in one's fingers. Nuts per kg 1485.

Swiss Stone pine (*Pinus cembra*)

Zone 2. Needles in fascicles of 5s. Maximum height to 20 m at maturity. Bearing age starting at 14 years. Number of seeds per kg 2150. One feature of this particular tree is that in its natural range, it grows in a heavy clay with good drainage. Our experiences show that it will do very well in other types of soils ranging to loam to sandy textures. Very outstanding as an ornamental as well, with a bluish colour which lasts year round.

Macedonian Pine (*Pinus peuce*)

Zone 4. Needles in fascicles of 5s. Maximum height to 25 m. Bearing age begins at 12 years. Number of nuts per kg 2070. Grows best in a well drained soil, but requires adequate drainage. Soils range from loam to sandy. Very ornamental tree with bluish colour in spring, changing to a darker green in August.

Dwarf Siberian Pine (*Pinus pumila*)

Zone 2. Needles in fascicles of 5s. Shrub growth type, similar to Mugho pine, but will withstand heavy snow without branches breaking. Will reach a maximum height of 6 m. Bearing age 10 years. Nuts per kg 1850. Prefers a well drained soil consisting from loam to sandy type. Two types are recognized, both are ornamental in appearance. One variety is a very bluish green all year, the other is a greyish green. Seed size is the same for both.

Italian Stone Pine (*Pinus pinea*)

Zone 8A. Needles in fascicles of 2s. Maximum height at maturity is 12-18 m. Bears nuts at age of 18 years. Nuts per kg 1350. Prefers a well drained soil ranging from loam to sandy.

Armand Pine (*Pinus armandii*)

Zone 4. Maximum height at maturity is 12-18 m. Bears nuts at age of 12 years. Nuts per kg 1850. Very ornamental in appearance with a bluish colour to needles. Grows best in a sandy soil, well drained.

Nepal Pine (*Pinus gerardiana*)

Zone 5. Needles in fascicles of 3s. Height at maturity 18-24 m. Bearing age of 15. From the Himalayan mountains. Very difficult to grow. Fine specimen or tree once established. Requires a well drained soil. Soil texture is best described as a mixture of very fine gravel with good loam to sandy soil. Nuts per kg 1890.

Digger Pine (*Pinus sabiniana*)

Zone 7A. Needles in fascicles of 3s. Mature height to 18 m. Starts to bear nuts at age of 18 years. Will grow in loam to sandy soil, prefers good drainage. Nuts per kg 1340.

Jeffrey Pine (*Pinus jeffreyi*)

Zone 4. Needles in fascicles of 3s. Maximum height to 45 m. Bearing age from 18 years. The tree is very unusual in appearance, especially when young. The trunk diameter is quite large in comparison to height of tree. The needles give off a very aromatic fragrance in the spring. Needles are long, sometimes up to 20cm long. Prefers a well drained soil ranging from loam to sand. Nuts per kg 2980.

Pinyon Pines (*Pinus cembroides*)

Zone 4. Maximum height at maturity 9-12 m. Bearing age from 15 years. Slow growing tree, colours of needles range from very bright blue to a light green. Prefers a sandy type soil, but will do well on a loam as long as there is good drainage. Nuts per kg 2035.

Sugar Pine (*Pinus lambertiana*)

Zone 4. Needles in fascicles of 3s. Maximum height to 60 m at maturity. Bearing age of nuts 15. A fast growing tree. Prefers a well drained soil ranging from a loam to sandy texture. Nuts per kg 2170.

Note: seed counts per kg were based on the actual nuts we obtained from our sources.

[Based on an article in a 1998 issue of Song, newsletter of the <u>Society of Ontario Nutgrowers</u>.]

[Quantities converted to metric by the Tree Crops centre].

<u>Society of Ontario Nutgrowers</u>: <Annnn>

GROWING OLIVES IN WESTERN AUSTRALIA

STAN KAILIS

University of Westem Australia

Nedlands WA 6907 <skailis@agric.uwa.edu.au>

Introduction

So you want to grow olives! The first question you must ask is why? Are you one of the many potential growers caught up in the current world-wide interest in olives and olive oil? It is important to know where you sit in the process. Are you an enthusiast or a serious grower? Do you wish to concentrate on the table market with pickled olives or is olive oil manufacture your goal? Do you want an income, profit or investment?

Why is there so much current interest in growing olives in Australia and elsewhere? The most important part of the olive tree is the fruit. The fruit when crushed and pressed yields the valuable edible oil, Virgin Olive Oil, which when eaten as part of the Mediterranean diet reduces the risk for heart disease and some cancers. Antioxidants such as polyphenols and Vitamin E together with a high proportion of monounsaturated fats are thought to provide this protection. Such health benefits have increased the demand for olive oil and together with relatively lower production by traditional producing countries has resulted in an increase in olive oil prices which has made olive growing more attractive. Concern has been shown in some quarters that olives may be the flavour of the month and their demise will follow other new industries such as tea tree oil, jojoba and emus. The major difference is that olives are a recognised international food commodity.

Economics of the Olive Industry

Twenty olive trees, which can be grown on a modest size block, are all you need to be self sufficient in eating olives and olive oil. Depending on the spacing between trees one can plant 100 to 300 trees per hectare. Scoping the type of Australian grower interested in olives reveals three classes:

- Lifestyle - 100-500 trees
- As part of existing horticultural or farming activities - 1000·2000 trees
- Specific olive operations - more than 5000 trees

Profitability will depend on marketing, quality of products, labour and infrastructure costs. Scenarios developed by Farnell Hobman and others indicate that olive growing and olive oil production can be profitable under dryland or irrigated conditions. Australia imports about 17000 tonnes of olive oil per year for the domestic market. Compared to this, domestic production is negligible. Imports translate to less than one litre of oil consumed on average by Australians each year. There is therefore scope for import replacement as well as extending the use of olive oil. It has been estimated that the average Greek citizen, consumes about 20 litres of olive oil per year. As oil and fat consumption, from a dietary point of view is relatively constant on a per capita basis, eating more olive oil means eating less butter, margarine or vegetable oils. As the latter tend to be less expensive they will always be competitors even though olive oil has recognised health benefits.

As a foodstuff, olive oil is popular world-wide and as well as an anticipated increase in consumption by those with a western type of lifestyle an increase in consumption by Asians is expected. However as an edible oil it only represents 4% of the total world edible production with a yearly production of nearly two million tonnes. World production of olive oil has been dependent on traditional growing countries and because of their rising labour costs as well as local factors such as urbanisation effects and climate, shortages and increased prices have occurred. Interest by countries, such as Australia, with suitable growing conditions for olives is escalating because of the opportunity to produce olive oil and other olive products for the domestic and international markets.

An innovative, well-structured industry, supported by government agencies is essential for Australia to be a significant international player. The Australian wine industry will be a useful model for the olive oil industry to consider. A major Australian olive industry will only develop if growers and producers can deliver quality products in volumes large enough to meet supermarket and food industry demands.

Where do Olives Grow?

The olive and olive oil industry is predominantly based around the Mediterranean Basin. The olive tree, a dryland evergreen tree suited to the Mediterranean climate, grows under a wide range of conditions. Olive trees grow in arid and semi arid regions where they are resistant to adverse conditions tolerating drought, infertile soils, and salty conditions.

Reference to olives and olive oil is made some 200 times in the Bible! The wild olive *Olea europaea* L. subsp. *sylvestris* is believed to have been domesticated in Asia Minor by 4000 BC. The domesticated form of the olive is termed the European olive or *Olea europaea* L subsp. *europaea*. The olive was introduced and cultivated predominantly in countries of the Mediterranean Basin including Turkey, Greece, Italy and Spain as well as north African countries such as Tunisia and Morocco. The olive is known by a number of different names which can appear on packaged products such as preserved olives or olive oil.

- Arabic - ceiton, zeitoun
- Greek - elia
- Italian - oliva
- Spanish - aceituna

The olive is a subtropical tree and outside of the traditional producing countries, olives will grow well in climates with cool winters and hot dry summers such as in southern Australia. Suitable growing conditions exist in parts of the USA, Mexico, Chile, Argentina, Brazil, and South Africa. There are also olive growing activities in New Zealand, India and China.

Olives grow under a wide range of conditions in Australia and new plantings are being made in every state including Tasmania and the Northern Territory.

The Olive Tree

The olive tree is traditionally grown under dryland conditions where water is delivered through natural precipitation. Special leaf adaptation will allow water absorption as well as conserve water during dry conditions. Rainfed olive trees require 500-600 mm annual precipitation although in countries such as Tunisia which have less rainfall there is an active olive industry. Higher rainfalls are beneficial in ensuring continuity of crop. Supplementary water is very beneficial in hot dry months particularly for young trees and when the fruit is developing. With an adequate water supply for irrigation, limiting factors for optimal olive fruit production are the temperature and soil conditions.

Left unattended, olive trees can survive for at least 500 - 1000 years and can easily reach 10m in height. Such tall trees are not suitable for modem olive fruit production where heights of up to 5 m are more suitable for hand or machine harvesting. Future groves which will involve a greater degree of mechanisation for picking and pruning for cost effective production, may very well have the olives in hedgerows 1-2 m high with up to 500 trees to the hectare. Groves being developed currently have about 250 trees/Ha which is in marked contrast to the 100 or so trees/Ha in traditional groves of the Mediterranean countries. Research is required to evaluate such new intensive growing procedures for olives.

Olive fruits develop after fertilisation of the small cream to white flowers. Sexually, olives are hermaphrodite with both male and female flowers present on the one tree. However self pollination and cross pollination can occur. Most pollination takes place either by falling pollen or wind-carried pollen. Bees may be involved in the pollinating process to a lesser extent. Mixed cultivar groves with specific pollinating cultivars such as Pendolina at a ratio of 1 to 8, are included in an olive grove because of their superior pollinating capacity. Some flower infertility occurs in association with ovary abortion, ineffective pollen, absence of pollen or incompatible pollen. High temperatures (40° C) can damage flowers. Flower drop is greater when olives are grown under dry land conditions than when they are irrigated.

Without irrigation the fruit-bearing age of the olive tree is about 9 years. This period can be halved when the olive trees are grown under intensive conditions including irrigation and fertilisation. The fruiting age is also cultivar dependent. Olive trees are alternate year bearing, with a heavier crop being produced every second year. Alternate year bearing can be evened out with irrigation.

Growing Aspects

Climate

Because olives grow well between latitudes 30 - 45, both in the northern and southern hemispheres, significant areas of Australia have the climatic conditions suitable for olive growing. Much of this land is already being used for agriculture, part of catchment areas or set aside for national parks. Although there is limited scientific documentation on olive performance in Australia, there are sufficient plantings in a wide range of locations indicating successful olive growing in south-west Western Australia, southern New South Wales, southern South Australia and parts of Victoria. Early plantings began with the colonial settlers who introduced a variety of trees to help in their survival. Many old homestead still have several olive trees which have cropped for over 150 years, even though the animals may have always been the beneficiaries.

Temperature

Olive trees do not tolerate temperature extremes. The most favourable temperature range for olive growth is 15 - 34° C which is common in Australia. High temperatures damage flowers and cause marked flower drop and hence influence fruit production whereas low temperatures and frosts can kill tissue and damage fruit. Below a base temperature of 10° C growth is restricted and when the temperature falls below -5°C, such as in severe frosts, tissue necrosis occurs, although roots and below-ground structures may survive. Some cultivars are more resistant to frost than others. Frost damaged olive trees in Tuscany (-25° C) cut at the base have regenerated into productive trees. Of course it takes 2-3 years to reach previous production levels. Trees in poor shape due to stress or animal damage cannot handle frosts as well as healthy trees. Higher temperatures are detrimental, causing early maturity, poor fruit set and tissue destruction. Desirable upper temperature limits for day and night are 40° C and 20° C respectively. Irrigation can overcome some of the hot weather effects.

A midwinter mean temperature of below 10° C, is required for flower production but not essential for good growth. Even lower temperatures induce vegetative rest. Ideally olives should be grown in areas where temperatures do not fall below 5° C or above 40° C. Both short and long days are required during the growing period. This can be achieved easily in southern Australia. Olive trees growing closer to the equator tend not to fruit and grow vegetatively. This is in part due to the lack of a chilling period required for flower development.

As mentioned previously, olives are a dryland plant and are quite resistant to drought conditions similar to the levels of rainfall experienced in large areas of rural Australia. Under rainfed conditions where water supply is low, alternate bearing is more pronounced and in some years there may be no crop at all. Providing supplementary water during lengthy dry periods, November to February in southern Western Australia, is very beneficial and allows for more consistent cropping.

Shade Effects

Olive trees are intolerant to shade. Leaf photosynthesis occurs throughout year as long as temperatures do not fall significantly during winter. Direct sunlight is required for adequate flowering and fruit production. Reduced light lowers the level of bud induction and differentiation. There is much discussion about the spacing of olive trees in groves. Factors that must be considered when planning an olive grove include water and nutrient competition, mechanisation procedures and shading effects. There is always the desire to plant as many trees as possible per hectare. Traditional groves may have had as few as 50 trees/hectare. Modern groves can have in excess of 250 trees/hectare. Such intensive groves may suffer shading problems particularly if trees are not trained and allowed to grow unchecked.

Salt and Wind Effects

Olives are moderately tolerant to salt spray and salt in root zone. Olive trees will crop if irrigated with saline water with a conductivity of 2,400 mS/cm. However trees receiving 3- 4 times this level have been unable to resist persistent frosts and a number of olive trees and other species died.

Olive trees have been used successfully as windbreaks on farming properties. Strong winds, 80-100 km/h are extremely harmful for crop production. Hot drying winds coming off the desert areas can induce water stress in olive trees with the leaves and flowers being particularly affected. Such wind damage can be minimised with irrigation.

Soil Requirements

A wide variety soils will support olives including calcareous soils. Deep soils, 40+cm, are the most suitable although more shallow soils, 21-40 cm, can be modified to support growth. Very shallow soils, <20 cms, are generally not suitable.

Soil pH

Soil pH is an important factor. Weakly acidic soils, pH 5.5-7, are the most favourable with soil pH up to 8.5 being suitable. Soil with an acidity of pH <5.5, which is often found on previously farmed land, can be modified with dolomite to give a more suitable growing pH.

Essential Nutrients

Nitrogen, phosphorous and potassium are the most essential nutrients and need to be applied if the soil is inadequate. Levels need to be monitored because nitrogen leaches out readily. There is a downside because overuse of nitrogen can result in excessive shoot growth producing numerous small fruit. When adding phosphate, the soil pH needs to be considered because phosphate availability is reduced in acidic soils and alkaline soils high in calcium. As a guide one should aim for a soil pH of 6-7.

Trace Elements

Trace elements required by olive trees include calcium, iron, magnesium, manganese, sulphur and zinc. Availability is pH dependent with greater availability from acidic soils. Where soils are alkaline or calcareous, complexes are formed so using foliar sprays is the better way to go.

Drainage

Fast drainage is important for olive trees as they do not like "wet feet". Flooding, particularly through the growing season leads to root anoxia and necrosis. Water logging for more than a few days can eventually lead to loss of trees. When planning an olive grove, trees should be planted in well draining areas. If waterlogging is a problem, contour channels should be established to allow adequate drainage of water. Poorly draining clay soils are prone to water-logging, particularly in winter and early spring. Experience on the east coast of Australia indicated that excessive summer rain in association with poorly draining clay soils is particularly detrimental to olive trees. Under anaerobic conditions created toxic substances such as hydrogen sulphide and methane are formed by microorganisms. There is also reduced bioavailability of trace elements. Effects include poor shoot growth, stunted growth, yellowing of foliage and tree death. Olive trees with root damage are less able to cope with the cold because of reduced carbohydrate storage and are more susceptible to fungal infection. Waterlogging is less of a problem with sandy soils. Uniform loam is the best for growing olives, whereas loam or sand over clay are also suitable. With fast draining soils irrigation should be adjusted to give less amounts of water more often.

Cultivars

With over 800 named olive cultivars available world-wide, specific cultivars are selected on the basis of their usefulness for preserving as table olives or for making olive oil. Although all olive cultivars can be eaten or crushed for oil, those preferred as table olives generally have a greater water content and lesser oil content than those used to make oil. Table olives are usually larger than those for oil which makes the latter more difficult to pick by shaking. Future picking methods may follow technologies being developed for the grape industry. Furthermore each country has its own traditional cultivars such as Picual in Spain, Leccino in Italy and Kalamata in Greece. Some country specific cultivars are listed below.

Algeria	- Sigoise
Australia	- Swan Hill (non-fruiting)
Chile	- Azapa
Cyprus	- Adrouppa
Egypt	- Aghizi Shami
France	- Picholine
Greece	- Kalamata, Koroneiki, Mastoides
Israel	- Barnea, Nabali, Souri
Italy	- Ascolana, Frantoio, Leccino, Pendolina, Carolea
Morocco	- Picoline Marocaine
Portugal	- Blanquita de Elvas, Cobranosa
Spain	- Arbequina, Picual, Sevillano, Manzanillo
Tunisia	- Chemlali
Turkey	- Memeli, Ayvalik, Domat
USA	- Californian Mission, UC13A6

Cultivar selection for a grove can also be made on the basis of fruiting period, resistance to frost or disease and usefulness as root stock. In Australia for olive oil production there is interest in planting the cultivars Frantoio, Leccino, Pendolina, Picual and Paragon for oil production. Newer cultivars for Australia, some of which are still in Australian quarantine, include Barnea (Israel), Koroneiki (Greece) and Minerva (Italy). These cultivars can be trained into medium sized trees, which are less labour intensive to manage. Fruit from these cultivars yield about 20-25% oil. There is also interest in developing DNA identified cultivars from wild olives growing in Australia as Australian cultivars.

It has been estimated that in olive oil production, cultivars contribute about 20% to the quality of the oil with most of the quality being attributed to regional effects, harvesting and the oil production process. The axiom is that you need high quality olives to produce high quality oil. If it is any consolation, less than one third of the olive oil produced world-wide meets the extra virgin standards. So world consumers are using lesser quality olive oils often labelled as olive oil or pure olive oil. The latter olive oils make up the ‘bulk of olive oils marketed in Australia for table use and in the manufacture of olive oil margarines and blended oils. When Australia becomes a major olive oil producer, even though the industry will be aiming for the quality end of the market, facilities will need to be developed to process lesser quality olive oils to international standards.

In the case of table olives, consumers prefer a fleshy fruit with a high flesh to pit ratio. Olives that are recognised as excellent table olives include Kalamata, Volos, Sevillano and Manzanillo. All grow well in most parts of Australia although Manzanillo does better in warmer climates. There is no doubt that those wanting to grow table olives should consider the Kalamata variety. Verdale has also been a popular table olive in Australia in the past, however it will become less important as more new cultivars become available.

Olive Tree Propagation

Traditionally olive trees have been propagated by grafting onto seedlings. Grafting is still the preferred method for difficult to strike cultivars such as the Kalamata variety. For most cultivars, current practice is to strike pencil length vigorous shoots using indolebutyric acid. Several regimes are available. Commonly cuttings taken in autumn are dipped for a few seconds in IBA (3-4000 ppm), placed in a synthetic medium such as perlite or peat moss and then kept moist in a propagating house with intermittent fog and spray and bottom heat. Rooting takes 2-3 months, after which the rooted cuttings are planted out into plastic bags. For serious growers tree propagation should be left to the experts.

Olive Grove Design

There is much discussion regarding the spacings, planting protocols and form for olive trees. Several questions need to be asked.

- what will be the size of the grove?
- which cultivars will be planted?
- will the trees be grown under rainfed conditions or will the grove be irrigated?
- what is the quality of the water?
- what is the quality of the soil?
- what level of mechanisation will be used?

Olive trees need maximum sunlight and training by selective pruning will ensure that the outer growing area of the crown where the olive fruit develops is maximised. Olives develop on one year old wood. Under rainfed conditions tree spacing needs to be greater than if irrigated to allow for effective root development. For example in countries with very low rainfall such as Tunisia, olive trees are spaced 20 m apart. A 9 m by 9 m spacing will allow a tree density of 120 trees/Ha whereas 6 m by 6 m planting will give 250 trees/Ha. For the UWA research trials we will be using a 5 m by 7 m planting design. Trees will be planted 5 m apart and the interrow spacing will be 7 m. The reason for the latter is to allow for machinery to pass between the rows. For irrigated groves the intertree spacing can be reduced with increased risk of shading. Shading reduces budding and fruiting and orchard production.

Early in the development of an olive grove, the inclusion of filler trees has been suggested so that commercial yields will be obtained earlier. The idea is that these filler trees are removed as the main trees grow. The economics for such an exercise have not yet been proven, and unless there is a shortage of land, should not be considered. It is far better to plant the trees in their permanent position.

Planting Olive Trees

Olives grow on a variety of soils good and poor. Some planting regimes suggest deep ripping. This is more important where old root systems are present and for heavy and loamy soils likely to compact. Deep ripping is less important for sandy soils. Rotted organic material such as straw, animal manures, blood and bone worked in to the soil prior to planting has been shown to be advantageous. Some commercial growers also recommend the application of commercial formulations of slow release fertilisers. Where soils are phosphate deficient or acidic, superphosphate or dolomite can be worked into the soil. Although herbicides are suggested to keep down weeds, mulching is a more environmentally friendly process. Growing a winter legume for green mulch is another strategy that should be considered. More research is required to determine nitrogen production from biological sources to reduce the need to add chemical fertilisers and so reduce the risks of pollution. Mechanical tilling particularly after harvest assists in improving water absorption, however promotes erosion and loss of top soil and should not be the preferred method for weed control.

Least problems will occur if olive trees are planted in autumn or spring. When planting olives, a hole big enough to take the roots should be dug, avoiding any glazing of the sides. Trees should be planted at a level lower than the top of the soil in the pot or bag. Grafted olives, such as Kalamata variety, should have the graft planted well below the ground. This will reduce the risk of losing grafted stems as well as promote root formation from the grafted variety. Trees should be watered immediately after planting and every couple of weeks especially during prolonged hot dry periods. Apart from water some protection from sun and small animals may also be necessary. This can be achieved by painting the trunks with white house type plastic paint or by using milk canons. A stout 2 m wooden or metal stake can also be of some use in windy conditions and for training the olive trees.

Irrigation

Irrigation is essential for large commercial orchards. A planned irrigation regime will allow the orchard to develop faster, yield earlier than under rainfed conditions, increase the yield and reduce the biennial bearing effects. characteristic of the olive tree. The type of system used will depend on the availability of water, the soil type and the tree spacing. Water is required over the hot summer period particularly when the fruit is developing. One thing for sure, in hot dry areas it is better to give the olive trees the water than to waste it to evaporation. The irrigation period is generally between November and April. This will depend on whether the site receives winter or summer rain. If the natural precipitation is of the order of 500 mm annually, about 200 litres should be supplied to each tree twice a month. A more detailed analysis can be undertaken with an irrigation specialist who can evaluate specific situations.

Pruning and Training of Olive Trees

Although old olive groves have well established trees bearing excellent crops, they are of lower tree densities and trees more than likely have multiple trunks. This combination is labour intensive and quite unsuitable for modern groves.

With new plantings it is essential to provide them with proper care. Very little pruning is undertaken with young trees so that they will bear as quickly as possible. Newly planted olive trees should be trained in either the free form vase shape or the monoconical shape. In both cases it is essential that a single trunk is established. This can be achieved by removing laterals at convenient times leaving a single trunk, about one metre in height. The free vase form is better for hand picking whereas the monocone is more suited to machine harvesting.

For the free form vase shape, 3 to 5 lateral shoots are selected to provide the scaffold branches. Tree growth is promoted to follow the scaffold, thinning the internal growth to allow light penetration and hence better cropping. The monoconical shape is developed by training the main axis of the trunk as the leader. Here a stout stake is important to keep the leader erect. Laterals are trained to grow out from the leader in a lateral fashion. Such training is undertaken in the first years after planting. After that only light targeted pruning is required. The crown of the monoconical shape, which is believed to have a larger fruiting surface, develops quickly and upward. The latter aspect could be an advantage in more intensive plantings. The economics of the two pruning methods have yet to be revealed. One thing for sure, proper training reduces the need for more radical pruning later!

Trees pruned in the ways described above have smaller crown volumes than untrained trees and so can take advantage of the available light, particularly with closer plantings. Such training allows for the development of a strong branching scaffold which can cope with heavy cropping as well as providing an efficient system for mechanical harvesting. Another advantage is that fruit bearing is brought on earlier.

Olive trees need some pruning every 2-3 years. The objectives of pruning are to remove suckers from the base, dead wood and excessive internal growth to admit more light into the crown of the tree to improve fruit quality. Excessive pruning particularly from the periphery of crown can result in loss of new wood, lower yields and possible sunburn damage. Another advantage in reducing dense foliage is that it lowers the risk of insect infestations and disease.

Old trees can be rejuvenated by cutting back to either the scaffold branches near to the trunk or to the main trunk itself. In old groves a cycle of heavy pruning over 6-8 years will result in the development of "young" healthy trees bearing commercial quantities of olives. Grafting on new varieties is also possible with such radical pruning procedures.

Research needs to be undertaken to develop and evaluate machine assisted pruning methods.

Fertilisation

Both in Australia and in Europe applications of superphosphate, nitrogen, potassium, animal manures and mulching agents have a positive effect on the yield of olive trees. Nitrogen is the most important nutrient being required for new shoot growth and flower set. Soil and leaf analysis can be used to guide the fertilisation process. A typical application for mature trees is about 4 kg of 17:7:9 NPK. For dryland groves 75% is applied any time between April and July with the balance in spring. With irrigated groves, the nitrogen can be divided into three applications, 50% in April and 25% each in January and September. If required, phosphate and potassium are generally applied in spring at rates per tree of up to 0.5 kg for phosphorous and 1 kg for potassium. In Australia 3-5 yearly applications of superphosphate are usually sufficient. Foliar sprays of urea and boron are also useful.

Diseases, Infestations and Pests

There appear to be less problems with disease in olive trees growing in Australia than in Europe. This could be a function of the low levels of olive activity in Australia and the strict national and international quarantine controls that are practised. Even so scale infestations, black scale (*Saissetia oleae*) and olive scale (*Parlaturia oleae*), parasitise the carbohydrate supply of olives reducing the sugar content and increasing the acidity of fruit. Infected trees have visible scale and fungus, the latter growing on the honeydew excreted by the scale. Fruits are deformed and leaf drop occurs. Olive lace bug (*Froggattia olivinia*) also extracts carbohydrates from the leaves and hence debilitates the tree.

Another common pest is the nocturnally destructive black vine beetle which lives in the soil during the day and moves onto the olive leaves at night. Evidence of its effect is the characteristic chewed margins of the leaves.

Fungal infestations can destroy total olive crops. Although not as widespread as scale, anthracnose (*Gloeosporium olivarum*) infection is most destructive. Infection sets into young fruit and evidence of the disease is not apparent until the fruit ripens where soft rot develops from the sides and tips of the fruit. Olive leaf spot or peacock spot caused by the fungus *Spilocea oleaginea* is less common in Australia. Signs include dark round lesions on leaves causing premature leaf drop and damage to young wood. Productivity of affected olive trees is reduced. Other fungi such as *Verticillium* and *Phythopthora* can be devastating to olive trees.

Bacterial and nematode infections are not a major problem at this point of time in Australian olive groves.

Birds and animals are a problem particularly where natural food sources have been lost to development and agricultural activities. A variety of birds damage or eat the olives, damage young shoots and hence reduce productivity. Land grazing animals, indigenous, feral or farmed can cause physical damage, eat the growing shoots and ringbark the olive trees.

Orchard hygiene and careful attention underlie the management of all the above problems. Ensuring clean surrounds, removal of damaged fruit that can harbour infection and removal of diseased parts of plants is the basis of disease control. Mulching with straw and ensuring branches do not have contact with the ground is vitally important. A second strategy is the application of appropriate cidal agents. Here care must be taken that the agents have been approved for use in olives. More research needs to be undertaken to determine herbicide and pesticide residue levels in olive fruit and olive oil. When using sprays there is always the risk that natural predators may also be killed causing further unexpected problems.

Olive Harvesting

Traditionally olives have been picked by hand. With increasing labour costs, methods such as machine harvesting with tree shakers, suitable for most cultivars has become popular. Hand picking is adequate for small groves, however proves to be impractical and too expensive in commercial groves. A major advantage of hand-picking is that the fruit is less likely to bruise resulting in better presentation for the fresh fruit and table olive market. For machine harvesting, olives must be of a weight that it will dislodge on shaking. The Koroneiki olive cultivar originating from Greece, produces one of the best commercially available extra virgin oils, however it is too small (1-2 grams) to pick with a tree shaker.

New growing methods with olive trees as hedge-rows and picking technologies similar to those used for grape picking need to be perfected to allow for more efficient olive production. Bruised olives and olives that have fallen naturally from trees are likely to produce oils that will not meet the olive oil purity and quality tests such as free acid and organoleptic tests because of increased likelihood of fermentation.

Olive cultivar selection is not only important for harvesting method but also in relation to fruit maturation. Cultivars will mature at different times during the season, which can be advantageous for hand picking, however when the groves are to be picked over a relative small period of time then an appropriate maturation index needs to be determined. A rule of thumb method is to pick when the crop characteristics are about one quarter green ripe, one quarter are black ripe and the reminder of the crop is half ripe. Green ripe olives will produce a green fruity oil whereas black ripe olives yield a yellow sweeter oil.

Depending on the cultivar and degree of ripeness, olives are picked between autumn and spring. Table olives are picked in the early to mid part of the period whereas oil olives can be picked in a later part of the period.

Post Harvest Handling

Olives should be processed as soon as possible and certainly within 3-4 days after picking. Processing within the grove facilities, particularly for table olive production is ideal and should be part of a vertical integration plan. If the grower also produces the oil profitability increases markedly. Olives must be handled carefully after picking because of their low bruising resistance. Olives should not be left standing around in bags, stacks or in trailers because of the risk of fermentation and the development of off flavours. Storage life of olives at 20°-30° C is only a few days after harvest, however storage life increases when they are stored in a cold room. Olives are very sensitive to deep freezing, temperatures, -15° to -5° C, however more research needs to be undertaken as to the quality of oil from thawed olives and the cost effectiveness of the process.

Uses of Olives

Foodstuffs

Olive fruit is a source of important foodstuffs, preserved table olives and olive oil. Table olives are popular as part of the Mediterranean diet and more recently an integral part of the take away pizza market. The latter has been a major market for preserved olives in the United States of America. To make olives edible the fruit flesh is modified by fermentation, salt treatment or drying to remove the bitterness due to polyphenolic compounds and in particular oleuropin. No toxicity to the fruit is known, however poorly preserved fruit can result in food poisoning such as botulism. Olive fruits are rich in oil and therefore high in energy. They are a good source of protein and β-carotene and contain other useful nutrients such as sugars, Vitamins B, C and E, Iron and other minerals.

Consumer forms of preserved olives are pickled green or black. Those prepared by the Spanish method are stored in salt solution whereas Greek style olives can have vinegar and added olive oil. Most commercially available black olives are artificially coloured during processing using sodium hydroxide and iron salts. Dried black olives and taponade are also popular and can be easily prepared domestically and commercially. The latter is a paste containing preserved olive flesh, anchovies and capers. Every country that is in the olive business believes that their olives are the best!

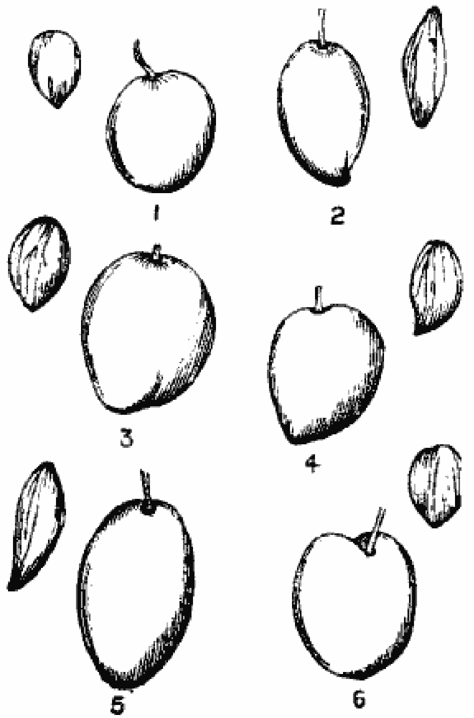
Olive Oil

Olive oil is obtained by pressing or centrifuging the crushed fruit including the seed. All olive oils obtained from olives are classified as Virgin Olive Oils with the highest quality being Extra Virgin Olive Oil. This has an acid value of less than 1 % and an organoleptic rating of greater than 6.5. Olive oils marketed as pure olive oil, although very popular with consumers, are generally poorer in quality than Virgin Olive Oils. They are processed from poor quality olive oil to remove impurities and off flavours. Olive Pomace Oil is made up of solvent extracted oil from the pomace remaining after pressing the crushed olives for Virgin Olive Oil production. Olive oils, particularly the virgin olive oils. are high in monounsaturated fats, Vitamin E, polyphenols and aromatic compounds. The price of olive oil has fluctuated aver the past few years, but there is a general upward trend.

Margarine containing 30% olive oil is now available in Australia. Although Australian growers have claimed that they will aim for the virgin olive oil market, this will only account for 25-30% of the Australian olive oil. The bulk of the olive oil will need to be directed to the supermarket shelf and to the food services industry. This will necessitate the development of olive oil refining facilities capable of producing consumer acceptable olive oil from lesser quality olive oils

Animal Feed

The fruit, leaves, and pomace are valuable as supplementary feed for animals, goats, sheep, fowl and others. More research is required to develop technologies to improve the feed value from parts of the olive tree. Animals can forage under the trees eating olives that have fallen to the ground. Olive pomace spread around the orchard also provides food for forage. The latter has value because of the protein and residual oil content. A problem in using pomace is that the crushed fruit contains both flesh and the poorly digestible woody pit. Current international research is focused around improving the availability of the fatty acids and breaking down the woody pit to improve digestibility. Animals find the olive leaves palatable and have no aversion to eating them from prunings and parts of the tree that can be easily reached. Methods for improving the nitrogen content of olive leaves are being investigated.



Early olive varieties in Western Australia, from The Handbook of Horticulture and Viticulture (Despeissis, 1921). Fruits and kernels: 1 - Verdale; 2 - Picholine; 3 - Sevillano; 4 - Gordal; 5 - Pendoulier: 6 - Manzanillo.

Compost and Fuel

Olive waste products have the potential for making compost or using them as mulching agents. Traditionally the pomace from oil making is spread around the grove providing valuable organic matter. Having the oil making facilities at the grove site allows the grower to take advantage of this valuable waste product. Where oil-making is associated with a larger centralised operation, the olive pomace needs to be disposed of in an environmentally acceptable manner. One process involves the solvent extraction of residual oil from the pomace, about 5%, which is then used to make olive pomace oil or used for technical grade oil for industrial or consumer directed products such as soaps. The olive pomace can also be incorporated into garden products by commercial compost producers. Because of its significant oil content, the pomace can be used as a fuel in the olive oil making plant or be pressed into blocks for commercial sale.

Farm Site Uses

The olive tree is a valuable shade tree for stock and for growing substory crops. Traditional broadacre farmers are seriously considering using olive trees as windbreaks and in alley farming practice. The olive tree will be a valuable landcare alternative to eucalyptus and other indigenous species. Being a long lived perennial, relatively deep-rooted under rainfed conditions, it will improve soil integrity and reduce soil erosion with the added advantage of providing a potentially saleable crop.

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[Dr Stan Kailis is a Senior (Honorary) Research Fellow at The University of Western Australia]

WINNING BACK THE MACADAMIA

GRAEME O'NEILL
CSIRO Publishing
PO Box 1139, Collingwood.
Vic 3066

Australia's macadamia industry is booming. By the year 2000, two million young trees in orchards from Lismore in northern New South Wales to Walkamin in northern Queensland - should begin yielding top quality native nut crops worth more than $100 million annually.

This burgeoning output, which has already seen Australia eclipse Hawaii as the world's leading macadamia producer, is merely scratching the surface of potential demand. In 1995, macadamias accounted for less than 0.5% of the global trade in tree nuts.

With such a rich future in store for the macadamia, the local industry is leaving nothing to chance. The Australian Macadamia Society, recognising the need to outperform its overseas competitors, is investing heavily in research. This year alone (1996) a 3.3 cents a kilogram levy will generate $1.26 million for studies aimed at a range of problems including improving cultivation and pest control and the breeding of cultivars better suited to commercial production. With access to the macadamia's native gene pool, Australian scientists have an advantage in this research.

Initial steps toward the development of new cultivars have been taken by Dr Cameron McConchie of CSIRO's Division of Horticulture in Brisbane. Along with botanists from the University of Queensland, McConchie and his team have been exploring the genetic diversity available in wild macadamias, with a view to borrowing their traits to enhance the performance of existing domestic species. "Our group is the first to define which of the Macadamia species interbreed and thus the extent of the germplasm available to improve the commercial macadamia by conventional breeding techniques," McConchie says.

Given that the *Macadamia* genus is native to Australia, and that macadamias are now one of the country's most valuable horticultural crops, it's surprising to learn that McConchie and his colleagues are the first to fully explore the available germplasm to capitalise on this valuable asset. Significant work on breeding and germplasm preservation has been done by private enthusiasts, and varieties they have developed are performing well in the Australian industry. Formal research of this nature, however, has been a long time coming. Why is this the case?

The answer to this question dates back to 1881, when an American, William Purvis, collected a pocketful of nuts from a macadamia tree planted in a Brisbane backyard. This hastily collected pocketful the beginnings of Hawaii's macadamia industry - is thought to have tapped the genetic diversity of two species. The Brisbane tree probably was a natural hybrid between the two edible Macadamia species, *Macadamia integrifolia* and *M. tetraphylla*.

Even though the world's first macadamia farm was established at Rous Mill in northern NSW in 1882, it was in Hawaii that the industry flourished. Their macadamias have been marketed so successfully that most international tourists now leave Honolulu convinced the 'Hawaiian nut' is native to the islands.

While the Australian industry slumbered, Hawaiian growers and breeders were selecting high-yielding cultivars whose nuts were tasty and productive. When a new wave of commercial plantings swept Australia in the 1970s, grafted Hawaiian cultivars were the best commercial stock available. Most modern Australian orchards therefore contain trees descended from Purvis's 'pocketful' .

Nutborer is the major pest of macadamias and if not controlled can cause serious losses. Larvae tunnel within the husk and kernel before shell hardening and cause premature nut fall. Nutborer eggs can be seen on the lower left of the damaged husk. The larvae appear to survive better in some varieties than others, offering hope that resistant trees can be developed.

Creating the perfect snack

Macadamias are members of a great dynasty of flowering plants that emerged from the humid rainforests of the southern supercontinent of Gondwana early in the Cretaceous period some 130 million years ago. From ancient DNA preserved in living Australian trees, McConchie's team plans to breed thoroughly modern macadamias that will ensure Australia dominates the industry in the 21st century.

The major focus of the new breeding program is to increase disease resistance, thereby reducing or eliminating the need for the presently low levels of chemical control,' McConchie says. "One of the best methods of biological control is to begin with disease resistant trees." A range of cultivars is being screened for resistance to a common fungal pathogen called husk spot, and to the macadamia nut borer (some trees are thought to have a less penetrable husk).

Queensland's Department of Primary Industries (QDPI) and New South Wales Agriculture are an integral part of this project. Dr Peter Mayers of QDPI will screen cultivars for resistance to husk spot, and those resistant to nut borer will be selected by Gus Campbell of NSW Agriculture. The involvement of these researchers, both of whom have extensive experience in their field, will ensure the optimum use of Australian expertise during the new macadamia breeding program.

An early priority of the program will be to select trees that have a short juvenile phase. These will flower sooner, giving early returns to the growers. At present, most cultivars take three to six years to flower, returning commercial yields in their seventh or eighth year. "We aim to prune this schedule by at least two years," McConchie says. "Although all future components of the program will benefit from a shortened breeding cycle, it is expected that 10 to 15 years will be needed to develop new cultivars improved by the introduction of wild genes."

Other traits to be examined during the breeding program include tree size and nut yields and characteristics. Existing cultivars yield well (between 20 and 30 kg of nuts at maturity), but their large size (up to 10 metres) hampers their capacity to produce stable yields. The large trees intergrow, making it difficult for machinery to penetrate the orchard rows, and yields appear to decline due to self shading. "The ideal macadamia tree will probably grow to about seven metres, little more than half the height of today's varieties," McConchie says. "We will be selecting trees that put more energy into producing greater quantities of high quality kernel, instead of structural wood and leaves."

Another part of the project aims to understand how nut quality can be influenced by the macadamia's genes and environment. More desirable characteristics can then be amplified, by breeding, and through the manipulation of growing conditions. "We also hope that by understanding more fully the composition of the nuts' oils and sugars we will throw light on their processing characteristics (such as their response to roasting) and shelf life," McConchie says.

"We are keen to learn from established industries such as wheat and beef which have diversified their products to suit particular end uses and developed objective techniques for quality measurement. This will help us to get the greatest value from our germplasm as quickly as possible."

An example of this might be the breeding of cultivars that produce smaller nuts, offering a diversity of product to suit the needs of growers, confectioners and the all-important nut eaters. "If you're using macadamias in confectionery, you don't want gobstoppers," McConchie says.

"Macadamias are more expensive than chocolate, so it's cheaper for a manufacturer to put fewer, smaller nuts into a chocolate bar. And people buying roasted macadamias may feel they are getting better value if they get 30 small nuts instead of 10 big ones."

Populations lost

The two edible macadamia species are indigenous to the coastal ranges between Lismore and Gladstone. But a combination of logging, dairying and sugarcane farms have decimated the sub-tropical rainforest that once existed there.

There is no way of knowing what genetic riches may have been lost due to clearing and development, but McConchie's team is pleasantly surprised at what remains. Dr Julia Playford of The University of Queensland's botany department has sampled the DNA of about 10 remnant populations of wild macadamias and found a wealth of genetic variation. As this is an ongoing project, more surprises may be in store.

"The more botanists look at the surviving wild populations of macadamias, the more genetic diversity is being discovered," McConchie says. "It's amazing that these trees with edible, commercial quality nuts are just sitting there, in such a highly developed, heavily populated area." But even these surviving trees are under threat, in part due to age and isolation.

Last year University of New England botanist Dr Caroline Gross conducted a botanical revision of the genus *Macadamia* for Volume 16 of Flora of Australia. Her revision of the genus recognises nine *Macadamia* species: four from south-eastern Queensland and northern NSW, four from the rainforests of northeast Queensland and Cape York peninsula. and a lone species from the Indonesian island of Sulawesi. (Macadamias are curiously absent from the rainforests of New Guinea.)

The Australian Macadamia Society is funding a new breeding program that will borrow traits from wild macadamia species to improve both the efficiency of Australian orchards and the quality and variety of nuts they produce

During field surveys near Lennox Head, just north of Ballina, Gross found two old, isolated trees of *M. tetraphylla* in a patch of rainforest. More than 400 metres away, across pastureland, she found several other trees in a larger patch of rainforest. While the species is well conserved in reserves north of Ballina, Gross says the viability of these small, scattered, orphan populations is in doubt because little is known about the population size needed to sustain macadamias.

In most commercial orchards, European honeybees pollinate macadamia flowers. But McConchie says that when native Trigona (stingless) bees perform the same service, yields can be up to 20% higher. The decimation of rainforests in heavily-cleared areas of northern NSW has made Trigona bees scarce, and isolated, aging trees may no longer be producing enough seeds to perpetuate the bees' precious genes. In other areas where surviving forest remnants harbour good Trigona populations, a critical issue may be the capacity of the bees to carry pollen between patches of trees.

A more encouraging sign is the discovery by Gross that the size and shape of macadamia flowers varies considerably within and between populations in different areas. Some *M. tetraphylla* trees have pink rather than cream flowers. Such visible traits are an indication of the hidden genetic wealth that awaits breeders.

Populations found

Another discovery that demonstrates the potential value of wild plants to a commercial breeding program was made by amateur naturalist Ray Jansen. In 1982, Jansen found a small, isolated population of low-growing trees with small nuts in a patch of rainforest near Gladstone. The 'runt' of the genus, *M. jansenii*, grows to seven metres and McConchie believes it could provide genes for more compact cultivars. It may also help to overcome a major limitation to the expansion of Australia's macadamia industry: a shortage of suitable land.

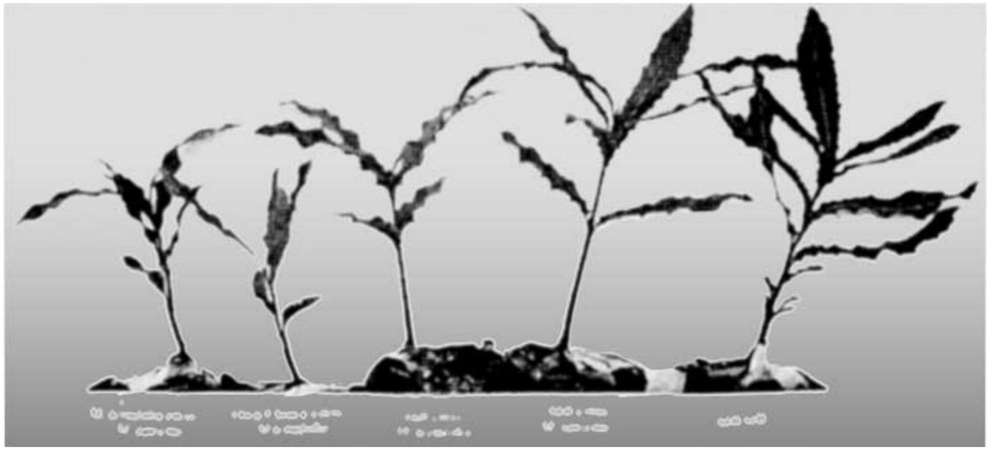
McConchie says existing macadamia cultivars are temperature sensitive and do not grow well in conditions above 30°C. *M. jansenii* is the most northerly growing of the four southern growing species (*M. integrifolia, M. tetraphylla. M. ternifolia* and *M. jansenii*), and therefore may be more heat tolerant. If cultivars could be bred with this trait, orchards could be established in more marginal areas further north.

M. jansenii could easily have slipped into extinction before it came to the notice of botanists. It almost certainly grew more widely in the recent past. McConchie says botanists have recently found trees with features intermediate between *M. jansenii* and another macadamia species, *M. ternifolia*, which ranges between Brisbane and Gympie.

These trees may be natural hybrids or even a new species, McConchie says. Along with *M. ternifolia*. which has small, relatively thin-shelled nuts, they could allow breeders to develop a peanut-sized macadamia for the snack food and confectionery industries.

At the other end of the scale, the macadamias from tropical north-east Queensland are giants, towering 30 or 40 metres into the rainforest canopy. Their nuts are much bigger than those of the southern species, none more so than those of *M. claudiensis*, a recently described species from the Iron Range north of Cooktown. *M. claudiensis* produces nuts up to six centimetres in diameter, without a hard shell.

A macadamia minus its hard shell would reduce the cost of processing, and consumers might like the idea of munching on a mandarin-sized nut. But McConchie says the giant



Interspecific macadamia crosses. The Australian research team was the first to define which species interbreed.

nuts are extremely bitter and toxic. A first, exploratory taste is usually enough to deter the hungriest predators (including humans) from ingesting a lethal dose. All species except *M. tetraphylla* and *M. integrifolia* are presumed to have toxic nuts, although Gross says that Aborigines are reputed to have eaten the very large, bitter nuts of *M. whelanii*, probably after a prolonged period of leaching in water to remove cyanogenic compounds.

Macadamia plants employ a variety of tactics to defend their protein and oil-rich seeds against would-be predators. While many species are protected by the presence of cyanide in their kernels, the two edible macadamia species *(M. integrifolia* and *M. tetraphylla*) have cyanide-free kernels which they protect with a formidable physical barrier: a tough, thick shell.

Two species from southern Queensland (*M. ternifolia* and *M. jansenii*) seem to have taken the middle road, producing small, relatively thin-shelled seeds containing moderate levels of cyanide. The small size of their nuts may also be a subtle deterrent to predators, which would have to collect and crack more nuts to make a meal.

McConchie says desirable genes from these species are readily accessible, because they hybridise with the two edible species. But none of the four Macadamia species from north-east Queensland hybridises with the southern species, reflecting their long evolutionary isolation. More advanced breeding techniques therefore may be required.

Cracking the cyanide defence

University of Queensland postgraduate student Adam Vivian Smith, working in McConchie's CSIRO laboratory, measured levels of cyanide compounds in the seeds of the four southern macadamias, (*M integrifolia. M. tetraphylla. M ternifolia* and *M. jansenii*) and of *M. claudiensis* and *M. whelanii* from north Queensland. He describes the huge, shell-free nuts of *M. claudiensis* as 'hypertoxic', while the two bitter-tasting southern species, *M ternifolia* and *M. jansenii*, have lower cyanide levels.

Ripe nuts from commercial hybrids and their edible parent species are free of cyanide. In 1992, however, another postgraduate student from the University of Queensland, Janelle Dahler, was surprised to find that when the nuts are germinating, they contain even more cyanide than the bitter kernels of *M. ternifolia*. Fallen nuts that absorb moisture then become bitter and inedible, and young seedlings have high cyanide levels in their leaves.

Dahler suspects these species time their cyanide production so that the genes switch on only when the nuts are vulnerable to predation: before the shell develops, and when it is cast off during germination. Her research could help reduce production losses due to nuts turning bitter after falling to the ground. Subsequently, Vivian-Smith found that cyanide also accumulates in the shell and husk of the edible nuts, but not in the kernel, during the pre-ripening stage, while they are still green and soft.

Vivian-Smith says that plants other than macadamias - including stone fruits such as apricots and the tropical grain sorghum - use a similar form of defence for their seeds and leaves. Genes involved in the cyanogenic pathway have been well studied in sorghum, which also synthesises a cyanide precursor molecule called dhurrin in its shoots. The first key step for the production of dhurrin and other cyanogenic compounds is catalysed by an enzyme called a cytochrome p450. After synthesis, dhurrin can be in turn cleaved by an enzyme called beta-glucosidase to release the cyanide. However, most plant species store cyanogenic compounds in different tissues to beta-glucosidases to prevent large scale release of cyanide. Therefore it is only upon tissue disruption that cyanide is released in large quantities (such as by chewing the nut). Macadamias and their relatives also synthesise dhurrin and proteacin (a closely related compound), as well as possessing beta-glucosidases that release their cyanide.

Vivian-Smith says that both the cytochrome p450 and beta-glucosidase genes have been cloned from other species, such as sorghum and cassava, and could serve as genetic probes to isolate the equivalent genes from macadamias. If the cytochrome p450 gene could be switched off, it would block the cyanogensis pathway, so that a species such as *M. ternifolia*, with its small but toxic nuts, would become edible. The challenge would be to manipulate the gene so that it was selectively silenced in the kernel, but not in the seed coat or outer husk, where cyanide may be a valuable deterrent to insect attack.

Another possibility is to increase or alter the activity of the beta-glucosidase gene, so that all the cyanide is released from the plant's tissues and dispersed before the nut ripens. A more conventional approach would be to hybridise the edible species with the cyanogenic species, to yield noncyanogenic hybrids with some of the desirable characteristics of the smaller, inedible species. Whatever techniques are adopted, the outcome is bound to represent a significant return on investment for Australia's macadamia industry.

More about macadamias

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[Based on an article in the CSIRO magazine 'Ecos' 88, Winter 1996].

Ecos<A1179>

Submission of Articles

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

Articles would be gladly received from any source - there is no requirement to be a member of WANATCA. If the text is available on a computer or word-processor disc, this is greatly appreciated. Text and enquiries can also be sent by fax or e-mail.

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

Please send articles or enquiries to:

The Editor, WANATCA Yearbook, PO Box 27, Subiaco. WA 6008. Australia
noels@perth.dialix.oz.au • Fax: +61-9-385 1612

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

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

There are various classes of **membership**. The standard grade is **Full Membership**. It is open to individuals, families, and any form of organization (companies, research units, libraries, etc.). New Full Members will be accepted on application; no entrance fee is charged. **Student Membership** is a concessional rate for current-year students unable to pay full rate. **Sustaining Membership** is a special grade for those supporting the aims of the Association who are able to give extra financial help to achieve those aims. **Life Membership** is available to existing individual members of at least 3 years standing who wish to commute all future payments into a single sum. **Overseas Members** are welcomed and pay no more, although they may optionally receive publications by air-mail for a small premium.

All subscriptions (except for Life Members) run for the calendar year; new members may join at any time, and receive all publications for the year. After October 1, new members may elect to start their subscription with the following year; they will have membership benefits for the rest of the current year, free of charge, but not the current *Yearbook*.

West Australian Nut & Tree Crop Association Inc
PO Box 565, Subiaco, WA 6008, Australia
E-mail: wanatca@AOI.com.au Home Page: http:www.AOI.com.au/wanatca