West Australian Nut & Tree Crop Association (Inc.) Year Book 9 -- 1984

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WESTERN AUSTRALIAN NUT & TREE CROP ASSOCIATION (INC)

West Australian
Nut and Tree Crop Association
(Inc)

Volume 9 -- 1984

W.A.N.A.T.C.A. Yearbook -- VOLUME 9, 1984

WEST AUSTRALIAN NUT AND TREE CROP ASSOCIATION (INC.)

The Association incorporated the West Australian Nutgrowing Society as from 1981. It has continued publishing the quarterly newsletter "Quandong" and the Yearbook. For details of membership and subscription rates, write to the Secretary, W.A.N.A.T.C.A., P.O. Box 565, Subiaco, W.A. 6008, Australia. Members are welcome from outside Western Australia and overseas, as well as in W.A.

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West Australian Nut and Tree Crop Association (Inc.)

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EDITORIAL

In our anxiety to succeed we sometimes lose perspective on what a growers association is about. That is, the opportunity to meet people of similar interest and to exchange ideas, information and materials to the mutual benefit of all participants and the advancement of the tree crops industry in general.

This Yearbook plays a role as a vehicle of information. Each editor tends to influence the type of information offered. For example, David Noel, who favoured little known or unusual nuts and fruits; myself being orientated towards Horticulture, nitty gritty practical information; and now warmly welcomed is our new editor, David Turner, a scientist - what is in store for us now?

This issue of the Yearbook contains an article on bee-pollination research. Although the authors worked with Almonds, their findings are very relevant to all bee-pollinated crops.

Regrettably, overseas or interstate publications remain the prime source of many interesting articles as minimal public research is conducted in W.A. on alternative horticultural crops. Therefore, although this information is being made available via the Yearbook, it must be remembered that it will probably have been written for conditions other than those to be found in Western Australia.

The Association became Incorporated in 1984.

Lois Evans,
Retiring Editor

BEES - ORCHARD V.I.P.s:
Recommendations for Almond Pollination in Australia

PROFESSOR ROBBIN W. THORP
University of California, Davis

Based on observations and research in Australia, July 1981 through March 1982.

Dr. D. E. Pinnock, Reader in Insect Pathology, Waite Agricultural Research Institute, University of Adelaide, also worked with Professor Thorp on this research.

Since most commercial almond cultivars are self-unfruitful, two basic factors are required: an orchard layout with two or more cross-compatible cultivars interplanted to optimize the flow of compatible pollen between them: and adequate numbers of bees to mediate the pollen flow. Almonds bloom at a time when weather conditions are marginal for or prohibit pollination. Therefore, it is critical to maximise the conditions for efficient pollination when the weather is marginal to permissive. Thus, almond growers need to consider the following based on our research in California unless otherwise noted:

1. **Colony strength**. Good pollination units are those with 6 or more frames covered on both sides with worker bees and containing 2,500cm or more of capped brood. It is critical that an active laying queen be present so that continuous supplies of uncapped feeding larvae are available to create a demand for pollen foraging.

2. **Hives per hectare**. Good pollination is obtained using 8 hives/ha., but as few as 5/ha. and occasionally as many as 12.5/ha. are used depending on local conditions.

3. **Hive distribution**. We found inverse relationships between bee activity in trees and distance from nearest hives, also in percent fruit set versus distance in most varieties (see report on 1981-82 research in South Australia by Thorp and Pinnock). These data support recommendations for distributing colonies at intervals of 160m-400m throughout orchards of more than 16 hectares.

4. **Orchard layout**. We observed that bees most frequently fly from one tree to the next nearest tree (see report on 1981-82 research in South Australia by Thorp and Pinnock)

confirming earlier studies in California. Bees also most frequently fly to a tree in the same stage of bloom. Thus, most current orchard layouts are not optimal. To make use of bee foraging behaviour for maximum pollination efficiency, distances between trees of cross-compatible cultivars should be less than between trees of the same cultivar and the cross-compatible cultivars should be synchronous in bloom period.

5. Hive movements. Hives should be introduced when there is about 10% bloom on the earliest cultivar. Hives should be removed when no more pollen is available on the next to last cultivar to finish blooming.

Most prominent among the differences between California and Australia are those relative to the bearing acreage of almonds, numbers of honey bee colonies required for pollination and numbers of colonies registered (Table la). The evolution of efficient and economically viable pollination services in California are closely tied to the demand for such services made by the rapid growth of the almond industry in the state (e.g., from about 60,000 ha. in 1970 to over 132,000 ha. in 1981). Supply and demand certainly are basic determinants for establishing prices for pollination services. Although Table 1 suggests a surplus of available colonies for almond pollination in South Australia, it does not take into account the fact that there are more available alternatives (pollen and nectar sources) for bee colony build up and honey production than exist in California during almond bloom. Thus, the actual numbers of hives actually available for almond pollination in South Australia must be calculated differently.

TABLE la: Comparison of bearing almond acreage, honey bee colonies required for pollination, honey bee colonies registered in California and South Australia for 1981.

	Bearing Acreage	*Colonies Required 5/Ha*	*8/Ha*	*Colonies in state*
CAL.	132,000 Ha	660,000	1,056,000	550,000
SA.	2,000 Ha	10,000	16,000	97,000

Future research on almond pollination should include:

1. production and maintenance of strong colonies (e.g., stimulative feeding for brood production prior to bloom, supplemental syrup feeding during bloom);

2. effects of pollen traps on increasing foraging activity, especially for pollen (this is important since pollen foragers are more efficient in almond pollination than are nectar foragers);

3. pollination efficiency relative to different cultivars and to different orchard layouts;

4. the potential for introduction and management of the orchard mason bee, *Osmia lignaria propinqua* Cresson, if it performs well in California (other species of Osmia from Japan and Europe may also prove efficient pollinators for the future);

5. search for cross-compatible cultivars which bloom synchronously or for self-fruitfulness in almond cultivars;

6. search for dwarfism in almond cultivars, for more trees and more production/ha.

RECOMMENDATIONS FOR HONEY BEE POLLINATION SERVICES IN AUSTRALIA

Fees for pollination services have become an increasingly important part of the income of the honey bee industry in California (Table 1). From 1974 to 1979 these fees have nearly trebled and the percent of income has nearly doubled from 24% to 47% in the same period. Average pollination fees for selected crops for 1980 (Table 2) have increased 25% to as much as 243% over 1977 fees. California has 500,000 colonies (1981) or more registered annually, but only about 450,000 are used in pollination services (Table 3). The bearing acreage of almonds requires more colonies than available in California, but not in South Australia (Table 4). About 63% of colonies used for summer pollination in California are required for lucerne seed. However, there are many other irrigated crops to which bee hives are rented during the same period (e.g. ladino clover, melons, onions, sunflower).

Pollination fees provide important augmentation to income of California apiarists, and adds stability and diversity to income sources, especially in years of low honey market prices. Also it is important in poor honey production years such as: 1976, 1977 (Table 2, 3); and 1981 the lowest production (4.1 million kg from 500,000 colonies = 8.2 kg/colony) since 1944 when accurate records started.

TABLE 1. California honey bee industry income in millions of U.S. dollars (and percent of total) derived from products or services for 1974-1979. Data provided by Dr. E. Mussen, Cooperative Extension, University of California, Davis.

Year	*Honey & Wax (%)*		*Queens, Packages, Nucs (%)*		*Pollination Fees (%)*		*Total*
1979	110.3	(37)	15.3	(16)	$15.2	(47)	$32.6
1978	10.1	(42)	5.8	(19)	11.5	(39)	29.7
1977*	6.2	(31)	5.6	(24)	10.7	(45)	23.6
1976*	7.3	(29)	5.8	(28)	9.0	(43)	21.0
1975	12.4	(44)	6.5	(28)	6.4	(28)	23.0
1974	12.1	(49)	5.7	(27)	5.1	(24)	21.1

* Drought years.

TABLE 2. Average fees for pollination services in California in 1980 in selected crops in $U. S. per hive. Data provided by Dr. E. Mussen, Cooperative Extension, University of California, Davis.

Crop	*Hives/Ha*	*S/Hive*	*(Range)*	*Crop*	*Hives/Ha*	*S/Hive*	*(Range)*
Almond (N)*	5-7.5	$12	(9-12)	Ladino Clover	2.5	$10	-
Almond (S)*	4-7.5	18	(15-20)	Lucerne (N)	7.5	17.50	(14-12)
Apple	2.5	15	(10-20)	Lucerne (S)	12.5-25	.50/day	-
Cherry	2.5	12	(10-15)	Melon	2.5-7.5	15	(15-20)
Plum	2.5-7.5	18	(13-20)	Onion, Sunflower	2.5-7.5	15	(12-20)
Prune	2.5	10	(5-15)	Vegetable seeds	2.5	15	(10-20)

* Lower prices in northern counties due to more hives from northern states overwintering in the area.

TABLE 3. Honey bee colony data for California. About 80% are managed by commercial apiarists. Data from USDA "Agricultural Statistics" and Dr. E. Mussen, University of California, Davis.

	Number	*Honey Production (kg)*		*Number used in Pollination*	
Year	*in State*	*Per colony*	*Range*	*from CA*	*from other states*
1980	504,000	20.9	0-54.6	450,000	150,000
1979	504,000	15.5	0.45.6	450,000	130,000
1978	504,000	30.0	9.1-72.7	350,000	120,000
1977*	525,000	11.9	0-36.4	450,000	110,000

*Second of two consecutive drought years.

TABLE 4. Comparisons of bearing almond and harvested lucerne acreages, honey bee colonies required for pollination, and honey bee colonies registered in California (CA) and South Australia (SA) for 1981.

			Hives Needed		*Colonies in State*	
Crops	*State*	*Hectares*	*@5/Ha*	*7.5/Ha*	*Total*	*
Almonds	CA	132,000	660,000	990,000	500,000	450,000
	SA	2,000	10,000	15,000	97,000	81,000
Lucerne	CA	37,600	-	282,000	500,000	450,000
	SA	5,500	-	41,250	97,000	81,000

* Colonies used in pollination (CA); or "Productive" colonies (SA).

Pollination service not only provides income, but as general awareness of the important contribution of honey bees as pollinators increases the true value of the honey bee industry to agriculture can be calculated. Figures for 1979 show a total income for the California honey bee industry of $(US)32.6 million from products and pollination services (Table 1). To this total may be added the value of California crops dependent upon or benefited from honey bee pollination, nearly $(US) 1.4 billion, or more than 42x the income for the bee industry. Awareness of the importance of honey bees as pollination has several benefits to the beekeeping industry.

Political arguments stressing the value of bees to agriculture through pollination and the dollar values of the crops benefited make the industry more visible and important in the eyes of the public and carry more weight with policy makers. These arguments are strengthened as growers are educated to recognise this importance and begin to utilise and pay for pollination services. Grower commodity organisations then provide important brood-based political allies for the honey bee industry.

Protection from pesticide damage is important to apiarists with colonies in any agricultural districts whether they are only after a honey crop or providing pollination services. Unless growers are convinced of the importance of bees to their crop, there is little incentive for them to be concerned about protection of the free bees in the area. Growers who pay for pollination services recognise the importance of bees and cooperate to protect them where they have control over pesticide applications. They also can be strong allies in soliciting cooperation from neighbouring growers of crops not benefiting from bees to modify existing pest management programs which provide a hazard to rented bees. Community efforts to protect from pesticide losses are essential due to the potential foraging range, usually 3 to 5 km or an area of 28.3 to 78.5 km^2. Both the beekeeper and the grower renting bees benefit from cooperative efforts to protect bees.

Critical elements in developing the current level of pollination services in California have been research and education programs. Most of the current income of the honey bee industry in Australia is from honey and beeswax (Table 5). There is increasing interest in and development of pollination services on a commercial level. Since migratory beekeeping is an important part of the honey industry as it is in California, the equipment and technology for moving large numbers of hives which is basic to pollination services are already available.

There are many differences between Australia and California which will influence the development, application and value of potential pollination services in Australia. In contrast to California, Australia has:

1. Smaller total acreages of most bee pollinated crops, especially relative to the number honey bee colonies potentially available for pollination services (e.g. Table 5).

2. Smaller individual plantings of bee pollinated crops.

3. Less acreage under irrigation.

TABLE 5. Honey bee colony data for Australia 1975-1980 (Australian Bureau of Statistics). About 71-79% percent are "productive" colonies.

Year	*Number in Country*	*Honey Production per Colony (kg)*	*Gross value ($A in millions) Honey*	*Wax*	*Total*
1980	511,000	62.0	19.1	1.7	20.8
1979	501,000	49.5	14.1	1.2	15.3
1978	479,000	51.2	13.5	1.1	14.6
1977	493,000	42.9	8.4	0.8	9.2
1976	497,000	57.2	10.3	0.6	10.9
1975	491,000	54.2	9.3	0.5	9.8

4. Fewer growers paying for pollination services and lower rental fees per colony.

5. Greater honey production per colony per year (cf. Tables 3 and 5).

6. More alternatives for honey production available most years.

7. Little income from pollination services, especially in contrast to income from honey production.

8. No large market for packaged bees.

9. Little locally generated research data on the benefits of bee pollination of crops.

Items 1-3 suggest a greater potential supply of honey bee colonies for pollination than demand for such services. This tends to keep rental fees low and to discourage large commercial apiarists from becoming involved in pollination contracts. Continual reductions in native bush and increasing petrol costs means more extensive and expensive travel in chasing the honey flows. These, plus from 1-3, make pollination services more attractive, especially to local part-time apiarists.

Some regions of Australia (e.g. Darling Range near Perth, WA) have feral populations of honey bees adequate for pollination of small orchards surrounded by native bush. However, such areas are decreasing as native bush is reduced and with the advent of diseases such as EFB which diminished feral honey bee populations in southeastern Australia.

Aggressive programs of research and education are needed both to convince growers of the need to pay for pollination services and to provide apiarists with information on how to modify their practices to operate quality pollination services. Australian apiarists need not "throw away their extractors before pollination services will be developed" as one colleague suggested. However, a shift in philosophy and colony management from those appropriate for honey production to those most appropriate for pollination services is needed. Apiarists will need to:

1. Provide strong colonies both in worker populations and brood for most crops.

2. Distribute bee hives at intervals through most crops where paddocks are larger than 16 hectares.

3. Maintain colonies in good condition during the pollination period.

4. Move bees in and out of the crop on time.

5. May be required to make extra shifts of colonies or other measures to reduce pesticide hazards and to maintain sufficient viable colonies to fulfil the contract.

The need for strong colonies, especially with large amounts of brood for colonies used for pollination services cannot be stressed too much. The more open brood there is to be fed the greater the demand will be on the field force of a colony to bring in pollen. Colonies with strong worker bee populations, but with little brood, may be good honey producing units for a few weeks at least. However, many crops are more efficiently pollinated by pollen foragers (e.g. almonds, lucerne) again supporting the need for good brood production.

Large amounts of brood also ensures continued production of new workers. Young naive foragers often forage closer to the colony initially and in lucerne trip more flowers than experienced foragers. In crops where nectar foragers may be the principal pollinators (e.g. crops using male steriles for production of hybrid seed) continued production of new bees can help offset losses of foragers due to pesticides.

To produce and maintain good brood production may require stimulative and maintenance feedings with pollen. Also continual surveillance to ensure colony well being. All of the above management practices require extra effort and expense by the beekeeper for which he should be compensated.

Pricing a pollination service is not easy to arrive at. An apiarist may estimate the "lost honey crop" he could have obtained if the colonies were not used in pollination. This may be relatively easy for an experienced apiarist to estimate and may be satisfactory initially, but the true value to both parties may be more complex. Other pricing schemes include:

1. Unit pricing: based on numbers of frames of bees and square inches of brood.

2. Time in crop: a daily or weekly fee.

3. Profit sharing: apiarists get a share of the crop produced over a specified minimum.

Crop value or relative risk of pesticide loss to bees might also be taken into account. Basically, the beekeeper should be able to recover all expenses and actual losses (e.g. moving, distribution, feeding and inspection costs, and bee losses) as well as make a reasonable profit for pollination services. A third party colony inspection system or a middle man contractor operation can ensure colony strengths agreed upon are met.

Apiarists should encourage and sponsor scientists (federal, state, academic, private) who are interested in and willing to conduct local research to determine which crops in Australia are benefited by bees, what the pollination requirements of such crops are and to determine how best to produce and maintain the most effective honey bee colonies for pollination.

Apiarists should take the initiative in ensuring the education of growers on the value of honey bees as pollinators. Not only should apiarists take advantage of existing opportunities, but they should create opportunities to educate and support efforts of agencies responsible for extension of research data to growers. Apiarists also should ensure that growers realise that bee colonies must be maintained for 12 months and that what happens to colonies after leaving their crops determines the availability and quality of next season's pollinating unit.

Apiarists need growers as allies:

1. for protection against pesticide damage in the crop being pollinated;

2. for aid in reducing pesticide damage from neighbour's sprays;

3. for political support (e.g. indemnification);

4. for support in protecting bees from pesticide damage (which they may suffer after they are removed from the crop);

5. for support in protection and increase of native and weedy floras on which the bees depend when they are not in the crop.

Apiarists should not fear growers attempts to utilise native or imported pollinators for the few crops which present special pollination problems, but look at these as positive actions that can benefit apiarists in several ways. It shows growers recognise the importance of pollination to their crop. This leads to more careful pesticide usage, especially if growers have invested in these pollinators. It takes many years to develop sufficient populations of other pollinators and techniques to manage them successfully and economically, and there are no guarantees of success. During this time apiarists have an opportunity to develop their services which will often be competitive in price and efficiency. Apiarists also may take over management of other pollinators and thereby be in a position to provide honey bees and other pollinators as a diversified pollination service.

GENERAL RECOMMENDATIONS ON COMMERCIAL POLLINATION IN AUSTRALIA

Considerable expansion of research on pollination of crops in Australia is needed. Overseas data developed for most crops serve as important and useful bases for investigation. However, for determination of specific requirements and development of management practices for most efficient pollination and crop production under Australian conditions, research in local environments is needed. In addition to continued and expanded research, the bases for development of successful pollination services in Australia are: communication, cooperation and coordination.

Communication of data generated by federal, state, academic and private researchers to growers and beekeepers is most effectively done through an efficient extension service network and with the cooperation of the researchers. Technical publications, important for communication among scientists, should be supplemented by popular articles designed to reach potential users of the information. In addition to news media publicity, open meetings organised by extension personnel, especially those involving interaction among apiarists, growers and researchers, can be particularly good forums for information exchange.

It is important that lines of communication be open for free exchange of ideas among apiarists, growers, pest monitors, pesticide applicators, and research and extension personnel. Positive dialogue among and within all groups leads to cooperation.

Cooperation between apiarists and growers involves modification of traditional attitudes and practice on both sides to make pollination services effective. The mutual benefits derived from reciprocal cooperation in pollination of crops by honey bees include the fees apiarists derive from providing and maintaining strong colonies of bees when and where growers need them, and the increased yields the grower obtains from renting bees, providing sites for them and aiding in protecting them from pesticide damage.

Cooperation should extend beyond the direct interaction during the crop pollination season. Growers benefit from a healthy honey bee industry, and need to recognise that since bee colonies are perennial social units what happens to them after colonies leave the crop determines the quality of bees available the next year. Apiarists benefit from strong crop industries. The greater the diversity and acreage of bee pollinated crops available, the more incentive there is for the development of efficient pollination services. Apiarists and grower groups benefit from becoming supportive allies throughout the year, protecting each other's interest in many ways for the good of all.

Pollination is an interdisciplinary area. Cooperation among scientists from diverse disciplines (e.g. bee behaviour, ecology and physiology; crop ecology, genetics and physiology) can result in more complete research than could be achieved by one or more scientists of a single discipline.

Coordination of research programs to prevent excessive duplication of effort, especially in the same local areas, is important since there are scientists within the same discipline working for different organisations (e.g. federal, state, academic and private). This coordination can be enhanced through centralised commodity boards or committees, especially if they are funding sources which solicit, screen and select projects for support. It would also be useful if these committees contained representatives of both grower and apiary industries to encourage interdisciplinary research. Coordination of information dissemination (extension programs) is also important.

The development and full utilisation of the broad range of pollination services means not only more income for apiarists and growers but will create additional occupations and employ more people. To ensure hive strength agreements independent third party inspection services should develop. Individuals may operate as middle men contracting with several growers for acreage to provide bees from several apiarists and ensure their quality. Other individuals will be needed to manage additional types of pollinating insects for crops for which honey bees are not the most efficient pollinators.

Types of crop pollination research areas needing study in Australia include:

1. Establishment of which crops depend upon or benefit from bee pollination (even self-fruitful crops may benefit from bee pollination under some conditions).

2. Effects of planting schemes and ratios of self-unfruitful cultivars (e.g. almonds) or male-steriles vs. fertiles for hybrid seed (e.g. sunflower, onions).

3. Effects of other flowering plants near crops being pollinated by honey bees which may be negative (e.g. competition for bees; pesticide hazard) or positive (e.g. supplemental pollen for maintaining colony strength in poor pollen crops).

4. Methods of producing and maintain pollen feeding) and effects of manipulating colony ratios of workers and brood.

5. Effects of other special management techniques (e.g. time of introduction and removal, rotation of colonies, hive distribution, pollen trapping, adding or subtracting brood or empty comb, two queen colonies) on numbers and ratios of foragers for pollen and/or nectar.

6. Effects of pesticides and diseases on bee foraging and colony populations.

7. Relative efficiency of other pollinating insects (native and exotic) and their potential for commercial management for specific crops. There are several caveats to be considered in studies of honey bee pollination of crops:

1. Plot sizes for honey bee-crop pollination studies often have been too small. Honey bees potentially forage 3 to 5 km from the hive or an area encompassing 28.3 to 78.5 km2. They also forage from a great diversity of plants. Thus, honey bees moved into a crop for pollination often do not respond in the same localised manner as other types of treatments (e.g. irrigation, pesticides, fertilisers) applied in agricultural field experiments. Pollination experiments may need to encompass large areas including several orchards or paddocks as a single treatment in order to evaluate applications of bees.

2. Increased crop production is the goal of pollination experiments. However, yield comparisons are not always the best measures of effectiveness of bee pollination. Bees are only a part of the chain of events which determine the final crop (e.g. flower production, pollination, seed and fruit maturation). Many factors (e.g. weather, pest and disease management, fertilisers, irrigations, harvest techniques) influence the basic chain of events. Each sets an upper limit for the next step and the final yield. To accurately evaluate pollination experiments, measures of effective pollination should be made as close to the act of pollen transfer as possible (e.g. tripping in lucerne, numbers of pollen grains on stigmas, numbers and rates of growth of pollen tubes, post pollination changes).

3. Differences in growing regions (geographic and climatic) and environmental factors from year to year mean that field experiments should be replicated not only locally but in different regions and over several years.

In summary, research should be conducted to validate overseas data for Australia and for diverse areas of Australia, and expanded to generate new data. Results of these data services will depend upon establishing good lines of communications, cooperation and coordination of efforts among the diverse groups involved.

Permission for publication of this research was granted by the Almond Cooperative Limited, Edwardstown, South Australia.

WILD FRUITS OF AUSTRALIA

JOHN M. RILEY
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Most of the native Australian fruit seed distributed by the CRFG have come from the generous donations of Paul Recher, Dave Higham and Geoffrey Scarrott. With the organizations of the Rare Fruit Council of Australia[1], perhaps additional seed will become available in the future. Most of these Australian fruit are not described in common literature. This paper suggests that many of these native fruits should be grown in California.

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

SOME GEOGRAPHICAL CONSIDERATIONS

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

Australia is also the flattest of the continents. About three quarters of the land mass is a vast ancient plateau averaging about 1,000 ft above sea level. A central portion is lowland with an elevation of less than 500 ft, and in one place it is below sea level. The eastern portion of the country is a highlands plateau with an elevation averaging less than 3,000ft, with a few peaks above 5,000 ft.[2]

CLIMATE

Although Australia is completely encircled by warm ocean currents and is the lowest,

flattest continent, it is quite arid. The major reason is that it lies in a region typified by high pressure and descending air currents of low velocity. There is no mechanism to carry the warm, moist ocean air inland to produce rain. During the winter, this high pressure band of air crosses the interior of Australia and all except the southernmost parts of the continent are dry. In summer this pressure belt has moved south of the continent, still giving dry conditions over the southern and western areas. Thus the total annual precipitation is less than 20 inches except in the extreme southwest and in a strip circling from southeast to northwest. The average precipitation is less than 10 inches in a large south-central area. In the south, the winter precipitation is of the cyclonic type; in the north, heavy summer rains are of monsoon origin; the rainfall of the eastern regions is due to the immediate presence of the highlands in the vicinity of the ocean.[3]

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

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

Australia and Gondwanaland had similar flowering plants that appeared about 70 million years ago. Subsequently Australia drifted away from its motherland. This voyage was northward away from a warm, gentle climate. The primitive, evergreen plants grew in long isolation, and were challenged by an arid climate and particularly poor soils. This resulted in a vegetation predominantly very different from that of the rest of the world. Among the successful plants are the Myrtaceae family of which Australia has 45 genera and nearly 1,200 species. The Eucalyptus genus is dominant with more than 500 species. More than 600 species of Acacia are found in Australia. There are 37 primitive members of the conifer family, but no true pines. As the northern end of the continent pushed into the tropical latitudes occasional plant species entered from the tropics and spread southward until limited by the desert. Today most native Australian plants are unique and specialized for their environment.[4]

FRUITS OF INTEREST

Since the Australian climate is in many ways similar to that of California the native Australian fruits should readily adapt to our conditions. Cribb[5] lists 178 fruit and nuts which are in some fashion edible. There is a preponderance of large-seeded, tropical trees whose seed may be eaten as 'nuts' after they are leached or boiled to remove toxins. There are numerous small 'conservation' fruits that are not of much value in their present state. These are deliberately omitted here in favour of fruit with obvious potential for development in California.

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

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

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

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

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

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

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

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

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

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

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

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

Diploglottis australis 'Native Tamarind' (Qld, NSW) is a relative of the litchi found in the Australian rain forest. The plant has a crown of very large, coarse-looking pinnate leaves sometimes reaching 60 cm long. The yellow fruit has three rounded lobes each about 1 to 2cm broad and contains a single seed enclosed in an orange, juicy, jelly-like pulp. This is very acid but pleasant and refreshing. For those who find the taste too sour, a good drink can be made by boiling the fruits with sugar and water. They can also be made into jam.

Diploglottis campbellii is very rare and much superior to *D. australis*. The fruit is a capsule, usually three-lobed. Each lobe is 4 cm in diameter, smooth, hard, and enclosing a single round seed. The pulp, a pleasantly acid, juicy red aril, encloses the single seed.

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

Acmena smithii (*E. smithii*) 'Lilly Pilly' (Qld, NSW, NT) is grown for its evergreen foliage and showy berries. Fruit is 1/4 to 1/2 inch in diameter, depressed, globular, edible and slightly acid. *Cleistocalyx* (*E. operculata*) is a tree with ovate-elliptic leaves, 5 to 8 inches long. The edible fruit is pea-like, ripening from dark red to purple.

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

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

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

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

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

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

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

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

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

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

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

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

Podocarpus elatus 'Brown Pine' (Qld, NSW) is a common rainforest tree belonging to the pine family, differing from most other members by lacking an obvious cone. The round, greenish seed is seated at the apex of a larger fleshy stalk which resembles a purple-black grape with a waxy bloom.

This stalk is edible, but is rather mucilaginous and resinous in flavour. It makes jam or jelly more acceptable than the raw stalks.

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

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

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

GENERAL COMMENTS

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

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

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

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Reprinted from California Rare Fruit Growers Yearbook, Vol. 14, 1982.

SUBTROPICAL FRUIT:
Varieties and Culture for Commercial Production

P. R. SALE

Horticultural Advisory Officer, Tauranga, N. Z.

The subtropical areas of New Zealand are mainly in the Auckland province. Traditionally subtropical fruits have been grown in Northland, Auckland, Bay of Plenty and Poverty Bay.

There are however, possibilities of production outside these traditional centres in areas such as Taranaki, Wanganui and for feijoas and kiwifruit, possibly the more favourable areas of Hawke's Bay and Nelson.

VARIETIES

Subtropical fruits grown in New Zealand include:

- Kiwifruit
- Citrus
- Tamarillos
- Avocados
- Passionfruit
- Feijoas
- Others, e.g. Macadamia nuts, cherimoyas, casano, naranjilla and mountain pawpaw are not yet market-proven.

KIWIFRUIT

This thrives under equable, insular climate and deep free-draining soil, e.g. Bay of Plenty.

Kiwifruit is the only deciduous crop of the major subtropical fruits grown in New Zealand, which gives it greater winter hardiness. Some winter chilling is necessary for maximum yields.

The current cultural methods are suited to the New Zealand type of orchard unit. It is a technically advanced and demanding crop to grow and is a long-lived plant.

It is a very export-orientated crop with New Zealand being the world's major supplier. New Zealand-grown kiwifruit is associated with quality worldwide. There are major export markets being developed, which means there is no dependence on one market and the economic, political and social condition of that market.

Only top quality fruit will meet export standards.

Assuming good shelter, Table 1 shows the time to reach full production and the income progression:

Year	Yield tonnes/ha	% export	Gross return export at $1700/tonne process at $450/tonne ($)
1	----	-----	-----
2	----	-----	-----
3	----	-----	-----
4	6.0	50	6,450
5	8.5	60	10,200
6	12.5	80	18,125
7	17.0	90	26,775
8	20.0	90	31,500
9	21.0	90	33,075

Table 1: Current cost of production is 40-45% of gross return for mature blocks.

CITRUS

New Zealand is marginal for citrus production, due to our limited summer heat. However, some citrus can be produced satisfactorily, major types are:

- Seminole tangelos
- NZ grapefruit
- Navel oranges
- Lemons
- Clementine mandarins
- Satsuma mandarins

Citrus orchards should be well sheltered into small blocks to conserve all possible summer heat. Because of our climatic limitations the skin of New Zealand-grown citrus is thick by world standards.

Poncitrus trifoliata rootstock is necessary for the best quality of all dessert citrus.

Heavy plantings of citrus have taken place in New Zealand in the last decade and production is rising dramatically. There appears to be no major export possibilities and it will need a suitable promotion campaign to increase local consumption and hold returns to growers. It is likely processors will take an increasing percentage of the citrus crop.

TAMARILLOS

A very frost-tender and brittle crop subject to breakage of branches. Its characteristics are:

Short-lived, 8-10 years.
5-10% tree replacement per annum.
Quickly into production.

Average return on New Zealand market 5500-700/tonne.

1st year	Nil crop	
2nd year	1/2 crop	7.5 tonne/ha
3rd year	full crop	15 tonne/ha

Red tamarillos more profitable than yellow on the auction markets.
Yellow tamarillos get premium for processing.
Some export of fresh fruit which is being developed.
Export of processed products has good possiblities.

AVOCADOS

A high value crop, sought after in western type countries.

Very large trees.
Tendency to biennial bearing.
Very susceptible to root rot.
Choice of site for drainage and freedom from frost very important.
Little New Zealand production as yet, but high level of planting.
Good prospects on New Zealand market and for export.

PASSIONFRUIT

A high risk crop with a high labour requirement.

Risks due to:

Weather - wind, frost and wet feet.
Crown canker - a soil-borne fungous disease.
Grease spot bacterial disease of stems, fruit and foliage.
Brown spot - fungal disease of fruit and foliage.
High labour requirement:
20-24 sprays per year.
Weed control.
Harvesting.
Passionfruit is short-lived - up to 8 years.
Cost of fencing a significant establishment cost.

Quickly into production:

1st year	nil crop	
2nd year	1/2 crop	5 tonne/ha
3rd year	full crop	10 tonne/ha

Average return on New Zealand market $750-$l000/tonne.

New Zealand market very sensitive to oversupply. Small export market for fresh fruit could possibly be developed.

Steady limited demand by processors sometimes complicated by imports from Pacific Islands.

FEIJOAS

The hardiest subtropical.

Seedling plantings not suitable for commercial orchards. Use vegetatively propogated plants even if it means waiting.

Recommended varieties:

Triumph
Mammoth
Also scope for seedling section.
Reasonable market in New Zealand for large fruit.
Processing outlet also developing.
Small scale export of fresh fruit could be developed.

LIMITING FACTORS

The main limiting factors for production of subtropical fruits are:

Frost
Wind
Water table
Drainage
Topography

Frost will affect most of these plants adversely.

Very frost tender - tamarillos, passionfruit, avocados, spring growth of kiwifruit, less than -- 2°C.
Frost tender - citrus - lemons being most susceptible and satsuma mandarines most resistant, -- 2- 4°C.
Less frost tender -- kiwifruit in winter - wood freezes at around - 8-10°C.
More frost resistant - feijoas.
Wind damages all these plants:
Damages shoots, retarding growth and establishment - all crops.
Discourages bees, important pollinating agents, from flying - kiwifruit, avocados.
Directly affects fruit set - tamarillos and feijoas.
Breaks brittle trees - tamarillos and feijoas.
Causes fruit blemish - all crops.

Water table level is critical for all these fruits as none can stand “wet feet”. A minimum winter water table of lm is considered necessary.

Drainage is also important for impervious soils even where the water table level is satisfactory.

Topography must be suitable for all orchard machinery including a loaded spray tank trailed by, or mounted on a tractor.

Ministry of Agriculture and Fisheries, Advisory Services Division, New Zealand.

NEW ZEALAND KIWIFRUIT:
Commercial Production in the Bay of Plenty

P. R. SALE
Horticultural Advisory Officer (Citrus and Subtropicals)

Kiwifruit, *Actinidia chinensis*, has captured the imagination of the fruit trade throughout the world, and in New Zealand is a rapidly expanding export crop.

Kiwifruit is well suited to the New Zealand family-enterprise orchard unit where the grower works directly with the vines alongside any employed labour. It is, however, a technically advanced and demanding crop to grow. Pruning, in particular, is critical. Every cut affects profitability, and the operation extends over 2 months in winter and 4 months in summer.

GROWING REQUIREMENTS

Kiwifruit has environmental requirements which must be met for maximum production. These include:

Temperature: Kiwifruit is particularly susceptible to cold. Although deciduous, plants can freeze, and to minimise this risk in low-lying or frost-prone areas, trunks should be lagged in winter. Young shoots in spring are very frost tender, and late spring frosts are a major hazard. Premature frosts in autumn or early winter threaten unharvested fruit.

Moisture: Plants need a lot of moisture in the growing season and they thrive best where rainfall is well distributed and humidity relatively high. An annual precipitation of 1250-2500 mm, as found in the growing areas of the Bay of Plenty, is ideal.

Plants cannot stand wet feet, requiring a minimum winter water table of 1 m to produce well. The deep, free-draining soils derived from volcanic ash in the Bay of Plenty are ideal.

Shelter: Under New Zealand conditions provision of adequate shelter belts is essential. Without them plants do not establish well, and many of the new flowering shoots blow off in spring, greatly reducing the crop.

Bees, so important for pollination, do not like working unsheltered orchards, and if pollination is not adequate, large numbers of small "scrub" fruit with only a small seed number are produced, drastically reducing profitability.

If strong winds partially or totally defoliate vines in summer or early autumn, cropping capacity for the next season is greatly reduced - fruit initiation within the buds does not occur until late in the season.

Wind rub of fruit close to harvest can also reduce the amount of export-quality fruit.

SUPPORTING STRUCTURES

The kiwifruit is a very long-lived plant; there are vines in commercial orchards in the Bay of Plenty 30-40 years old and in China, plants have survived for more than 80 years. With this in mind it is false economy to stint on the supporting structures.

T-bar and pergola: The two favoured supports are the T-bar fence and the overhead pergola. Both are generally about 1.8 m high using 2.7-2.9 m poles driven 0.6-0.9 m into the ground. Poles must be substantial enough to carry the loads required of them over many years. The end assemblies must be even stronger strainer posts, well-stayed and footed.

The centre wire should be 3.15 mm (10 gauge) high tensile (HT) wire, but the other wires can be 2.5 mm HT (121/2 gauge) wire. The T-bar fence has three horizontal wires, the centre wire running over the top of the posts, and the two outrigger wires running over the outside of the T-bar. Wires on the pergola are usually 0.6 m apart, and the cross timbers are laminated, 100 x 25 mm.

Pergolas should give a crop less prone to wind rub of the fruit. In theory the yield between the two systems should be the same, provided the fruiting arms of a T-bar system meet in the middle of the row if lifted up. To achieve this, a correlation must be made between the inter row spacing, width of T-bar, and the length to which fruiting arms are terminated. An extra correlation is the width of machinery to work the block.

If these factors are not all suitably correlated, the yield potential of the block would be less than for a well covered pergola block.

TRAINING YOUNG VINES

Training the young vines is important, as a simple, well-defined basic structure allows easier management later on.

There should be one straight trunk, with one leader going along the wire each side - these are the only permanent parts of the vine. Off these, fruiting arms are produced, ideally every 50 cm, and about at right angles to the leader. In turn, fruiting laterals are produced on the fruiting arms, whole arms being replaced after 1, 2, or sometimes 3 years. Under some pergola systems the fruiting arms may remain on the vine for longer.

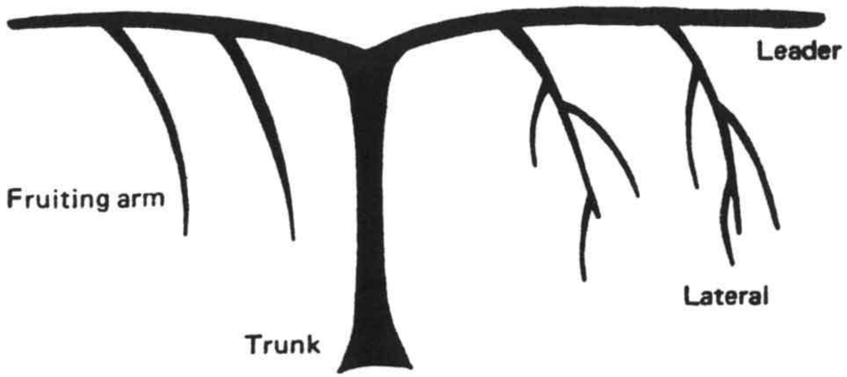


Fig. 1: Parts of vine

FRUITING HABIT

Kiwifruit produce fruit on current season's growth, but only on growth originating from 1-year-old wood. Shoots arising from older wood will not produce fruit in the first year, but can give rise to fruiting laterals the next season.

PRUNING

Pruning is such an important aspect of management that to fail has extremely serious consequences.

The aim of winter pruning is to leave the permanent framework of the vine carrying the optimum quality of well-spaced, one-year-old shoots that will give rise to fruiting shoots in the next season. This is achieved by suitable spacing of fruiting arms and removal of excess growth.

Summer pruning should maintain the order in the vine obtained in winter, and make the first selection of shoots likely to be suitable for cropping the next season. Only one layer of shoots should be left after winter pruning. In summer, it is also necessary to accommodate next year's fruiting shoots, as well as those carrying the current season's crop. But a dense multi layer canopy

should not be allowed to develop so that proper maturation of the wood and fruit, adequate light penetration of the vine and adequate spray penetration is allowed.

As far as possible only one layer of shoots should be maintained to allow proper maturation of the wood and fruit, adequate light penetration of the vine and adequate spray penetration.

VARIETIES

The only variety to consider for the best-quality fresh fruit is Hayward, which is now the preferred one on all export markets. There are two types of male - long-flowering, and late-flowering. Pollen of all males evaluated to date has been viable. The long-flowering types are generally preferable to the late-flowering ones, but there is some merit in having more than one type of male in a block. Blossom periods of males and females should overlap.

The named strains of male are Matua, a long flowerer, and Tomuri, a late-flowering type.

Traditionally, male plants have been planted on a ratio of 1:8 and allowed, therefore, to occupy one ninth of the area. Recent experience suggests that the male to female ratio could be smaller, but that the total area occupied by the male vines should still not exceed one ninth. To achieve thi the leaders are terminated closer to the trunk on either side of the male vine.

Another possible arrangement of males is to train them at right angles across the block instead of up and down the rows. For T-bar blocks this is done by stretching a wire at a height of 2.1-2.2 m across every second row of poles, which have been extended upwards by 0.3 m.

To obtain maximum benefit from this system, the male must be kept trained and pruned in a narrow band across the block. If it is not kept narrow it can shade out the females beneath it, causing a loss of production (Fig. 2.)

POLLINATION

Pollination is vital for production of a good crop of export-standard fruit. To assist this, bees are normally brought into the orchard for the blossom period. Unfortunately, the kiwifruit flower is not particularly attractive to bees so more hives/ha, are needed than for many other crops; 7-8/ha are recommended.

Where kiwifruit is grown in association with citrus, competition from the citrus blossom, which is often out at the same time, is very strong.

NITROGEN APPLICATION

Kiwifruit requires a good basic soil fertility, suitable for most other orchard crops. Information available to date suggests that nitrogen has a significant effect on cropping.

Timing of nitrogen applications is important; 66% of the annual requirement should be applied in early spring, and the rest around the blossom period. Later heavy applications of soil-applied nitrogen are likely to produce a softer fruit with a reduced storage life.

The spring nitrogen application on a mature block is usually 120 kg of elemental nitrogen/ha, followed by a further 60 kg/ha in the blossom period.

PEST AND DISEASE CONTROL

Good pest and disease control is essential for export fruit; international plant quarantine requirements are stringent. Most important is to follow the recommended spray schedule, and also to make frequent observations of the vines. Seek further advice if an unusual situation arises.

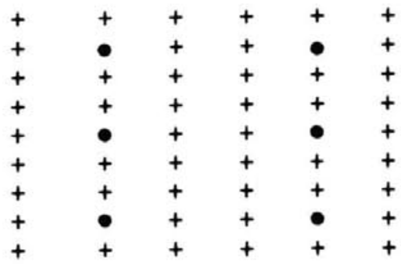
HARVESTING

Harvesting for export can commence when the maturity index for the block concerned is 6.2% soluble solids (ss) or above. However, fruit should be between 7.0 and 10.0% ss for optimum storagability and eventual palatability.

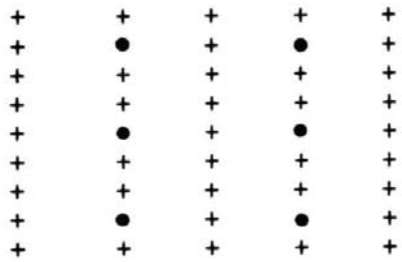
Even though the fruit is mature, it is still hard and not ripe; even so, careful handling is essential to avoid bruising and damage, which may include rapid ripening and reduce storage life.

For keeping, the fruit must be put into storage, and the field heat removed as soon after harvest as possible.

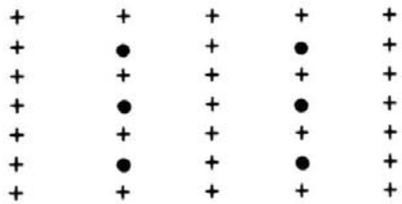
Storage should be about 0°C, with a relative humidity of at least 90 percent.



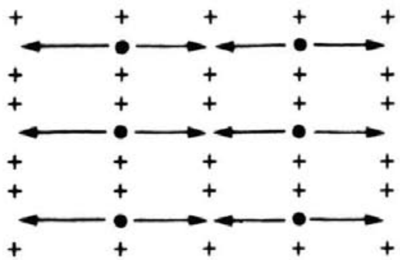
Males at ratio of 1 : 8; every 3rd plant in every 3rd row.



Males at ratio of approximately 1 : 6; every 3rd plant in every 2nd row.



Males at ratio of approximately 1 : 5; every 2nd plant in every 2nd row.



Males run at right angles across the block (plant against the poles) on every 2nd row of poles.

+ Female ● Male

Fig. 2. Male/female arrangements.

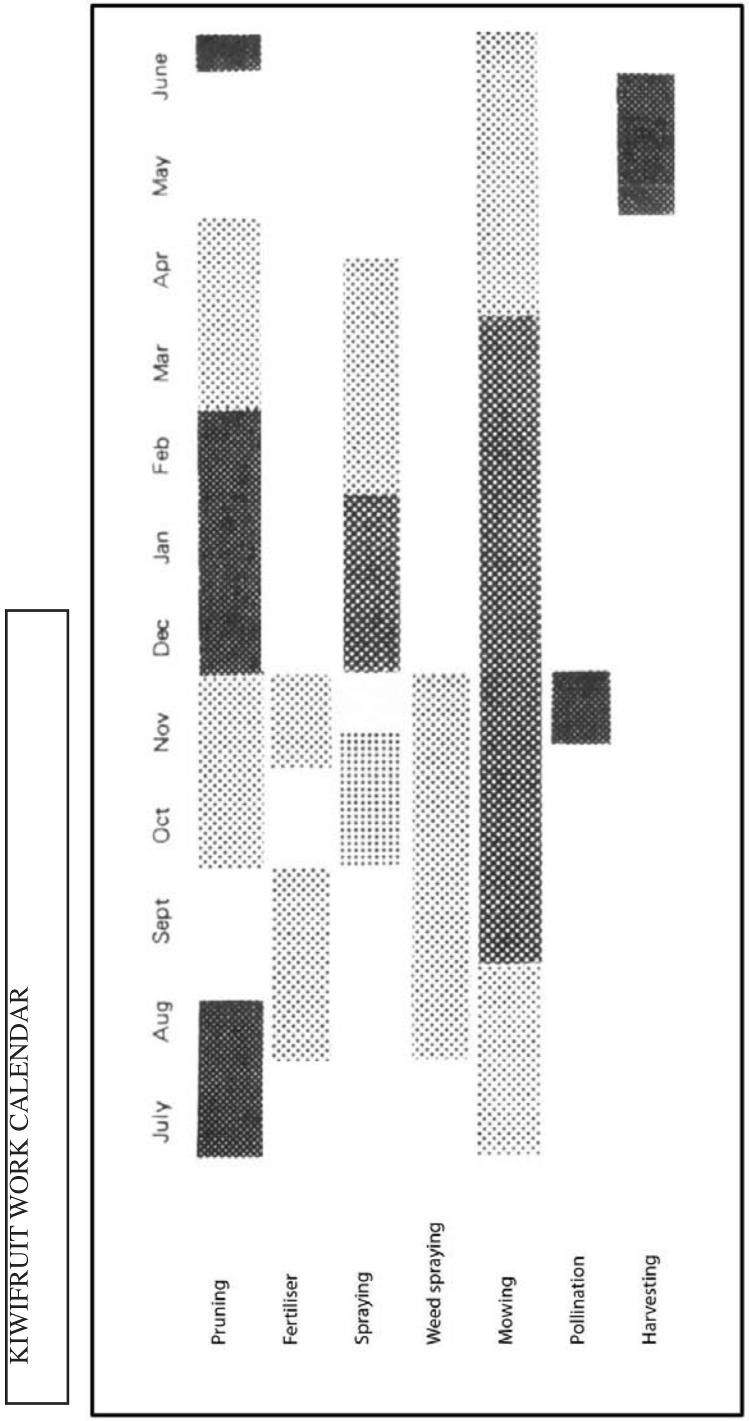


Fig. 3: Kiwifruit work calendar.

Ministry of Agriculture and Fisheries, New Zealand.

KIWIFRUIT:
Training and Pruning on T-bar and Pergola Systems

P. R. SALE
Horticultural Advisory Officer (Citrus and Subtropicals)

Training young kiwifruit vines into a simple well-defined structure allows easier management after the vine is established. Good pruning techniques are equally important and will ensure high yields. Training and pruning procedures are to be discussed in detail.

TRAINING

To train vines properly over a T-bar fence, or pergola requires constant attention while the plants are developing.

T-bar fences

The aim should be to obtain a well-defined basic vine structure, with a single straight trunk, and a single strong leader along the centre wire in each direction. A balanced and distinct system of fruiting arms should be trained at right angles from these leaders. (See Fig. 1.)

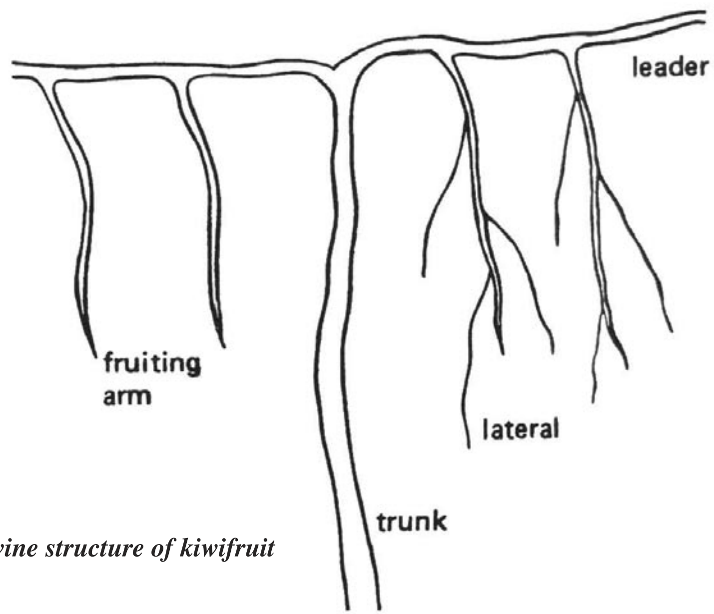


Fig. 1: Basic vine structure of kiwifruit

Select a strong growing shoot to be the main trunk, to carry the vine up to the wire. A light stake should be driven into the ground beside the plant and attached to the wire. This will provide support to the trunk, as it can be tied in at frequent intervals to prevent wind damage. Do not allow the trunk to twist tightly around the stake.

If an ungrafted seedling is planted, growth additional to the selected leader can be left on in the early season, as the extra foliage will assist in the development of the root system. If drought stress occurs later in the season these extra growths can be removed to conserve moisture for the plant. However, if the plant has been grafted all growths below the graft should be removed. When an ungrafted seedling reaches the wire, further growth can be allowed to develop unrestricted as this top growth will be removed for grafting in the following winter. When a grafted plant or rooted cutting reaches the wire, one permanent leader can be allowed to grow out in each direction along the centre wire.

This may be achieved by training the leader one way along the wire and waiting for a suitably placed shoot to train as the other leader, in the opposite direction. Or by cutting the initial shoot just below the wire, to produce two new leader growths which can be trained as leaders along the wire, either side of the trunk.

Summer and winter pruning become more difficult and time consuming if the number of permanent leaders is increased. Any overcrowding causes unnecessary shading of the fruit and affects its size and quality.

A system of temporary fruiting arms, 25-40 cm apart should be developed from the permanent leaders at right angles along both sides of each leader. Carefully tie these arms down to the outrigger wires to hold them in position. Care must be taken not to break them out of their sockets in the process.

The first crop of fruit forms on these arms, and later crops form on laterals that develop from them or replacement fruiting arms. Fruiting arms should not be trained along outrigger wires parallel to the permanent leaders, or shoots from them will compete with the fruiting arms which originate directly from the leader. A dense dark tangle of growths can result which adversely affects management and vine performance.

As the leaders grow they should be supported by the centre wire with a loose twist every 50-60 cm, and loosely tied in for added stability. The leaders should not be allowed to twist tightly around the wires, or a restriction of sap flow in future years could result and cause debility of the vine beyond the constriction.

Using substantial shoots for training as leaders will hasten the full development of fruiting arms and the time of full production. If a leader shoot becomes thin and starts to twist tightly around the wire it should be pinched out at the tip to stimulate strong growth from a good bud, in a favourable position.

Growth may be relatively slow in the first season, but within 3-4 years the fence should be furnished with strong leaders and fruiting arms in each direction.

Pergolas

Training of vines over pergolas is similar to that for a T-bar fence. The vines are grown as straight, single trunks until they reach the top of the structure. A single strong permanent leader is then allowed to grow in each direction along the main wire.

A system of fruiting arms is then developed from the leaders at right angles to the wires, forming the canopy of the pergola. Fruiting arms can be retained longer on pergolas and may be more permanent than on T-bars, although an annual cane replacement system can be very successful for both methods. On the more permanent fruiting arms, temporary fruiting laterals are allowed to develop.

It takes up to 7 years for a pergola to become fully furnished with vine growth.

PRUNING

Pruning is one of the most important aspects of vine management, and plays a major part in obtaining consistently good yields each season.

Successful management needs good open pruning to prevent the vines becoming dense and tangled. This allows:

- access for bees during flowering
- penetration of sprays
- air movement around the vines
- light penetration through the vines to minimise conditions favourable to fungal diseases (e.g. *Botrytis*)
- adequate light to ripen fruit and mature the fruiting canes for the following season.

It is only under conditions of reasonable light penetration that new shoots will originate from points on, or close to the main leader.

Fruiting habit

Kiwifruit crop on current season's growth that originates from 1-year-old wood. Usually only the six bottom buds on a fruiting shoot produce fruit.

(Fig. 2)

The trunk, and leaders are usually permanent wood, but leaders can be renewed by laying down a new shoot as a replacement, if necessary. Fruiting arms can be renewed annually or left for 2 or more years.

Fruiting wood

Selection of the best fruiting wood is important for top vine performance. Ideal fruiting shoots have short internodes, well developed buds, grow nearer to the horizontal than the vertical, and are well exposed to sunlight.

Self terminating shoots are often ideal as they should be well mature by the end of the growing season. (Fig. 3.)

Types of fruiting wood:

- Replacement fruiting arms arising from 1-year-old wood.
- Fruiting laterals originating from a 1-year-old fruiting arm, or from 1-year-old laterals on an older fruiting

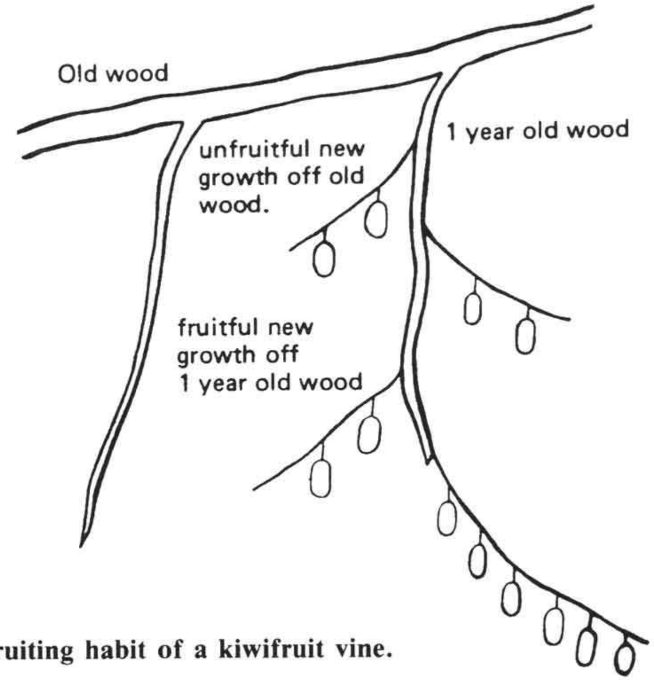


Fig. 2: Fruiting habit of a kiwifruit vine.

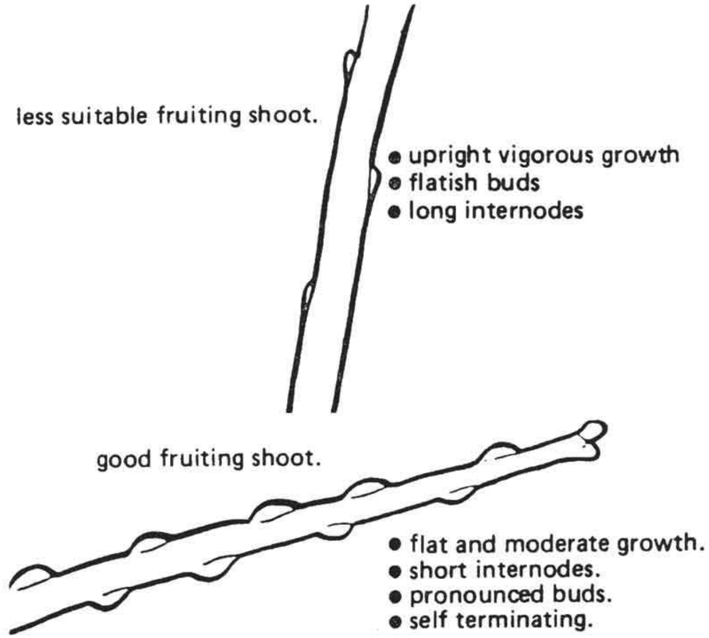


Fig. 3: Fruiting shoots of a kiwifruit vine.

• A spur, which is a short self-terminating lateral arising from 1-year-old wood, usually close in to the centre wire (Fig. 4.).

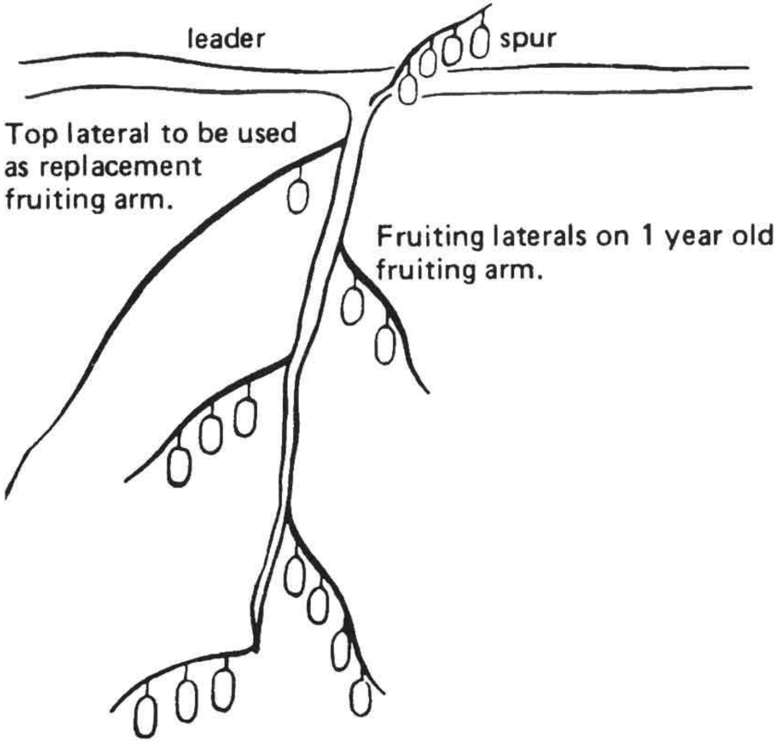


Fig. 4: Types of fruiting wood on a kiwifruit vine

In practice a combination of replacement fruiting arms, 2-3 year-old arms and spurs, is often achieved after the first year or so of cropping.

Winter pruning

The aim of winter pruning, which is done in the dormant season, is to leave the optimum amount of 1-year-old wood on the vine. This growth should be evenly distributed, and well spaced out. There should be only one distinct layer of shoots.

Each fruiting arm should originate near the centre wire, with 25-35 cm between each, and well exposed to sunlight. (Fig. 5)

Each vine must be restricted to its allotted space, and not allowed to tangle with its neighbour along the row, or across the row in a pergola system. The hanging curtain on the T-bar system should be trimmed to knee height or slightly above. A common fault when pruning T-bar systems is cutting the fruiting arms too short. (Fig. 5.)

Summer pruning

Summer pruning is essential to maintain the order, spacing and light access achieved in the winter pruning. It will be necessary to prune the vines several times through the growing season.

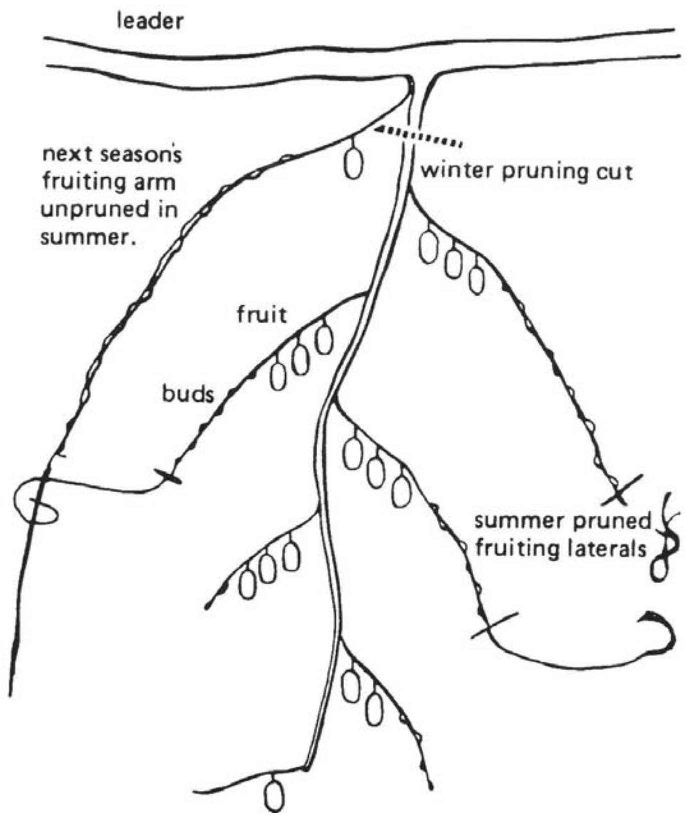


Fig. 5: Pruning cuts for summer and winter on a kiwifruit vine.

Commence in October or November when unfruitful shoots not required next season can be removed. Erect water shoots can be cut back to a short stub as this will retain the growing point from which more suitable replacement fruiting arms or spur growths can originate. Any shoots starting to curl and tangle should be shortened back.

December and January are critical months for summer pruning as growth can be extremely rapid. During this period shoots to be retained for next season are selected and allowed to remain on the vine. Excessive growth on a lateral beyond the fruit can be shortened to a suitable length. The length is determined by the competition for space from surrounding shoots. (Fig. 5.)

Tangles are removed and again the vine is restricted to its allotted space. Shorten or remove all strong growths if they are blocking access between the rows on a T-bar system. On a pergola system, some light should penetrate the canopy to show a pattern on the ground beneath the vines.

By February in most seasons, the Hayward variety will have slowed its growth rate and summer pruning consists of a final tidying up of vines. However, male vines and other female varieties will usually grow on through March and into April and further pruning may be required to maintain order.

Pruning male vines

Order must also be maintained in male vines, which are non-fruiting and planted only as pollinators. They should have the same basic structure as the females.

The major pruning of males is given immediately after flowering when the flowering arms are cut back to new growth originating close to the leader. In January these should be cut to 50-60 cm and if necessary, again to 75-80 cm in February or March. The male vines are finally trimmed up in winter.

Summary

Pruning is vital to the success of a kiwifruit orchard. Failure to understand the basic concepts, or keep pace with this demanding job throughout the season, can mean at the worst failure or at least a significant reduction in profits.

Ministery of Agriculture and Fisheries, N. Z.

KIWIFRUIT:
Agronomic Aspects of Kiwifruit Research in Queensland

A. W. WHILEY AND J. A. BAKER

Kiwifruit research was begun in Queensland in 1969 with the establishment of vines and names varieties on the Maroochy Horticultural Research Station. During the following years research plots were established in various areas in south-east Queensland to assess varietal performance over a range of environmental conditions.

CHILLING REQUIREMENT

This has been the most significant factor in the development of the Kiwifruit industry. The vine is deciduous and like most temperate fruit crops has a chilling requirement for fruitfulness.

From plantings on the Maroochy Horticultural Research Station it soon became evident that the coastal lowlands of S.E. Queensland were unsuitable for commercial production of this crop. Preliminary work has been done with the variety Monty in Queensland to define minimum chill hours necessary. Results indicated a minimum of five hundred hours below 7°C are required to produce a commercial crop of this variety. Field experience suggests other varieties have greater chill requirements.

VARIETIES

The future of any fruit growing industry rests largely on the development of varieties with both acceptable agronomic and post harvest characteristics. This enables the promotion of a standard high quality product which in turn gives an acceptable financial gain to the grower.

Varietal authentication and assessment has been the dominant area of research with Kiwifruit in Queensland. Four New Zealand varieties have now been authenticated in Queensland.

These are:

1. **Abbott** - also known in New Zealand as Allison but they are identical varieties. Large fruit can be obtained with this variety which tends to over-crop and produce “scrub” fruit. The shape is oblong with a rounded shoulder and pointing to the base. The calyx protrudes from the base.

2. **Bruno** - a fairly large, elongated fruit with rounded shoulders and base. Generally cylindrical but often flattened laterally - more so in some environments than others. Usually a darker brown than the other varieties.

The vines are extremely vigorous under Queensland conditions.

3. **Hayward** - initially the programme was frustrated as it was discovered that Hayward was not amongst the varieties first acquired which has meant the loss of several years data. Vines have fruited for the last two years. The fruit has been large and oval with square shoulders. In some areas the fruit slightly tapers to the blossom end which can be pointed rather than flat. The vines are much less vigorous than the other varieties which bears out New Zealand experience.

4. **Monty** - this variety has added confusion with identification in that it has been found that fruit shape expression is sensitive to the environment. Initially fruit were not recognised as this variety and were called Gracie. However, further introductions of scions which were grafted in several areas showed that the original wood was authentic but fruit shape varied between districts.

It is a prolific producer with a tendency to overcrop with adverse effects on fruit size. The fruit is oblong in shape and cylindrical - however some fruit exhibit a distinct flattening laterally which is more pronounced in some environments. The calyx is sunken into the base.

Several other miscellaneous varieties are claimed to be in existence, however, detailed comparisons need to be made against authenticated lines at the one site before they can be acknowledged. Indications to date in Queensland plots suggest that Gracie (ex Tamborine Mt.) and Dexter (ex Coffs Harbour) are Abbott types.

Aside from female cultivars, male pollinators have also been authenticated and assessed.

1. **Matua** - an early flowering male reaching its peak flowering slightly before the female cultivars but with adequate coverage for their flowering period.

2. **McLean** - has a similar flowering pattern to Matua and is a prolific flower producer.

3. **Moonya** - a prolific flowering male from Tamborine Mt. Once again peaking early in the female flowering period.

4. **Tomuri** - a late flowering male which has generally performed poorly under Queensland conditions. Tends to be erratic with a few flowers produced. Not recommended as a pollinator.

Of the four males Matua, McLean and Moonya are all suitable for pollinators for the female varieties. Tomuri is not recommended.

FRUIT MATURITY

For convenience the fruit maturity standard defined by New Zealand at 6.25% T.S.S. has been accepted as a minimum value for Kiwifruit in Queensland. This must be tested using sound fruit taken directly from the vine as once picked or stung by fruit fly, the conversion of starch to sugar commencers and a fibre reading will be obtained.

Using this criteria it has been determined that varieties mature in the following order - Bruno, Monty, then Abbott. No data is available for Hayward. Bruno is significantly earlier than the other two varieties which tend to show little difference. There has also been a district pattern of maturity between areas with Kingaroy being the earliest followed by Tamborine Mountain, the Blackall Range and then lowland coastal districts.

From an address given at the Maroochy Horticultural Research Centre Queensland, November 1982.

NATIVE FRUITS AND NUTS OF CHILE

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Instituto de Investigacionses Agropecuarias, INL4 (CHILE)

Chile extends through 4,200 Km and is located in the South West part of South America. It ranges from 17°30' to 56° southern latitude, which together with large differences in altitude gives a wide diversity of climatic conditions. Native fruits and nut species have been historically used as food of native populations. Some species are collected and commercialized in local markets and eventually exported.

AVELLANO. *Gevuina avellana* MOL., Proteaceae. Evergreen tree up to 20m tall, small whitish flowers grouped in long and thin clusters. Round nut 2-4 grs. Widely distributed in the Andes among 34°-43° S latitude and also in the coastal mountains. It is used as an ornamental tree in landscaping, the wood is also in demand. Tree starts bearing at the 8th year. As a natural food nut, it contains 12.5% proteins, 49.5% oil, 24.1% carbohydrates. Internal consumption mainly, some exported. Research is being done to domesticate the species.

PIÑ0N, Pehuén, Pino de Chile. *Araucaria araucana* (MOL.) K. KOCH. Araucariaceae. Beautiful evergreen conifer, 25-30m tall and 1.5-3m diameter. It lives 500-1,000 years. Andes mountains, from Volcano Antuco 37°30' S to Volcano Osorno 4Ø03Ø1 S. It is also found in the coastal mountains of Nahuelbuta at altitudes of 400-1,800m, from 37 '30' to 38'50' 5

Bearing cones are large, seeds 4-5 cm long. 1.5 cm wide, reach maturity after 18 months (March), rich in carbohydrates. It is a good source of food for wild parrots and native people. Even though it is a protected tree, some seeds are sold in local markets and eventually exported.

PALMA CHILENA, Palmera de Coquitos. *Jubaea chilensis* (MOL.) BAILLON. Palmaceae. Palm tree 20-35m tall, 0.8-2m diameter. Trees bear fruit when they reach 10-12 m high (50-80 years old). Fruit is a drupe, usually one seed. Tree bears 3-4 panicles that yield 50 Kg each. Fruit 7grs, consumed fresh, in pastries, used in cosmetics etc. Fruit production is not economically attractive, internal price is low.

Honey palm extraction, from the tip of the trunk of uprooted trees, has almost extinguished this ancient species. This practice was already known before the Spanish Conquest. Trees are pulled in August and yield honey during spring and summer, stop in winter and some resume exudation the following spring. Each palm yields 80-600 litres of exudate which is concentrated to 20-150 litres of honey, 370 Baumé, of excellent quality.

There are just two commercial plantings and minor groups of individuals. Replanting programs are needed urgently.

This is the most southern growing of the palmaceae, capable of living up to 2,000m altitude. It ranges from 30°30' to 34°30' in special microclimatic conditions. Trees can survive over 1,000 years.

MURTA, Murtilla, *Ugni molinae* TURCZ. Myrtaceae. Shrub up to 2m tall. Coriaceus leaves, white-pink flowers, fragrant. Round berry, sweet and nice aroma, purplish when ripe, some white fruits as well, harvested around March and April, 0.6-1 cm. Distributed in the central and coastal plains from 33'-45' 5, up to 600m altitude, also found in the Juan Fernández islands. One of the most delicious wild fruit. Used commercially in jam, juice, etc.

MAQUI, *Aristotelia chilensis* (MOL.) STUNTZ. Elaeocarpaceae. Evergreen shrub 3-4 m tall. Axillary clusters of small white and yellow flowers. Dark blue berries, 4-5 mm with 3-4 seeds, astringent but fresh. Distributed from 30 'to 43'20' 5, up to 300-400m altitude in humid places. Originally used as a dye, and to make an alcoholic beverage called Tecu by the native Indians. Now consumed fresh and in juices.

FRUTILLA, *Fragaria chiloensis* (L.) EHRH. Rosaceae. Stoloniferous hardy Fragaria. Andes and coastal mountain. White hermaphrodite flower. False fruit very aromatic, red or whitish, 1.5-2 cm length. Grown from 36°40' to 52°30'. Native population used to dry the fruit and use it to flavour an alcoholic beverage. Collected for fresh use, jam, etc.

FRUTILLA DE MAGALLANES, Miñe-miñe. *Rubus geoides* J.S.M. ex. HOOK. Rosaceae. Pink flowers, red ovoid fruits, 1.5-2cm diameter. Grows in forest clearings, from 36'30' to 540301, mainly in the Valdivia area, also in Juan Fernández islands. Delicious fruits, very much appreciated, consumed fresh, juices, etc.

COPIHUE. *Lapageria rosea* R. ET PAV. Philesiaceae. National Chilean Flower. Evergreen vine, large flowers, bell shaped, white, pink or red, isolated or grouped in the leaf axil. Cylindroid, yellow berry, 2.5-3.5 cm length. White, juicy and sweet pulp, several seeds. Consumed fresh and processed.

Grows in the forest from 32'30' to 43°20', mainly in coastal sites. Also commercialized as an ornamental plant.

CHUPON. *Fascicularia bicolo*r (R. ET PAV.) MEZ. Bromeliaceae. Grown on several woody trees such as Roble, Olivillo, Coigue, etc., no crown, rosette type leaves, blue flowers, seen March-April. Triangular berries, with a pulpy, sweet base. Distributed 30'40' to 39°40'. Commercialized only in local markets.

PINGO-PINGO. *Ephedra andina*. POEPP ex C. A. MEY. Ephedraceae. Tree up to 15 m tall, pyramidal, flexous shoots. Dioecious. Pulpy, roundish fruits, yellow to bluish-purple, 2-3 cm diameter. White pulp, one seed. Fruits are called 'Andean grapes', consumed fresh, in jam, and an alcoholic beverage is also made. Andes, from Maule river to Aysen.

CHAÑAR. *Geoffroea decorticans* (GILL. EX HOOK, ET ARN.) BURK. 5-7 m tree. Grown in Northern Chile from Tarapacá to Combarbalá, 180 to 31°50', 500-1,000m altitude. In one location, near the ocean. Yellow flowers. Sweet legume, 2.5 cm diameter. Fruits consumed over-ripe, as a honey or Arrope, or as an alcoholic beverage named Aloja de Chañar.

QUISCO. Guillave. *Trichocereus chilensis* (COLLA) BR ET ROSE. Cactaceae. Tree-type cactus, arms up to 8 m, strong spine, white flowers. Fruits consumed fresh and processed. Grown from Coquimbo to Curicó, in sunny and dry hills.

QUILO. Mollaca. *Muehlenbeckia hastulata* (J. SM.) STANDL. EX MACBR. *M. tamnifolia*. Polygonaceae. Woody shrub with flexous shoots. Small yellow flowers. Pink fruits (0.5 cm), juicy and pleasant. Distributed central plains, road hedges, from Coquimbo to Valdivia.

COGUIL, Coile, Collivoqui. *Lardizabala biternata* DCNE. Lardizabalaceae. Vine with strong trunk that reaches the top of large trees. Dioeceous, bluish-purple flowers. Yellow green berry (one side reddish), 6-10cm long and 2.5 cm diameter, sweet and pleasant pulp, consumed fresh. Distributed from Aconcagua to Chiloé.

CALAFATE. *Berberis buxifolia* LAM. Berberidaceae. 1-3 m shrub. Yellow flowers. Fruits 1 cm diameter, up to 7 seeds, excellent taste, very much consumed in Southern Tierra del Fuego.

QUEULE. *Gomortega keule* (MOL.) JOHNST. Gomortegaceae. Evergreen tree up to 25m, very bushy, elliptical-lanceolate leaves 2.5-4 cm length, fragrant, coriaceous. Round fruits, yellow tasty pulp, 4-5 cm diameter, ripe late April. Consumed fresh or as a syrup. Grows from Maule to Concepción.

Other known native fruits are:

COPAO, Rumpa. *Eulychnia acida* PHIL. Cactaceae.

COPAO.

Trichocereus coquimbanus (MOL.) BR. ET R. Cactaceae.

T. litoralis (JOHOW) LOOSER.

T. atacamensis (PHIL.) W. T. MARSH ET T. M. BOCK

PEUMO. *Cryptocarya* alba (MOL.) LOOSER. Lauraceae.

BELLOTO DEL CENTRO. *Beilschmiedia berteorana* (GAY) KOSTERM.

Lauraceae.

ZARZAPARRILLA. *Ribes magellanicum* POIR. Saxifragaceae.

PERLILLA, Romerillo. *Margyricarpus pinnatus* (LAM.) OK. Rosaceae.

PACUL. *Krameria* cistoidea HOOK. ET ARN. Krameriaceae.

PALO GORDO. *Carica chilensis* PLANCH. Caricaceae.

DAUDAPO. *Myrteola nummularia* BERG. Myrtaceae.

PALO COLORADO. Margyricarpus pinnatus (MOL.) A DC. Sapotaceae.

CARBON, Carboncillo. *Cordia decandra* H. ET ARN. Borraginaceae.

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AN ANNOTATED LIST OF EDIBLE NUTS IN THE PHILIPPINES

ROBERTO E. CORONEL*

The Philippines grow more than 200 tree species bearing edible fruit. Several of these have a nut-like edible portion. Of these edible nuts some are exotic and the rest are native of the country. Ranked among all fruit crops, all edible nuts are economically minor crops, although efforts are being made to develop them into major crop commodities.

The most important edible nuts in the Philippines are cashew and pili. Commercial plantations of cashew are being established to meet both local and export demand. Pili is native to the Philippines and limited quantity of processed products is being produced from backyard trees in one geographic region. With availability of outstanding parent trees and knowledge of asexual propagation, experimental pili orchards will be established to study the cultural requirements of this crop. Other economically promising edible nuts are bago, gab and kubili.

The following is a brief description of the edible nuts in the Philippines. The species are arranged alphabetically by their common names.

BAGO

Gnetum gnemon L.

Gnetaceae

Bago is indigenous to the Philippines and is of wide distribution at low and medium elevations. It is a small to medium sized tree, about 10 - 15 m high, with opposite, ovate oblong to lanceolate, pointed, dark green and shiny leaves that are 10 - 20 cm long and 4 - 7 cm wide. Fruits are produced in small clusters, sessile, oblong ovoid, about 1.5-2 cm long, red when ripe, smooth and containing one large seed which is enclosed in a thin and brittle seedcoat. The nut contains 47.6 - 50.4% starch, 1.7% fat, 9.5 - 10.9% protein and 277 cal food energy per 100g edible portion. It may be eaten boiled or roasted, or made into thin, round chips, dried and fried until it swells and becomes very crispy. Young shoots are edible and may be used as a vegetable.

Bago grows successfully at low to medium elevations both in humid and dry districts. It can be propagated by seeds, marcotting, budding and grafting. Seeds take about 45 days to germinate. Fruiting commences 6-7 years after planting. Fruits ripen in June to July.

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BAROBO

Diplodiscus paniculatus Turcz.

Tiliaceae

Barobo is indigenous to the Philippines. It is very common and widely distributed in forests throughout the country at low and medium altitudes, but is not cultivated. It is an attractive, medium sized to large tree, up to about 20m tall. Leaves are alternate, thin, smooth, pointed at both ends and about 12 - 25 cm long. The flowers, which are borne on large compound inflorescences at the tips of shoots, are rather small and whitish or yellowish. Fruits are produced in loose clusters, yellowish when ripe and contain 4 seeds which maybe eaten boiled or roasted.

Barobo thrives well at low and medium altitudes. It can be propagated by seeds, shield budding and marcotting. Seeds take about 10 days to germinate. Fruiting season is March to April.

CASHEW

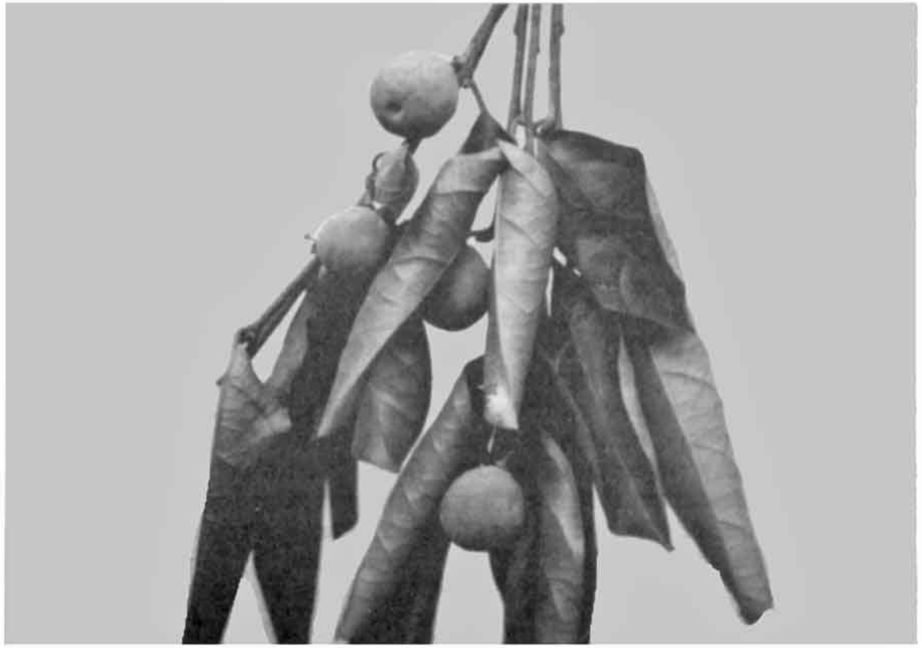
Anacardium occidentale L.

Anacardiaceae

Cashew is native to north eastern Brazil and was introduced into the Philippines by the Spaniards during the early times. It is now well distributed, specially in Central Luzon, Southern Tagalog and Ibocos. It is an evergreen, small to medium sized tree, 7 - 20m high. Leaves are simple, leathery, alternate obovate to obovate oblong, dark green or yellowish green and shiny above, bright green and dull beneath, 7 - 15 cm long and 4 - 8 cm wide. Flowers are produced in panicles at the tips of young shoots. A panicle may produce 120 - 1000 flowers, about 95% which are male and the rest are hermaphrodite. Fruit has 2 distinct parts: a large, soft, yellow to red, fleshy pseudocarp and a kidney-shaped, one-seeded nut. Ripe pseudocarp is eaten raw or made into candies, jams, wine or vinegar. Kernal contains 6.9% moisture, 50% fat, 17.5% protein and 22.2% starch. It is eaten roasted and used in bakery goods and confections and as flavouring for ice-cream. Shell contains a dark brown, sticky oil which is used as an insect repellent for books, a water-proofing and preservative for fishing lines, nets and boats and as a protectant for posts, floors and rafters against termites. Processed oil is used in the manufacture of typewriter rollers, automobile brake linings, clutch facings, magneto armatures, cation exchange resins, laminating resins, varnishes, paints and many others.

A very hardy and drought resistant plant, cashew grows well on all types of soils in areas with pronounced dry season. It is commonly grown from seeds but can also be propagated by marcotting, inarching, grafting and budding. Because of difficulty in transplanting, direct seeding is most widely practised. Tree bears fruits in 3 - 4 years. It flowers from December to March and matures its fruits from March to June. Important pests are twigs bores, tea mosquito, anthracnose, pink disease and powdery mildew.

Barobo *Diplodiscus paniculatus* Turcz. **Tilliaceae**



Galo *Anacolosa luzoniensis* Merr. **Olacaceae**

Kubili Cubilia cubili (Blanco) Adelb. **Sapindaceae**

Pili *Canarium ovatum* Engl. **Burseraceae**

GALO

Anacolosa luzoniensis Merr.

Olacaceae

Galo is indigenous to the Philippines and is distributed in forests from Northern Luzon to Visayas. It is of rather rare occurrence and is not cultivated. It is a small to medium sized tree of upright and robust growth and grows to a height of 15m. Leaves are alternate, oblong, ovate oblong or elliptic oblong, 8-12 cm long and 3-5 cm wide, dark green, slightly shining, with acute base and obtuse apex. Flowers are small, pale green, densely crowded in small clusters at the leaf axils and 2-3 mm long. Fruit is a nut, ellipsoid, green, about 2 cm long. Young fruit is very delicious when boiled. Pulp of mature fruit is also edible when cooked, while the nut, which can also be eaten raw, has good flavour and quality. The nut is 87% of the fruit weight and contains 38.5 - 59.6% moisture, 3.9 - 11.1% protein, 144 - 273 cal food energy per l00g, 1.8 - 8.0% fat, 33.4 - 39.5% carbohydrates and 1.9% fibre.

Galo thrives well at low and medium altitudes in moist as well as in dry climate. It is propagated by seeds, marcotting and grafting. Seeds take about 105 days to germinate and marcots are well rooted in 4 months. They bear fruits about 5-6 years from seeds. The fruiting season is March to July.

KAYAM

Inocarpus edulis Forst.

Leguminosae

Also known as Polynesian chestnut, kayam is a native of Polynesia. Its date of introduction into the Philippines is not known, but it is now found sparingly in Visayas and Mindanao. It is a medium sized to large tree with spreading branches. Leaves are simple, dark green, leathery and pointed.

Flowers are small and greenish white. Fruit is a large, flat pod, about 7.5 cm long, 6 cm broad and 3.4 cm thick. It consists of a thick, fibrous husk which encloses a large nut. Nut is eaten boiled or roasted. It contains 48.6% moisture, 5.6% protein, 41.5% carbohydrates and 1.8% fat.

Kayam grows well at low altitudes with equally distributed rainfall or with no prolonged dry season. It can be propagated by seeds, budding, grafting, inarching and marcotting. Fruiting age is about 8 years for seedlings. Flowering season is from March to June while fruiting season is July to November.

KUBILI

Cubilia cubili (Blanco) Adelb.

Sapindaceae

Kubili is indigenous to the Philippines and is distributed from Luzon to Mindanao in primary forests at low to medium altitudes, but is not cultivated. It is a medium sized tree, up to 15 m tall, with compound leaves. Leaflets are large, smooth and pointed at both ends. Flowers are small and borne on rather large inflorescences at tips of shoots. Fruit is oval, bright green, 5-6 cm long and covered with very numerous projections. Aril is white, fleshy, juicy and covers one-half of seed or nut. Nut is roundish oblong, 3 - 4 cm long and 2.6 - 3.8 cm in diameter, dark red, depressed at point of attachment and is covered with a very thin seedcoat. It contains 48.2% moisture, 1.5% ash, 1.2% crude fibre, 5.2% protein, 1.9% fat, 23.1% starch and 18.8% other carbohydrates. It is delicious either boiled or roasted.

Kubili grows well at low to medium elevations in areas with evenly distributed rainfall. It can be propagated by seeds, inarching and budding. Seeds take about 45 days to germinate. Flowering season is November to December and fruiting season is March to June.

PILI

Canarium ovatum Engl.

Burseraceae

Pili is indigenous to the Philippines where it is quite abundant in Bicol and parts of Visayas and Mindanao in primary forests at low and medium elevations. It is a handsome, evergreen, dioecious, medium sized to large tree, 20 - 25 m tall, with a straight trunk and a dense crown. Leaves are alternate, compound and about 40 cm long. Leaflets are odd pinnate, rather thick, smooth, dark green, entire, 10 - 20 cm long and prominently veined. Flowers are borne in cymose inflorescence at leaf axils of young shoots. Female inflorescence is about 7 cm long and has 3 - 6 female flowers. Male inflorescence is 9.7 cm long and has about 18 male flowers. Fruit is a drupe, ovate to oblong, 4 - 7 cm long and 23 - 3.8 cm in diameter. Pulp is composed of a thin skin which is smooth and shiny and turns from green to purple or nearly black when fruit ripens, and a fibrous, fleshy, thick mesocarp. Shell is thick and very hard. Seed is made up of brown, papery seedcoat surrounding the embryo with 2 white cotyledons (kernel). Kernel is 4.4 - 16.6% of the whole fruit and contains 35.6 - 51.4% moisture, 11.5 - 15.7% protein, 69.2 - 76.6% fat and 14.2% total carbohydrates. It may be eaten raw or roasted and may be made into candies, preserve or ice cream ingredient. Boiled pulp is also edible.

Pili grows well on deep, fertile and well drained soils in warm, humid surroundings from sea level up to 400 m elevations. It is propagated by seeds, marcotting, grafting and budding. Seeds take about 30 days to germinate. Seedling trees bear fruits 5-6 years after planting while asexually propagated ones bear much earlier. Fruiting season is June to August.

ULAYA

Castanopsis philippinensis (Blanco) Vidal

Fagaceae

Ulaya, also known as Philippine chestnut, is an indigenous nut tree. It is found at low to medium altitudes in the forests of Visayas (Samar and Leyte) and Southern Luzon (Rizal, Mindoro, Camarines) but is apparently not abundant and not cultivated. It is a medium sized tree, usually 15 - 25 m tall. Leaves are entire, alternate, smooth, pointed at both ends and 4 - 15 cm long. Fruits are borne in bunches of 3-6 or more fruits, semi-flattened and covered with a spiny husk. Within are oblong nuts about 1.5 cm long containing an edible kernel with chestnut-like flavour. Kernel is eaten raw or roasted.

Ulaya grows well at low to medium elevations. It can be propagated by seeds.

WANATCA TISSUE CULTURE REPORT - MAY 1984

CHRIS NEWELL

Microculture, Russell Road, Wanneroo 6065

1. OBJECTIVE

To test the suitability of tissue culture propagation for *Pistacia vera*.

As the plant is dioecious, research concentrated on the female.

2. PROBLEMS

Problems encountered were stock availability, culture initiation, explant survival and culture maintenance.

2.1 STOCK AVAILABILITY

There is a shortage of stock plants locally and nationally, hence the rationale for this initial research. To date, experimental explants have totalled less than 200. Most of these were secured from Merbein, Victoria.

2.2 CULTURE INITIATION

Merbein supplied 200 tips of SIRORA budwood. These were placed under glasshouse conditions to break dormancy and the actively growing buds were used. Dormant apical buds or lateral buds did not grow in culture.

A disinfestation method involving repeated chlorine rinses was developed. Some chlorine toxicity was observed even after extended water rinses. On average 50% of the initial explants were apparently sterile after a 10-day incubation period. Including the mortality rate, the disinfestation procedure yielded 30 - 50% usable explants.

2.3 EXPLANT SURVIVAL AND CULTURE MAINTENANCE

The buds quickly stained the surrounding media with a toxic (phenolic?) exudate. The source of this exudate was a necrosis of the bud tissue. Repeated subculturing onto a range of different culture media did not help. Continual trimming of the explant followed by vitamin drips proved unsuccessful in stopping this necrosis.

The buds' leaf morphology was not normal. No real bud emergence occurred and the explants would eventually die after 4 - 10 weeks. The odour one associated with *Pistacia* spp. wood was always present in the culture vessels.

2.4 RECOMMENDATIONS

In order for any progress to be made a source of readily available plant material in quantity must be found.

Generally, juvenile seedling tissue works the best when tissue culturing woody species. Unfortunately this approach is not suitable for *Pistacia vera*.

If plant material is secured then it would be a good idea to assess some conventional propagation methods prior to continuing with tissue culture.

Softwood cuttings dipped in concentrated liquid rooting hormones (auxins) and placed on bottom heat should work.

Successful propagation of softwood cuttings taken from mature trees (over 6 years old) of *Pistacia vera* was achieved after dips in very concentrated solutions of IBA (0.22M).[1]

It is very important to note that the CSIRO does not recommended *Pistacia vera* as a rootstock because of its susceptibility to nematodes and soil fungi. For rootstocks *P. atlantica* and *P. terebinthus* are preferred (personal communication).[2] Bench grafting of P. vera onto cuttings of suitable rootstock should be considered as a possible way of producing this plant.

1. Barazi Z. & Schurabe W. Rooting softwood cuttings of adult *Pistacia vera*. *J. of Horticultural Science* 57(2) (1982), 247-252.

2. Personal communication with D. Alexander, Senior Principal Research Scientist, Division of Horticultural Research, CSIRO, Merbein, Victoria.

GROWING BLUEBERRIES

RIDLEY BELL, FRUIT CROPS BRANCH,
KNOXFIELD

Taken from Dept. Agriculture, Victoria Agnote, January, 1979.

THE PLANT

The blueberry is a member of the family Ericaceae. It is normally a deciduous, perennial shrub, growing up to 5 metres high in the wild, with attractive white or pink flowers.

Three main species of blueberries have been tested in Victoria. These are:-

• the highbush blueberry (*Vaccinium corymbosum*), a complex hybrid which has evolved over thousands of years from hybridisation of several species of Vaccinium. This species grows from 3 to 5 metres tall and shows the most potential for development in Victoria.

• the lowbush blueberry: (*V. lamarckii* and *V. angustifolium*). Lowbush blueberries are native to the northern areas of the U.S.A. and Canada. The plants grow from 100 to 400 mm high and form colonies by means of underground shoots (rhizomes). The fruit is smaller and a lighter blue than the highbush blueberry, and is particularly suited to processing. Field plantings in Victoria have been hampered by weeds and water stress.

• the rabbit-eye blueberry (*V. ashei*). This species is heat and drought-tolerant are generally darker and smaller than the highbush blueberry. Some of the rabbit-eye-highbush hybrids are showing some commercial potential in the U.S.A.

THE FRUIT

The fruit is a many-seeded berry with a white or pale green flesh. The skin varies in shades of blue, with a grey to white bloom. Depending on the variety, the fruit may ripen between early December and late January. The fruit is suitable for mechanical harvesting.

USE

Blueberries are nature’s convenience food, needing no peeling or coring. They are rich in vitamins A and C and iron and contain only 42 calories per half cup serving. Blueberry pie, blueberry mousse, muffins, cheesecake, pancakes, ice cream, yoghurt, jam, wines, juice or fresh fruit are only some of the many uses to which blueberries may be put.

GENERAL REQUIREMENTS

Site

Blueberries are susceptible to late spring frosts and hot drying summer winds. Areas subject to long periods of flooding are unsuitable as blueberries are susceptible to Phytophthora root rots. An easterly or north-easterly aspect is best, although they will do well as long as they have plenty of sunlight.

Soils

Blueberries belong to the same family as azaleas and also like very acid soils. Blueberries need a pH of between 4.5 and 5.5 and this may be achieved on more marginal soils by acidifying with ammonium sulphate or ground sulphur (250 g of ground sulphur per 10 sq. metres on a medium clay-loam soil will lower the pH by one unit.)

Soils should be open, porous and well-drained, with a water table preferably 350 to 450 mm below the surface. Blueberries have a shallow and dense root system, with no tap root.

CULTURAL REQUIREMENTS

Soil preparation

Incorporation of organic manures, such as well rotted chicken or farmyard manures, and planting of cover crops, such as peas and oats, will help to improve soil structure and fertility. Blueberries will not tolerate limed soils. Finely till the soil before planting to a depth of at least 200 mm and throw it up into lands at 3 m centres.

Planting

Planting of established two-year-old plants is preferable, as younger plants may struggle. Rub off all fruit buds before planting in early spring.

Plant spacing

Leave 3 m between rows and 1.3 m between plants. This lets the plants develop fully and yet allows working between the rows with machinery. This gives about 2690 plants per hectare.

Mulching

Results from trial at Knoxfield Horticultural Research Institute show that black polyethylene mulch is superior to pine bark, sawdust, sod culture or clean cultivation for establishing blueberries. It may be preferable to remove the polyethylene and replace it with an organic mulch as the plants age.

Irrigation

The demand for supplementary water by blueberries normally is heaviest between late November and early February, although late watering is important for the development of the buds for next season. Trickle irrigation with microtubes, jets or the Drossback ® system is recommended because of its low labour requirement and convenience.

FERTILISERS

Take care not to 'overfeed' blueberries as they tend not to be as hungry as many other horticultural crops. Young plants should be fed 60 g each of complete 2:2:1 (N:P:K) fertiliser in early spring, followed up by another 60 g in early summer. Ammonium sulphate is preferable to nitrates as a source of nitrogen. Potassium sulphate is preferable to potassium chloride (muriate of potash) as a source of potassium.

Take care that the fertiliser does not burn the plants. Where plants are becoming established under polyethylene, work enough fertiliser to last 12 months into the soil before laying the polyethylene, as fertiliser burning under polyethylene may occur.

Feed mature plants 150 g of complete fertiliser per plant in early spring, followed by a side-dressing of ammonium sulphate at the rate of 130 g per plant at intervals of five or six weeks until the middle of summer.

PRUNING

Remove spindly, older growth from young plants and encourage young, healthy shoots to form a 'vase'-shaped bush. Pruning in older bushes is geared to fruit production, as the fruit is borne on the previous year's growth. Note the following points:-

- remove low, spreading and diseased branches,
- open up dense centres, and
- thin the fruiting branches to encourage fruit size and overcome biennial bearing problems.

Prune during the dormant season.

POLLINATION

Most varieties are self-fruitful, although it has been found in the U.S.A. that cross-pollination improves fruit set and size. Beehives at the rate of two colonies per ha will improve pollination. Use sprays carefully when bees are active.

PESTS, DISEASES AND WEEDS

Pests

The introduced species of birds, such as sparrows, blackbirds, starlings and Indian mynahs are by far the most important pests of blueberries. Netting of areas with moulded plastic mesh seems to be the most economical means of control.

The light brown apple moth and looper caterpillars also damage fruit and foliage, but they may be controlled by spraying.

Diseases

Grey mould, *Alternaria* leaf spot and *Phytophthora cinnamomi* have been recorded on blueberries in Victoria. Consult your district horticultural adviser for control of these and other problems.

Weeds

The most effective means of controlling weeds is by mulching. However, good weed control in experimental plots has been obtained with terbacil (Sinbar ®) and simazine (Gesatop ® , Simadex ® , Simafox ®), at recommended rates.

HARVESTING

Pick fruit by hand every 10 days, three to five times during the harvest period. The berries can be harvested mechanically using hand-held vibrating units or self-propelled over-the-row harvesters. The latter machines are produced overseas and are expensive and would need large areas of blueberries to be economical. Mature bushes may average yields of between 5 and 7 tonnes per ha.

MARKETING

Pick the berries into shallow containers and keep them in a cool, shaded area to reduce loss of moisture. Cool the fruit quickly to a temperature between 1 and 5°C. Blueberries will keep well for at least two weeks if cooled promptly. The best way to package blueberries for market in Victoria will probably be in 280 g or 480 g punnets covered with cellophane.

POTENTIAL

It is expected that blueberries in Victoria will be well received by the migrant communities, particularly people of European descent who are familiar with the wild lowbush blueberry. With careful educational and marketing programs, there is no reason why blueberries should not be popular with the Australian community in general.

MACADAMIA

R. A. STEPHENSON

GENERAL

Although the genus *Macadamia* is native to coastal south-east Queensland and northern New South Wales, it is only in the last two decades that it has become a significant commercial crop, commercial development occurring mainly within this ecological zone. Nevertheless, yields have generally been below expectations and certainly well below the potential yield of which trees are capable.

It is essential that a basic understanding of the physiology of macadamia trees and the influence of environment in eliciting potential yields be gained so that management practices can be applied more effectively to optimize the exploitation of the environment. Much of the research effort on macadamias is directed to providing a better understanding of what makes the crop perform and how the crop and its environment can be manipulated to dive enhanced performance.

Macadamia grows well on a variety of soils, the main requirement being good drainage and a sufficient depth of reasonably well structured topsoil to support good tree growth. An important constraint on sustained, high production in some areas is the susceptibility of the brittle macadamia wood to wind damage. Windy aspects should be avoided and effective windbreaks provided to reduce the incidence of tree splitting, possibly with some limited corrective tree training.

Another potential constraint to achieving high production is insect damage by flower caterpillar, spotting bug and macadamia nut borer. Chemicals and technology to achieve effective control over these pests are available. If they are not used to maximum effect, however, insects can negate improvements in production which can be achieved by applying good management to the trees' growth and production.

By combining basic soil requirements with good insect control measures and sound management to achieve favourable manipulation of tree growth and production, optimum tree performance can be achieved.

TREE CYCLING

The mature macadamia tree, like many other fruit trees, undergoes annual cycles which are, in fact, the result of complex interactions between numerous physiological processes and environment. Annual cycles consist of vegetative (growth) and reproductive (production) components and good tree management depends on achieving an ideal balance between the two. This balance is necessary to prolong the economic life of the tree while at the same time, producing high yields each season. Sufficient vegetative growth is necessary to provide an adequate framework for future bearing sites and for the foliage to service them. Excessive vegetative growth, however, is likely to compete with the current season's crop, thus giving lower yields. Such imbalance may require several cycles of corrective treatment before complete recovery is effected.

CARBOHYDRATE PRODUCTION

Carbohydrates produced by photosynthesis provide energy for all tree processes including vegetative growth and nut production as well as providing approximately 95 percent of the dry matter of trees and nuts. The dry matter consists of structural components as well as storage carbohydrate materials. In tree tissues the latter is utilized at certain times to support growth flushes and is also likely to contribute to nut production. The major contribution to nut yield, however, is from current photosynthesis by leaves. The storage carbohydrate component of mature kernels is primarily oil, nut quality depending on a threshold oil content of 72 percent being achieved. The overall health and status of a tree is dependent, both directly and indirectly on carbohydrate production. Unfortunately this cannot be readily seen or measured under normal field conditions and thus its importance is seldom appreciated. Nevertheless, climate, soils and management practices such as fertilizing, irrigating and pruning influence tree growth and production indirectly through their effect on the carbohydrate status of the tree.

Some of the main factors which determine the level of photosynthesis, and thus the carbohydrate status of trees, are beyond our control, e.g. temperature and carbon dioxide concentration. Others such as light can only be modified slightly be orienting rows and orchard spacings to enable maximum interception by the canopy or by pruning to increase light penetration into the canopy. We are able to exercise a high level of control over the water and mineral supply to the tree and although these variables do not control photosynthesis to the same degree, they are often the main yield limiting factors.

Part of our management strategy is therefore directed towards ensuring that water and mineral nutrients do not limit carbohydrate production, particularly at critical stages in the crop cycle.

Storage carbohydrate is accumulated during winter and again in late summer-early autumn. These tree reserves are depleted during spring - mainly by the spring vegetative flush and again in autumn, partly by the autumn flush and partly by the filling nuts.

THE VEGETATIVE CYCLE

The general pattern is for major spring and mid autumn flushes with the possibility of a minor summer flush in certain situations. The early to mid autumn flush is usually greater than that in spring. No significant tree growth occurs during the winter period from April through to July. The timing and extent of these growth flushes has a large influence on the reproductive cycle.

THE REPRODUCTIVE CYCLE

The tree initiates flower buds in early May in response to shortening days. Floral buds can be recognised by a small white tip protruding from under the grey bud bracts. These floral buds generally remain relatively dormant over the next 2-3 months after which the inflorescences commence elongation. Dormancy is probably induced by cool winter temperatures. A proportion of buds also abort during winter, presumably due to low temperature.

Flowers open in mid September, nuts are set by early October and the newly set nuts commence dropping, the greatest rate of drop being in late October-early November after which the rate declines steadily. Normally nut drop is negligible by December.

Nut growth follows a normal single sigmoidal pattern with a steep linear increase in fresh weight from mid November to mid December and levels off from mid January to mid March when nut weight begins to decline slightly This decline is associated with ripening of the mature nuts.

The accumulation of oil also follows a sigmoidal pattern commencing early December. The rate of increase, however, is much less than that of nut fresh weight and the percentage oil in kernels levels off in March. The oil accumulation stage is very important as nut quality depends to a large extent on the oil content and if conditions are not suitable for oil production and accumulation, unacceptable quality may be obtained.

CURRENT MANAGEMENT PRACTICE IS RELATION TO CYCLING

Irrigation and fertilizer application can be used to manipulate the tree cycle. Care should be taken, however, to avoid upsetting the balance between vegetation growth and reproductive development. For example large applications of nitrogen and water will promote excessive vegetation growth to the possible detriment to nut set, nut yield and/or nut quality.

FERTILIZING

The Department recommends that soil and leaf analysis be used to guide fertilizer practice - elements being applied when sub-optimal levels are reached. Soil pH should be maintained within a range of 5.5 to 6.5 to enhance tree growth and nutrient availability. Phosphorus, calcium and magnesium, the latter normally being supplied in the form of lime or dolomite, move slowly into and through the soil. Thus, they remain in the soil for extended periods and only need to be applied once a year in most cases. Similarly, copper, zinc, and boron only need adjustment once a year.

Nitrogen and potassium are mobile in the soil, being readily incorporated, and leached, by water. Since these fertilizers may be lost to the tree by leaching below the root zone, split applications are desirable to ensure adequate supplies to the tree throughout its cycle.

Nitrogen, particularly, has a dramatic effect on the tree and large applications will stimulate excessive vegetative flushing to the detriment of nut set, development and yield. Experience with other crops suggests that these effects of nitrogen can be offset by maintaining a balance between nitrogen and potassium. Furthermore, potassium is required for carbohydrate accumulation both in tree storage tissues and in the developing kernels and should be maintained at optimum levels to maximize tree productivity.

Data on leaf nutrient levels collected over several years from a range of environments in Australia indicate that elements, particularly N, P and K, are accumulated during winter when growth is slowed and depleted during spring-early summer when they are utilized by the spring vegetative flush and the period of rapid nut growth. A lower level of nutrient accumulation commences again in late summer and is depleted during autumn, being utilized by the autumn vegetative flush.

Existing D.P.I. recommendations are for a major fertilizer application in July to ensure adequate supplies particularly for nut set and development in Spring. Caution is necessary, however, to ensure that an excessive Spring flush, which will compete with nut development, is not promoted. Nuts probably receive nearly all their mineral requirements in Spring. A minor application is recommended in December to promote carbohydrate production and accumulation. This should benefit oil accumulation in kernels and also the major vegetative flush in autumn - which is promoted by summer rains. Large applications at this time are likely to be largely wasted through leaching, and possibly by excessive competition from a larger Autumn flush. A further minor fertilizer application may be desirable in Autumn to promote the accumulation of carbohydrate reserves for the following season. As more information is accumulated, this late autumn application may prove to be more important for accumulation of carbohydrate reserves during winter, and consequently enhance flowering, nut set, retention and filling.

IRRIGATION

Water is a powerful manipulator of tree-growth, and the macadamia tree has a large requirement for water at certain critical stages of its cycle, particularly during flowering, nut set and the stage of rapid nut growth when half the increase in fresh weight of nuts is due to their water content. If the tree does not have sufficient water at this time, it will tend to adjust its crop load accordingly by dropping nuts. These critical stages of the reproductive cycle of macadamia coincide with the driest time of the year.

By early summer nuts have reached their maximum size, but not their maximum dry weight. The dominant stages during summer and autumn is oil accumulation in the kernels and good water supply is needed to maintain active carbohydrate production by the canopy. Natural rainfall at this time is generally good and supplementary irrigation when required will ensure that water does limit the yield and quality of the crop.

RESEARCH

An understanding of “how the crop works” is being developed but much more needs to be known. Research to close the information gaps is in progress and results will enable more soundly based management decisions to be made to more effectively exploit the potential of the crop.

TREE NUTRITION

A three year programme of monthly monitoring of leaf nutrient levels at 3 different environments has been completed, together with observations on vegetative growth and nut yield. These data establish threshold levels for nutrients in well managed trees and will assist interpretation of diagnostic leaf analysis.

Following on from the work to establish threshold nutrient levels, a trial to manipulate tree growth and production using urea has commenced. Initially, it seeks to identify tree responses after application at different stages of the growth cycle. The trial has only been running for six months but early observations indicate that 1.5 kg of urea applied in early July did stimulate the tree to produce its Spring flush much earlier but also resulted in a heavier and earlier flowering. At the completion of this experiment which will take three years, we will be able to determine the best time at which to apply nitrogen. The next step will be to establish optimum rates of application at these times to get a good balance between vegetative and reproductive cycles while achieving maximum yields and premium quality of nuts.

A comparison of leaf analyses from Hawaii with those obtained locally indicates that boron is frequently deficient here. Soil applications so far have failed to show any benefit either in yield or quality of nuts. Boron sprays on inflorescences, however, have tended to reduce premature nut fall and later applications have tended to increase kernel recovery, an important quality factor. Further experiments are being carried out to confirm these benefits.

WATER REQUIREMENTS

The macadamia industry has contributed to a research project on the water requirements of the crop. This work is establishing the response of trees to stress conditions and aims to identify the times at which water stress is most damaging to crop production and the quality of nuts. On the other hand, it seeks to find out if there are times when stress can be experienced by trees without affecting the yield and quality. Finally, irrigation programmes based on this information will be developed and tested to determine firstly if irrigation is an economic proposition and just as importantly, the minimum amount of water which is needed, and when, to give maximum economic return to growers. This is particularly important when water resources available for irrigation are limited.

REDUCTION OF PREMATURE NUTS

The large drop of young developing nuts in November represents a large reduction in potential yield and is of considerable concern to the industry. Research on individual racemes has shown that applications of NAA and kinetin under certain conditions reduces nut fall. Consistent responses however, have not been obtained from different experiments and further work is being carried out. Dry Spring conditions may aggravate the nut drop problem and the water stress research will determine the importance of water stress in promoting premature nut drop. Other environmental and tree growth factors may also have an effect and these are also being studied.

NUT QUALITY

Macadamia is a luxury priced nut which can only compete with other nutmeats if nut quality is consistently superior. Future work to study the relationships between the chemical composition of nuts during development, carbohydrate reserves in the tree, other crop cycle factors and meteorological conditions to identify factors limiting quality is planned.

VARIETY AND ROOTSTOCK SELECTION

In the slightly longer term, the development and selection of superior varieties which are better adapted to local conditions is of vital importance. An extensive programme to evaluate new "Australian" selections together with new introductions from Hawaii has commenced. Populations of seedling progeny from selected mother trees are being established in the search for superior selections. The development of tissue culturing techniques should greatly facilitate the quest for better varieties.

Rootstocks can influence the trees growth and production characteristics. Little information is available on the effects of macadamia rootstocks and it takes many years to assess them. However the likely benefits are substantial.

Observations in the field indicate that incompatibility between rootstocks and scion occurs but the impact of this on yield and quality of nuts and overall tree health is not known.

PROBLEM SOLVING RESEARCH

Other areas of research are undertaken in response to short-term problems which arise in the industry. One such area is the use of chemicals such as Ethrel to promote uniform nut drop at harvest.

From an address given at the Maroochy Horticultural Research Station, Queensland, November 1982.MACADAMIA FERTILISER MANAGEMENT

MACADAMIA FERTILISER MANAGEMENT

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INTRODUCTION

Fertiliser use in macadamia as in any tree crop should be based on management decisions with respect to the plants' needs rather than a set recipe of application. The plants needs varies depending on the stage of its development. The ability of the soil to supply these needs depends on the soil type and its natural nutrient levels and also the past fertiliser programme used. As needs vary and supply varies, management is related to determining these variations and then being able to compensate for them. In practice fertiliser application is simply adjusting the supply of nutrients in the soil to satisfy as closely as possible the needs of the plant. Experimentation and experience are telling us the needs of the plant, results of leaf analysis are telling us how the plant is faring and soil analysis gives us an estimate of the soils capacity to supply nutrients. Based on these three factors, management decisions are made as to what fertiliser programme should be used.

Basic rates and schedules may be developed from the tables and other information supplied in this paper. In addition adjustment of the rates may be made by using leaf analysis. Soil analysis is suggested where difficulties arise.

BENEFITS DERIVED FROM FERTILISER MANAGEMENT

Fertiliser is used to maximise both yield and nut quality. Both factors have the greatest control of total income and ultimately nett income. Many growers adopt a pot luck approach to what elements are applied. In addition the rates used are selected without due attention to the needs of the plants in question. The cost of fertiliser, before application costs, is in the order of $300.00/ha/year for a mature orchard. Nett income is therefore jeopardized greatly due to lack of attention to available management procedures.

Experience has shown that excessive rates have been used in many cases for some elements, so opportunity for economics is available. In addition, imbalances and outright deficiencies have been located by leaf analysis which are grossly affecting yields and quality.

Some fertiliser elements are readily lost from the soil either by volatilisation or leaching. If care is not taken with respect to timing and incorporation with water the value of this fertiliser is lost to the plant and money is wasted. Lime, dolomite and superphosphate fertiliser are often lost with surface erosion as they are fairly insoluble and only move slowly into the soil.

The benefits from management of nutrition are related to assuring that yields and quality are maintained with the most efficient use of fertiliser. The principle of management of fertilisers is to adopt a schedule and then by leaf and soil analysis and experience adjust the schedule to meet your local conditions. Switching wildly from one schedule to another or applying fertiliser at random leads only to confusion. To obtain useful advice on fertiliser management you must firstly have an identifiable and continuing schedule.

UNDERSTANDING FERTILISER APPLICATION PRIOR TO PLANTING

The basic aim for nutrition adjustment prior to planting is firstly in the incorporation of low solubility materials by cultivation and secondly to prepare the site for early rapid plant growth.

Incorporation of low solubility materials relates to phosphorus as superphosphate, pH adjustment and calcium and magnesium application using either lime or dolomite. The minor elements copper and zinc are also in this category.

Soil analysis is the only logical way to assess if the elements are needed and to gain some indication of rate required.

These elements may be applied in three ways. Firstly they may be broadcasted over the total area which would mean a major outlay at this point in time. On large scale plantings it may be laid in a strip over the planting row and rotary hoed in as deep as possible. At least two passes of the rotary hoe are needed and the back plate kept down to get mixing. Incorporation will not exceed 20 cm in this case. In smaller plantings the material can be applied a metre square over the planting site and incorporated to 45 cm if possible but 20 cm at least. Some of the value of elements, such as superphosphate, between plants may not be obtained with strip application. The difficulty of marking planting sites, then applying and cultivating in the fertiliser followed by remarking the site is time consuming, making strip application the better alternative.

Phosphorus is not recommended on a broadcast basis as the element would be wasted by leaching from the inter row area prior to being used by the plant. It is recommended on the strip situation and should be incorporated. On heavier soils movement into the root zone is slow and the incorporation is vital. In some red soils phosphorus is tied up in plants' phosphorus status.

Where the problem is known to occur, the phosphorus at the recommended rate can be banded about 30 cm away from the plant and at a depth of 15-20 cm. Do not come any closer to the plant as you may damage them. The fertiliser should be kept in a solid band and not mixed with the soil but just covered. By mixing organic matter such as husks or fowl manure with the superphosphate the situation is further improved.

TABLE I --- GENERAL RATES USED PREPLANT

Deficiency	*Soil Analysis*	*Material*	*Rate per ha broad-cast*	*Rate for 2m strip*	*Rate per sq m incorporated to 20cm*
pH alone	pH5.5 Ca 1000 ppm	Lime	2.5 t/ha	50 kg/100m row	250 g (500 g per 40 cm depth)
pH & magnesium	Mg 200 ppm	Dolomite	2.5 t/ha	50 kg/100m row	250 g (500 g per 40 cm depth)
Phosphorus	p 60 ppm p 30 ppm p 10 ppm	Single Superphosphate " "		12 kg/100m row 36 kg/100m row 60 kg/100m row	60 g 180 g 300 g
Copper	Cu 0.3 ppm	Copper sulphate	30 kg/ha	600 g/100m row	3 g
Zinc	Zn 2.0 ppm	Zinc sulphate Heptahydrate	50 kg/ha	1 kg/100m row	5 g
Organics		Fowl manure or filterpress			12 l 20-30 l

NOTE: Where soils are very low in Phosphorus, Zinc, and Copper together then a commercial form of Superphosphate containing Copper, Zinc and Molybdenum may be used to cover the three elements. It is used at the recommended phosphorus rate.

In land previously fertilised, especially in those used for vegetables, residual levels of phosphorus can be very high. High levels can be toxic to macadamia and by adding superphosphate the problem can be further aggravated, hence the need for soil analysis beforehand.

Organic additives are of particular value on light sandy soils. The purchase price and spreading costs make these materials very expensive. People who have ready access may have a cost advantage. Their cost and hence economic benefit limits their application to the actual plant site only.

All the elements applied preplant should preferably be incorporated three months before planting and a minimum of at least one month. Good soil moisture conditions should prevail in the period before planting to allow chemical and biological reactions to occur. If sufficient rain does not fall to wet the soil to 0.75 m at least twice irrigation should be used to achieve this wetting. Raw fertiliser and organic matter can be damaging to young plants.

UNDERSTANDING FERTILISER APPLICATION YEARS 1 TO 5

The basic aim of the nutrition programme during these five years is to obtain maximum growth. Tree yields are directly related to tree size and any limitation on growth in this period limits yield which commences at about five years. For this reason growth rate greatly influences early cash flow and the number of years to reach the break-even point between costs and returns.

Macadamias, although they have major vegetative flushes in spring and mid summer, can flush during most of the year. For this reason nutrition as well as water application in this five year period should aim to keep growth as continuous as possible. Wind protection is also important for this purpose.

Nitrogen and potassium should be applied in equal amounts in February, April, July, October, and December for the first five years. Phosphorus, Calcium (lime), Magnesium (dolomite) could be applied in one annual dressing in March or April during the wet season. Copper as Copper Sulphate and Zinc as Zinc Sulphate heptahydrate could also be applied in this month to gain incorporation from rain. If surface drainage or erosion is likely to transport these less soluble materials from the orchard due to low infiltration type soils, or steep slopes with extreme rainfall, then application should be delayed until after the likelihood of high intensity rainfall passes. With more soluble elements including boron as borax or solubor they may be better applied in April at the end of the wet season. In open sandy soils the annual rates of the elements phosphorus, calcium, magnesium and minor elements should be split in two applications, one in April and the other in October. This is to avoid excessive rates being firstly washed into the root zone in these freely draining soils and causing damage and secondly maintaining a supply throughout the year which may be offset in these soils by loss from leaching.

All elements need incorporation in the soil to gain effect, hence application should be followed by rain or irrigation to get results. Fertiliser sitting on the soil surface may as well be in the shed as far as the tree is concerned. The amount of water required is that which wets the soil to the bottom of the root zone at about 60-80 cm. This will depend on the soil type and soil moisture beforehand. A follow-up application within a week is desirable.

UNDERSTANDING FERTILISER APPLICATION YEARS 6 AND ONWARDS

Once trees reach a sufficient size to bear a crop, which is economical to harvest, then the management must be designed to promote production. This occurs at about 5-7 years in macadamia.

Present thinking suggests that the tree should make active growth in mid summer (February). Nutrition should be high at this time, and maintained through into autumn to lay down reserves for the next flowering and fruiting season. Active vegetative growth at flowering or early after is thought to be at the expense of nut development and may increase nut drop.

Excessive use of nitrogen before or at this time is not recommended. During nut development and oil formation over the December-January period it is believed there is a high requirement for potassium. Excessive vegetative growth at this time may be detrimental to oil accumulation and nut quality.

On the above assumptions the timing of applications are based.

The actual rates used may be assessed by leaf analysis or leaf and soil analysis or less desirably by using a standard rate per year of age from planting out. Soil analysis is recommended on problem soils or where problems exist with the plants, and especially where fertiliser responses are not as expected.

ANNUAL APPLICATION RATES

(a) N.P.K. Nitrogen, Phosphorus and Potassium

Rates listed in Table 2 are the first annual application rates which apply to a measured leaf level. The actual rate for the age of the tree is obtained by multiplying the stated rate by the age of the tree. e.g. for Nitrogen with a leaf level of 1.3% the basic annual rate of Urea is 175 g. For a 5 year old well grown tree the rate is 5 x 175 g or 875 g of Urea.

At year 10 the maximum rate is reached and this becomes a set rate for all tree ages thereafter if the hedgerow has formed.

The mature tree rate is based on a hedgerow planting using a spacing of 5 metres between plants. If trees are thinned at or after 10 years to a spacing of 10 metres then the rate per tree is increased proportionally with growth. Using the 10 year rate and 5 metre diameter as the base, increase the rate proportionally with each metre increase in diameter.

TABLE 2 - BASIC ANNUAL RATES OF N.P.K.

Nitrogen		*Phosphorus*		*Potassium*		*Mixture* 13.2:2.2:13.2
% Leaf Level	*Rate of Urea grams*	*% Leaf Level*	*Rate of Super-phosphate in grams*	*% Leaf Level*	*Rate of Muriate in Potash in grams*	
1.3	175	0.05	200	0.3	200	
1.4	150	0.07	100	0.45	130	
*1.5	120	0.09	50	0.6	80	500g
1.6	60	0.11	--	0.75	nil	

Where nitram is used in place of urea increase rate by one third.

(* This rate is that recommended as a standard where leaf analysis is not used.)

If after using the above rates for a leaf level the trees are not vigorous higher fertiliser rates relevant to a lower leaf level may be used. In this latter case you take the chance of antagonising possible excessive levels in the soil which may be the reason for the low vigour. If you know the history of the soil this difficulty may not occur. Hence once again the need to use soil analysis with leaf analysis when problems occur.

(b) Calcium and Magnesium

The decision firstly to apply, and secondly the rate required for these two elements should be determined by at least a soil pH test and/or a leaf analysis. The application of these elements without an analytical guide can only lead to problems. The problems can be, under application, over application, loss of yield and waste of money.

TABLE 3 - BASIC RATES FOR CALCIUM AND MAGNESIUM
(Rates determined by reference to leaf analysis)

Calcium			*Magnesium*		
%Calcium leaf level	*Rate of Lime-Tonnes/ha*	*Rate in kg for a 2 m strip 100 m long*	*%Magnesium leaf level*	*Rate of Dolomite per ha*	*Rate in kg for a 2 m strip 100 m long*
1.0	nil	nil	0.11	nil	nil
0.8	1	20	0.09	2	40
06	2	40	0.07	3	60
0.4	4	80	0.05	4	80

When trees spread beyond 2 m the elements should be broadcast on a proportionately wider and heavier basis using the tree width plus one metre as a basis.

Soil pH requires adjustment only when it falls below pH 5.5. This is best done with lime at 2.5 t/ha in one application. This is the maximum rate applied in any one year. Repeat applications are applied once per year, following the resampling and testing for pH. Where magnesium levels are low the lime should be replaced by dolomite. The routine application of lime or dolomite without pH testing is not recommended.

(c) Minor Elements, Zinc, Copper and Boron

These elements can become deficient in the plant due to actual low soil levels, by antagonism with excessive levels of phosphorus or due to unavailability at soil pH's below pH 5. Once again it is difficult to make recommendations regarding these elements without referring to leaf analysis. Soil pH should be checked routinely or if response is not achieved.

TABLE 4 - ZINC RATES
(Rates determined by reference to leaf analysis)

ppm Zinc leaf level	*Foliage Spray Rate Zinc Sulphate heptahydrate*	*Number of sprays per year*	*Soil application for sands and sandy loams Zinc sulphate heptahydrate*	
			per ha	*2 m strip, 100 m long*
20	nil	nil	nil	nil
15	1 g/litre	1	50 kg	1 kg
10	1 g/litre	1-2	50 kg	1 kg
8	1 g/litre	1-2	50 kg	1 kg
			Apply up to twice this rate for heavy soils.	

Where strip application is done expand the strip and rate proportionately using the tree width plus one metre as the basis.

Foliage sprays are applied to recently matured growth. A good wetting of the external canopy is required.

TABLE 5 - COPPER RATES
(Rates determined by reference to leaf levels)

ppm Copper leaf level	*Foliage Spray Rate Copper oxychloride*	*Number of sprays per year*	*Soil application of copper sulphate*	
			per ha	*2 m strip, 100 m long*
6	nil	nil	nil	nil
4	6 g/litre	1	30 kg	600 g
2	6 g/litre	1-2	30 kg	600 g

Where strip application is done, expand the strip and rate proportionately, using the tree width plus one metre as the basis.

Foliage sprays are applied to recently matured growth. A good wetting of the external canopy is required. Where a commercial solid fertiliser mixture is used, instead of straight fertilisers, products containing copper and zinc may be obtained. These can be used routinely where soils have a recurring copper and zinc problem.

TABLE 6 - BORON RATES
(Rates determined by reference to leaf levels)

ppm Boron leaf level	*Soil application rate per tree of Borax*		
	Trees to 4 yrs old	*Trees 4-8 yrs*	*Trees older than 8 yrs*
80	nil	nil	nil
60	14 g	28 g	28 g
40	28 g	42 g	56 g
20	28 g	56 g	75 g

Use half the rate nominated where solubor is applied or soils are very sandy. Excessive boron is toxic so rates should not be exceeded. The chemical should be spread very evenly under the canopy and slightly outside. Even application can be achieved by boom spraying both copper and boron on the soil. The herbicide sprayer may be adapted for this operation. In young trees the minimum area to which the rate is applied should be at least 4 sq metres.

APPLICATION TIMES - SUMMARY

(a) Phosphorus as Superphosphate
Calcium as Lime — Always apply in March or April.
Magnesium as Dolomite — Where soils are very sandy or free
Zinc as Zinc heptahydrate — draining application is evenly split between
Copper as Copper Sulphate — April and October.
Boron as Borax

Where mechanical sweeping is used care should be taken not to sweep the fertiliser out from under the tree.

(b) Zinc and Copper sprays - Apply when major vegetative flushes are just mature. This will be approximately late March-April and late October-November.

(c) Nitrogen as Urea or Nitram and Potassium as Muriate of Potash or Sulphate of Potash.

Years 1 to 5
Nitrogen - 1/5 Feb, 1/5 April, 1/5 July, 1/ Oct, and 1/5 Dec.
Potassium - 1/5 Feb, 1/ April, 1/5 July, 1/ Oct, and 1/5 Dec.

Years 6 and onwards
Nitrogen - 1/2 February, 1/4 April, 1/4 October.
Potassium - 1/3 February, 1/3 April, 1/2 October.

Adjustment in timing is required for locality, with relation to vegetative flushing, and nut development. The February treatment should coincide with the first of the active mid-summer vegetative flush. The October treatment should occur at the end of the fall of the small nuts and at the commencement of the rapid nut development.

PLACEMENT OF FERTILISER

The fertilisers should be distributed evenly under the canopy and outside the canopy by one metre. In practice as the trees become larger the distribution under the canopy is limited to about 2 metres while maintaining the one metre outside.

In mature orchards fertiliser can be spread more over the total soil surface although there should still be a bias under the trees. The actual distribution depends on the irrigation system in use. With trickle which has no incorporation capacity the above applies. With under tree sprinklers then there is a strong need to get a good proportion under the tree. This is particularly important with nitrogen. It is even better to apply nitrogen through the irrigation, irrespective of system.

INCORPORATION OF FERTILISER

Nitrogen and potassium should be applied either in the irrigation water or be followed by spray irrigation. This is firstly to carry the fertiliser to tile root zone to gain immediate absorption and action within the plant. With nitrogen, particularly urea and to a lesser extent nitram, the fertiliser is broken down on the soil surface while it remains there and lost to the air as a volatile form. Without incorporation significant amounts are lost in 2-3 days. The plant will never have the advantage of this lost fertiliser.

All other elements are applied in late March or April towards the end of the wet season. As they are not volatile they are not lost. Rainfall will ultimately incorporate the elements hence time of treatment should be adjusted to suit the rainfall pattern of your locality. Without rainfall, in protracted dry periods, the plant will not receive the fertiliser and sprinkler irrigation must be used. Rates equivalent to 50 mm of rainfall or irrigation are required. Under tree sprinklers delivering 60 litres/hour and run for eight hours will achieve approximately this application rate.

SAMPLING FOR LEAF AND SOIL ANALYSIS

A detailed guide to sampling for leaf and soil analysis is available. Leaf samples are presently recommended for January, just prior to the summer vegetative flush and for June, just prior to flowering. Soil samples are taken at the same times.

CRITICAL MANAGEMENT STEPS IN FERTILISING MACADAMIAS

1. Before planting, a complete soil analysis should be taken to determine the levels of all the elements in the soil. Then apply and incorporate liming materials and fertiliser as per the resultant recommendations prior to planting. This soil test will at least point your nutrition in the correct direction and the plants should make a good start. It is particularly important that lime or dolomite, phosphorus and some trace elements, if required, be incorporated in the soil prior to planting. These materials are fairly insoluble and to obtain the affect throughout the root zone in the short term, cultivation is needed to mix the elements with the soil.

2. For the establishment years 1 and 2, apply nitrogen, phosphorus and potassium based either on the original soil analysis or by using the maintenance levels of straight fertiliser or mixed fertilisers in the attached tables.

3. Commence regular leaf sampling in the second or third year. Sample at east once per year, in January or June, and preferably twice a year. Continue sampling for 2-3 years or until you are confident your fertiliser programme is maintaining leaf levels in the desired range.

4. If major problems are observed with nutrition or the leaf levels cannot be stabilised, soil analysis will be necessary in conjunction with leaf analysis. A check on soil pH is required every 2-3 years once it has been adjusted to the 5.5-6.5 range at planting or afterwards. The pH level becomes critical when it falls below pH 5.0.

5. Once leaf levels are stabilised continue the fertiliser programme as per the recommended schedule. Use leaf analysis every 2 or 3 years to check if the pattern is being maintained or to investigate any irregularity which arises. Changing schedules without reference to analysis, applying random fertiliser treatments or abandoning fertiliser for periods throws the management of nutrition into confusion. To obtain good advice on fertiliser management you must have an obvious, continuing and recorded schedule.

Reference: The reader is referred to two papers namely "understanding the Background Behind Macadamia Crop Management with Respect to Water and Nutrition" and "Managing Fertilisers and their Application". These are available from the Queensland Department of Primary Industries.

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EXOTIC FRUITS:

N. T. VOCK AND B. W. CULL

From an address given at the Maroochy Horticultural Research Station, Open Day, Qld. November 1982. Considerations for intending growers.

With its climatic range, Australia, especially Queensland already produces a wealth of temperate, tropical and sub-tropical fruits. However, it is vital that new fruits from around the world be continually assessed for their potential as crop plants in Queensland.

This is because:-

(a) they may allow horticultural production in situations which are considered unsuitable for existing fruits e.g. poorly drained soils, frost susceptible areas etc.

(b) they may provide a better income for growers.

(c) they may prove more rewarding for growers and thus provide them with a more satisfying life style.

(d) they may prove for an improvement in the diet resulting in health benefits for some of the population.

(e) they may possess desirable medicinal, industrial and other properties in addition to their eating qualities.

For a fruit to be successful in meeting these needs, it should rate highly in five areas:-

1. It should have good **consumer potential** i.e. be able to develop and maintain a strong demand from the consumer.

2. It should have good **marketing characteristics** i.e. be able to be successfully transferred from the grower to the consumer.

3. It should have good **environmental adaptability** i.e. be able to perform in a wide range of conditions.

4. It should have good **production potential**.

5. It should have good **economic potential**.

1. CONSUMER POTENTIAL

Is dependent on:-

(a) **Fruit Quality**

- must remain consistent throughout production period
- must be pleasing to the eye and remain free from disease and breakdown

- must be enjoyable to eat with good flavour, acceptable sugar/acid ratio, acceptable texture and no astringency

(b) **Buyer Confidence**

- visual appearance must relate consistently to good eating quality

(c) **Market Supply**

- good quality fruit must be supplied over an extended period

(d) **Competition from Other Fruits**

- fruits which are available during late winter-spring when the market is generally short of variety have an advantage over fruits which are available during summer-autumn when variety of fruit is at a peak.

(e) **Place in Dietary Chain**

- whether fruit has potential as a staple, speciality or novelty fruit

(f) **Ease of Consumption**

- fruits which meet convenience requirements of modern society are desirable

(g) **Ability to Promote**

- for special attributes such as food value, decorative use etc.

(h) **Ability to Sell on Particular Markets**

- fruits which are able to be placed on overseas markets during a gap in traditional supply are desirable. Fruits which cater for ethnic markets within Australia and those with potential to replace imports also have good prospects.

(i) **Processing Ability**

- in addition to fresh fruit potential

2. PRODUCT MARKETING CHARACTERISTICS

Are dependent on:-

For **Fresh Fruit**

(i) **Fruit life**

- must reach consumer and remain usable for some days. Fruit which can be immature at harvest and ripen with time generally have an advantage over those which must ripen before harvest. Also fruit which remains in an edible state without deterioration for an extended period are preferred to those which are acceptable to eat for only a short period.

(ii) **Fruit Storage Ability**

- if fruit has long storage life, it is able to be consigned to distant markets and an even supply can be maintained.

(iii) **Packaging Ability**

- even shaped and uniform size fruit can better fit existing packages and fruit packing machines.

(iv) **Transport Ability**

- the more perishable the more costly the transport and the closer to the market the fruit has to be grown. Fruit must also have a good value to weight ratio for efficient transport.

(v) **Trade Barriers**

susceptibility of fruit to pests and diseases may limit export to markets where restrictions apply unless the fruit can withstand treatment.

For **Processed Fruit**

(i) **Guaranteed Supply**

- must be available over an extended period either directly or from storage.

(ii) **Type of Processing**

suitable for drying, freezing, canning, juicing.

(iii) **Siting for Processing Plant**

- must be near crop of fruit needs to be able to be transported in bulk or in a partly processed form.

3 ENVIRONMENTAL ADAPTABILITY

Is dependent on:-

(i) **Temperature tolerance** (both heat and cold)

(ii) **Influence of water**

- tolerance of rainfall distribution, humidity, poor quality irrigation water

(iii) **Wind tolerance** with particular reference to fruit quality

(iv) **Soil tolerance**

- able to perform within a reasonable range of drainage, pH and fertility conditions.

(v) **Land use limitations**

- special requirements which limit potential.

(iv) **Genetic material available for selection**

- environmental adaptability is particularly important for fruits which are harvested over a very short period. These must rely on being able to grow in a wide range of environments to spread the harvest time and assure a continuity of supply.

4. PRODUCTION POTENTIAL

Is dependent on:-

(i) **Crop size**

(ii) **Reliability** of annual cropping

(iii) **Reasonable time to commercial harvesting from planting**

(iv) **Length of productive life of plant**

(v) **Crop losses**

- from pests, diseases, environment

(vi) **Ease of harvesting**

- e.g. easily found, easily reached, easily dislodged, resistant to damage, number of harvests necessary to remove fruit.

(vii) **Tree should be able to be managed with relative ease and low cost**

5. ECONOMIC POTENTIAL

is dependent on:-

(i) Likely grower return for fruit on market.

(ii) Capital investment requirements

(iii) Integration with established crops

--to use similar equipment and similar technology. Some of the more promising exotic fruits are rated using these criteria on the following page.

SOME POTENTIAL EXOTIC FRUITS FOR QUEENSLAND

(Some characteristics and ratings for commercial production)

Common name	*Scientific name*	*Family*	*Origin*	*Tree type*	*Size*	*Skin colour*	*Flesh colour*	*Flavour*	*Con-sumer potential*	*Marketing character*	*Envi-ron. adapt*	*Production potential*	*Economic potential*
Longan	*Euphorbia longan*	SAPINDACEAE	S.E.Asia	Evergreen 20 m	up to 25 mm diam.	Brown-yellow	White	Musky	Good	Good	V. good	Good	Good
Rambutan	*Nephelium lappaceum*	SAPINDACEAE	Malaysia/ Sumatra	Evergreen to 25 m	50 mm x 25 mm	Red	White	More acid than litchi	V. good	Good	Average	Average	Good
Jackfruit	*Artocarpus heterophyllus*	MORACEAE	India/ S.E.Asia	Evergreen to 30 m	to 800 mm long	Brown-yellow	Clear-white	Resembles pineapple pungent odour	Good	Average	Good	Good	Average
Carambola (Five corner)	*Averrhoa carambola*	OXALIDACEAE	S.E.Asia	Evergreen to 10 m	up to 150 mm long	Yellow-green waxy	Clear	Sweet crisp (sweet types)	Good	Good	V. good	V. good	Good
Purple mombin	*Spondias purpurea*	ANACARDIACEAE	Central America	Semi-decidu-ous to 8 m	25 - 50 mm diam.	Deep red	Red	Crisp sweet/acid aromatic	V. good	Good	Good	Good	V. good
Yellow Mombin (Hog plum)	*Spondias mombin*	ANACARDIACEAE	Central America	Semi-decidu-ous to 18 m	30 - 50 mm long	Yellow	Yel-low	Sub-acid aromatic	V. good	Good	Good	Good	V. good
Sapodilla	*Manilkara zapota*	SAPOTACEAE	Central America	Evergreen to 25 m	to 90 mm diam.	Brown	Light-brown to yel-low	Pleas-antly sweet slightly gritty	Good	Average	Good	Good	Average

Common name	Scientific name	Family	Origin	Tree type	Size	Skin colour	Flesh colour	Flavour	Consumer potential	Marketing character	Environ. adapt	Production potential	Economic potential
Mangosteen	*Garcinia mangostana*	BUTTIFERAE	S.E.Asia	Evergreen to 9 m	to 80 mm diam.	Purple	White	Sub-acid	V. good	Good	Poor	Average	V. good
White sapote (casimiroa)	*Casimiroa edulis*	RUTACEAE	Central America	Evergreen to 15 m	to 90 mm diam.	Green-yellow	Cream	Sweet sometimes slightly resinous	Average	Poor	Good	V. good	Average
Feijoa (Pineapple guava)	*Feijoa sellowiana*	MYRTACEAE	South America	Evergreen to 5 m	to 80 mm long	Dull green	White	Combination of strawberry pineapple	Good	Good	V. good	Average	Average
Jaboticaba	*Myrciaria cauliflora*	MYRTACEAE	Brazil	Evergreen to 10 m	to 30 mm diam.	Dark maroon	Clear	Sub-acid grapelike	Good	Good	V. good	Average	Average
Tamarillo	*Cyphomandra crassifolia*	SOLANACEAE	Brazil/Peru	Evergreen to 6 m	to 80 mm long	Red	Light orange	Sub-acid	Poor	Good	Average	Good	Average
Fig	*Ficus carica*	MORACEAE	West Asia	Deciduous to 5m	to 40 mm diam	Purple-brown	Pink-brown	Sweet gritty	Good	Good	Good	Good	Good
Mulberry	*Morus alba, Morus nigra*	MORACEAE	S.E.Asia	Deciduous to 10 m	to 40 mm long	White, black	White, black	Sweet granular	Average	Poor	V. good	Good	Poor
Blueberry	*Vaccinium ashdi*	ERICACEAE	North America	Deciduous to 3 m	to 20 mm diam.	Dark blue	Blue	Bland	Average	Average	V. good	V. good	Good

PROGRESS REPORT: MACADAMIA TRAINING TRIAL, DUNOON

T. TROCHOULIAS
Senior Research Horticulturist, Tropical Fruit Research Station, Alstonville

The Macadamia training trial was established on 0.2 ha of Dr. McAdams property near Dunoon. *Macadamia integrifolia* cv. Keauhou (246) trees were planted in August 1978 at a spacing of 5m x 3m and supported within the row by horizontal wires. All trees were irrigated and each test plot made up of three trees along the row with two buffer trees each side and replicated four times. The buffer trees were pruned according to the modified palmette system devised by the shareholder-manager Mr. Hugo Baisi (treatment 5).

The five training systems are as follows.

1. Control - no pruning in the first three years and then as necessary to maintain access for machinery.
2. Palmette - pruning with laterals at 30°C angle starting at 50-80 cm and intervals of 30 cm. One-dimensional shape along the wires for the first three years.
3. Central leader - pruning similar to conventional system practiced without wire supports in broadacre situations.
4. Espalier - pruning with horizontal laterals; one dimensional shape at intervals of 30 cm.
5. Modified palmette - multidimensional with laterals at 45° from main trunk.

In the first three years pruning was carried out every 4-8 weeks with fresh and dry weights of prunings recorded (Table 1). In 1981, five of the 12 control (no pruning) trees flowered heavily and produced an average of 1.3 kg of nuts in shell at 10% moisture. Yield for the 12 control trees ranged from 0.5 - 3.5 kg. Although these trees are less than four years old they have produced the equivalent of 870 kg/ha. The only other treatments to set a small number of fruit were treatments two and five (Table 2).

There is no doubt that the control trees look untidy and in order to allow for equipment access lower branches had to be removed. The weight of prunings from the control trees after three years of no pruning, was greater than total prunings from other treatments in the first three years. The no pruning treatment has given the greatest tree girth to date followed by modified palmette while espalier had the smallest girth (Table 2).

It will be interesting to continue the trial for another two years to find out:

1. When the control trees reach peak production at such a close spacing.

2. If the control trees produce a crop in 1982 after the removal of lower limbs.
3. When the trees intensively pruned in the first three years will start to produce a crop.
4. The harvesting problems associated with such close spacing.

This experiment has been a valuable contribution to our knowledge on Macadamia cropping behaviour. It is not unexpected that the control trees came into production first as young macadamias produce nuts on the inside of the tree low down on small twigs attached to mature wood. However it is too soon to make firm conclusions about such a long term trial.

TABLE 1

Mean dry weight of prunings taken from various treatments from 1979 to 1982.

	Dry wt. (kg) per tree	
	1979-81	1982
1. Control	.394	4.288
2. Palmette	1.765	0
3. Central leader	1.151	0
4. Espalier	1.581	0
5. Modified palmette	3.068	0

TABLE 2

Mean tree yield (1981 and 1982) and girth (1982) in response to pruning treatments.

	Yield (kg) per tree		Trunk girth (1982)
	1981	1982	(mm)
1. Control	0.027	1.303	306
2. Palmette	0	0.004	201
3. Central leader	0	0	195
4. Espalier	0	0	173
5. Modified palmette	0	0.007	258

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PECAN GROWING
by prescription
Big Changes in Pecan Production For The Future

O.S. GRAY

A revision and enlargement of material used by the author in talks made before the Oklahoma and Louisiana Pecan Growers Associations.

PRESCRIPTION FOR PROFITABLE PECAN PRODUCTION

1. SELECT GOOD SOIL in an area free from such hazards as hail, frost, etc.
2. PROVIDE IRRIGATION. Ample water may be the difference between profit and loss.
3. CHOOSE PRECOCIOUS, PROLIFIC VARIETIES. Use 4 to 8 varieties, not just one or two. Carefully evaluate for varieties that will resume production quickly after pruning.
4. USE CLOSE SPACING. Bring orchards into profitable production at an early age by planting more trees per acre.
5. PROVIDE POLLINATION. Be sure ample pollen is available for setting a crop of nuts.
6. PRUNING. Plan to prune high density orchards mechanically to prevent crowding, etc. A variety that will not resume production quickly after pruning perhaps has no place in a modern orchard.
7. PROVIDE NECESSARY SPRAY TO CONTROL INSECTS AND DISEASES. Disease control will make it possible for you to plant profitable disease-susceptible varieties that otherwise could not be used.
8. MANAGEMENT including fertilizing and cultural procedure, must be carefully considered and adapted to your particular needs. It has been said the ‘best fertilizer for a pecan orchard is footprints’.

These steps in the operation of a pecan orchard may be compared to the links of a chain. The failure of any single link destroys the strength of the chain. Just so, the failure of any ingredient in the Prescription may weaken or destroy the efficiency of a pecan orchard to the extent that its cost of production of nuts may be so high that it cannot be profitable.

Much of the discussion in this booklet is speculative and theoretical, not a hard and fast guide to be followed in detail. It is intended to call attention to some modern, up-to-date thinking about planting new pecan orchards for future production. Much of the future success (or failure) of a commercial pecan orchard depends upon decisions made before it is planted.

During the past few years we have been in the middle of many changes in commercial pecan production, and I want to discuss some of the changes that are taking place.

I read a book, the title, "Tomato Growing by Prescription". The author's contention in this book was since like causes produce like results over and over again, if you would do what he laid down as the principles of tomato production that you would come out with a good tomato crop ever time. This book intrigued and interested me.

Can we approach pecan growing in this manner? Can we do certain prescribed things, and expect to come out with a profitable pecan crop? That is the thing that interests me and that is a thought I would like for us to keep in mind. I don't expect all of you to agree with me and I hope you will not. I read years ago in "Progressive Farmer" that if two people swap horses they each still have only one horse, but if two people swap ideas, each of them then has two ideas.

I want to outline a prescription, so to speak, for profitable pecan production.

GOOD SOIL

Choose good soil. Choose a good location, which would involve good soil. In some cases, it would also involve choosing places free from possibility of frequent hail. Hail seems to follow a certain pattern and some districts are just hailed out more often than some others; so things like that should be watched in choosing a good location. A frost free location is also desirable. In other words you must choose a good location if you are to expect profitable production.

WHAT IS GOOD SOIL

No pecan orchard can be any better than the soil in which it grows. A lengthy discussion on the selection of soils for pecan growing would be beyond the scope of this booklet, but a few comments might be helpful.

One of the best indications of good pecan soil that I have found is in LARGE, OLD, THRIFTY-GROWING pecan trees. I have dug many hundreds of test holes beneath large, healthy native pecan trees, and usually find the following conditions.

1. **Good Drainage**. "The pecan does not like wet feet". While willows will grow on good pecan land, pecans will not do well on "willow land". What we call good drainage is frequently a matter of subsoil drainage rather than surface drainage.

The best native pecan trees are almost invariably found growing on soils under which, at a depth of 6 to 10 feet is a sandy or gravely substratum that affords sub-drainage. From a practical standpoint this means that water would drain out faster than it could come down through the upper soil - providing a well drained condition for the roots of pecan trees.

2. **Soil Depth**. The pecan, with its great depth and spread of roots thrives best in a deep soil. I have seen fine looking pecan trees growing in shallow soils but seldom find large areas of good pecan timber on shallow soils unless there is some unusual specialized condition such as a flow of subsoil moisture Deep loams, silty and silty clay loams are moisture retentive, permit better root distribution and grow larger, better filled nuts with less nut shedding than heavy clays or shallow soils.

3. **Pervious.** It is highly important that the soil be permeable so as to permit easy penetration of both moisture and the root system of the tree. Tight, heavy clay soils may have moisture holding capacity and often lack in fertility, but if subsoil drainage is sufficient, moisture and fertilizer may be supplied and a productive orchard maintained. If subsoil drainage is not good, sandy soils may become waterlogged, tree roots will rot and the orchard gradually die out.

4. **Fertile**. A poor infertile soil can support nothing but poor pecan crops and the cost of fertilizer necessary to grow pecans on a naturally infertile soil could increase the cost of producing a pound of pecans to a point beyond a profit.

While it is true that pecan orchards might be planted on a wide variety of soils, I feel that the cost of producing a pound of pecans on "good soil" will be less and therefore more profitable than on a "poor soil". If you are not familiar with soil requirements, you should consult some reliable and competent authority.

IRRIGATION

Next is irrigation. It is my frank opinion that if one is planting on a commercial basis, the person who cannot irrigate his orchard, will find that sooner or later competition from irrigated orchards with their cheaper production will run him out of business. He is going to have more years of failures, short crops, small pecans, etc. In my opinion, irrigation in a commercial pecan orchard is an absolute necessity for profitable commercial production.

TRICKLE IRRIGATION

I might say a little bit about trickle irrigation. We don't know a lot about it from a pecan standpoint, but folks claim a lot of things for trickle. First they claim a water saving of over 60%. Undoubtedly trickle is OK for young orchards. On a mature orchard, I just don't know what trickle will do, but I think that trickle is going to be used quite a bit on young orchards. I believe that under the trickle system, you can grow a tree say one or two years older. With trickle, we are going to see an increase in growth and a decrease in the amount of time for trees to get large enough to begin producing pecans profitably.

PROFITABLE VARIETIES

The third thing in our Prescription deals with the choice of profitable varieties. People will very often ask "What's the best variety"? I don't believe there is any such thing. If it's the best today, it probably won't be the best tomorrow, but I do think you can choose several good varieties. A man talking to me the other day said he wanted only two varieties in his orchard. I said that I thought if I were planting a commercial orchard, I would want six or eight varieties. I think we make a mistake in trying to find "the" best variety.

PLANT 4 TO 8 VARIETIES

It is easy to make the mistake of not choosing enough varieties. I suggest a choice of as many as four or five, six or maybe eight for a commercial planting. Some varieties are going to prove less desirable and others are going to prove very profitable; so my suggestion is to choose several of the more promising varieties.

The question you first need to answer about varieties is, "What do you want in a variety"? Have you ever stopped to ask your choose from such varieties as GraPark Giant, Mahan, GraKing or Choctaw.

Some people will want pecans with the thinnest shell and best flavour, especially for home use. You can get these in a number of varieties such as Sioux, Schley, GraTex or Choctaw. I don't know of any variety I would rather sit down and crack and eat in my home than Choctaw, but who would want an entire orchard of Choctaw? A man came to me saying it had been recommended to him to grow only Choctaw. So we talked it over and decided that Choctaw like every other variety has its good points and its bad points.

Suggestions for selecting Pecan Varieties

Precocious & Prolific Primarily for the commercial sheller	*Large Size nuts Primarily for home use and in-shell trade*	*Precocious & Prolific Dual-Purpose nuts*
Cape Fear-Cherokee	Choctaw-Desirable	GraBohls
GraBohls-Cheyenne	GraKing-GraTex	Wichita
Shoshoni-Tejas	GraPark Giant	Western Schley
Western Shley	GraZona	
Wichita	Maramec	

CHOOSE PRECOCIOUS PROLIFIC VARIETIES

We must try to choose the variety and varieties that will make us the most money. Early production from a young orchard is very important.

Actual production, 6 year old trees in Louisiana

Variety	Lbs Per Tree	Projected Per Acre 30 x 30 ft
Candy	22.8	1103
Cape Fear	27.4	1326
Desirable	2.4	117
Stuart	0.0	0

Actual average production of 7 year trees under irrigation 30 x 30 ft

Variety	Average lbs/tree	Projected lbs/acre	Pounds/100 acres
Cherokee	26	1,258	125,800
Wichita	23	1,113	111,300
Another?	13	629.2	62,720

This illustrates the difference in varieties. Some are very precocious, that is, they start to bear at a very early age. I want to emphasize that there are quite a number of varieties that bear at an early age (are precocious).

Mr. Madden of the U.S. Pecan Station at Brownwood has classified as some of the most precocious varieties, which will start bearing very early: Cape Fear, Cherokee, GraBohls, Cheyenne, Western Schley and Wichita. He said that those could come into profitable production in about the fourth or fifth season.

Then Mr. Madden gives a group which can produce profitably the fifth or sixth year: Candy, Sumner, Mohawk, Sioux, Peruque. I just mention some of them.

There is another group, including Stuart that will take anywhere from 9 to 12 years. The Stuart pecan is "out" unless you just want a tree for your yard. It makes a pretty yard tree and it will give you a moderate production of pecans. But Stuart would hardly be selected as a profitable variety for high density plantings.

IMPORTANCE OF KERNEL PERCENTAGE

Most pecan orchardists have in the past been talking in terms of pounds of whole nuts at harvest time, but this is certain to change. The value of the pecan nut is almost altogether in its kernel and pecan varieties differ widely in kernel content. While this may not be too important under our present system of marketing, it is sure to be a major factor for future orchards. The following table illustrates the importance of kernel percentage:-

Variety	Kernel Percentage	From 1000- nuts	From 2000- nuts
		Kernels Per Acre	
Stuart	47%-50%	500 lbs	1000 lbs
Western			
Wichita			
GraBohis	57%-60%	600 lbs	1200 lbs
Cherokee			
Cheyenne			
Shoshoni/Tejas	55%-58%	580 lbs	1160 lbs

From another viewpoint:-

1200 lbs Stuart produce 600 lbs kernel
1000 lbs GraBohls produce 600 lbs kernel
1034 lbs Shoshoni produce 600 lbs kernel

Or from still another viewpoint:-

In order to obtain 1000 lbs kernels:-
Shell 2000 lbs Stuart nuts or only 1666 lbs GraBohis.

Shelling percent will be an important consideration in pecan variety selection for the future orchard as it is sure to help determine the price pecans will bring in the market. Not how many pounds of “nuts” - but how many pounds of “kernels” will the orchard produce.

IN-SHELL VS SHELLING VARIETIES

It is estimated that something like 90% (or more) of all pecans go through the commercial shelling plants. Therefore, most of this discussion deals with orchards to produce nuts for commercial shelling.

If 10% of total pecan production is sold “in-shell” for home processing, this indicates a considerable market for perhaps 10,000,000 to 20,000,000 pounds that will bring a higher price than the sheller can pay. Where commercial orchards are located near large centres of population, near resort centres or on well travelled highways, it may do well to consider varieties for some proportion of the orchard that bears large “fancy” pecans for which these in-shell buyers will pay a premium price.

Some varieties to be considered are GraKing, GraTex, Choctaw, Desirable, GraPark Giant, GraZona and Maramec. The newer GraBohls is very eye-catching with its attractive purplish shell stripes, is easy to crack and large enough for the fancy trade - a real dual purpose pecan for either the sheller or home buyer. GraPark Giant seems sufficiently early-bearing for high density, but most large varieties are not sufficiently precocious to make ideal varieties

for close spacing and may be alternated (every other tree) with some early-bearing variety during the early life of the orchard, after which they may be removed if a pruning program cannot be satisfactorily adapted.

It may be well to keep in mind that many mechanical harvesters tend to remove the natural markings from the shells, giving the nuts a drab, polished appearance. This distracts from the attractiveness of the in-shell nuts and may seriously affect the price the customer will pay since so much buying is done “with the eyes’’.

CLOSE SPACING

Before planting trees, one must make a choice of tree spacings. Use close spacing, referred to as ‘high density’ planting. The person who does not take advantage of close spacing is standing in his own light. A 100 x 100 ft. spacing has about 4 trees to the acre. If Cape Fear bore 27.4 lbs. the sixth year, say 109 lbs. to the acre from a spacing of 100 x 100., it would still be unprofitable.

I think unless a person uses close spacing (high density) planting), he is going to have to wait a long time to get profitable production from an orchard with old time spacings like 100 x 100 ft.

A spacing of 70 x 70 ft. (9 trees per acre) would yield 246 lbs. to the acre the 6th year. One would still have a hard time to pay expenses and have something left to live on.

Take a 50 x 50 ft. spacing (18 trees to the acre), yield would be approximately 493 lbs. to the acre the 6th year.

A spacing of 35 x 35 ft. (36 trees to the acre) would produce 986 lbs. A 30 x 30 ft. spacing (48.4 trees to the acre) of 6 year old Cape Fear trees yielding like the ones in the Louisiana test, would yield well over 1300 lbs. to the acre.

HEDGE ROW ORCHARDS

Take a 30 x 15 ft. spacing, that is 96 trees per acre, and incidentally there is a large orchard in Arizona, that is reported at the age of 8 years to have averaged around 2300 lbs. per acre on something like two thousand acres. That was made possible by precocious, prolific varieties and close spacing.

There may be possibilities in Hedge Row plantings, at least in earlier years, spacing the trees closely in the row (say 12½ to 17½ft.) with rows 25 ft., 30 ft. or 35 ft. apart, letting each row from a dense hedge. Managers of such orchards that have been in existence for several years seem inclined to favour removing every other tree by a gradual cutting back and ultimate removal. The utilization of sunlight is of major importance in hedge row orchards. Movement of spraying and cultivating equipment is restricted as it cannot be moved across the rows.

The economies of ‘Hedge Row’ plantings is an interesting study that at this time is somewhat speculative. There are several developments under way that will provide more information in the future.

HEDGE ROW PRUNING

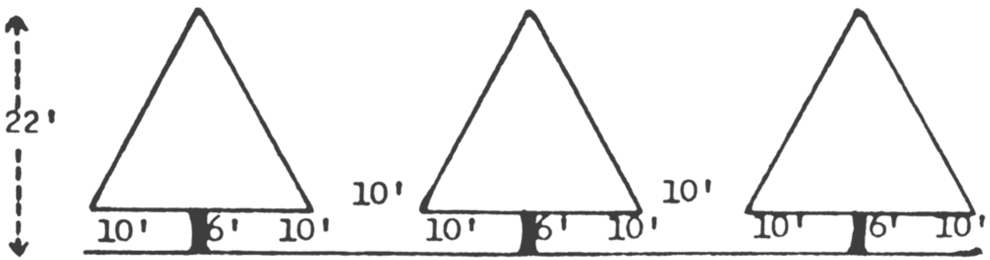
The future possibilities in hedge row pruning are sure to be explored. Reference is made elsewhere to the production of about 2,300 lbs. per acre on an 8 year old orchard in Arizona planted 15 x 30 ft. and grown in solid hedges, pruned on the two sides. I understand they are experimenting with the gradual removal of every other tree in the hedge row in order to modify the tall hedges and allow the entrance of more sunlight.

Reference is also made to the 17½ x 35 ft. Western Schley block at Brownwood that produced approximately 3,600 lbs. per acre the 15th year. This block is presently becoming badly crowded, and something is going to have to be done to permit the entrance of more sunlight.

In the Oklahoma State University experimental orchard, a high density planting of a Western Schley (17½ x 17½ ft. - 142 trees/acre) averaged 1,500 lbs. per acre per year from the 7th to 10th year, and in their 11th year will produce 2,000 lbs. per acre. Since the 7th year they have been pruned, cutting the sides back on even years to produce a hedge row and cutting the tops to 18 ft. in height on odd years.

30 x 30 FT. SPACING

As to my preference for a 30 x 30 ft. spacing. My thinking now is that probably we are going to want the trees headed 5 or 6 ft. high so we can get through the orchard with tools and sprayers. If the trees are 30 ft. apart with a 20 ft. spread, there will be 10 ft. between trees. They will be pruned to a pyramid. I am not saying that I am right about this, but that this is my present thinking. Just remember that **sunlight is absolutely essential** for a green leaf to manufacture whatever it takes to make a pecan nut and fill it with a good kernel. You must have SUNLIGHT along with precocious, prolific varieties (early bearing and heavy bearing).



A **Theoretical** Pecan Orchard Plant

1. Trees spaced 30 x 30 ft. (48.4 trees per acre).
2. Trees headed 5 ft. to 6 ft. from the ground.
3. Trees mechanically pruned on 4 sides, perhaps one side per year.
4. Tree height limited to around 22 ft. to 24 ft.
5. Pyramidal (4 sides) shape to utilize maximum sunlight.
6. Space for movement of orchard machinery on four sides of the trees.

MECHANICAL HARVESTING

The future varieties will need to be adapted to mechanical harvesting by both the shaker and the picker (picker-upper) It would be desirable to have varieties that ripen uniformly and remain on the tree (stick in the shuck), so that the mechanical shaker could complete its work with one operation. Size and shape of the nut are not major harvesting requirements.

We need varieties suitable for mechanical picking or gathering from the ground. The shell must be thick enough so that the nuts will not be cracked or broken into pieces in the gathering. Some of the present day varieties are liable to serious damage by present day mechanical harvesters.

As new pecan and other nut orchards begin production throughout the world, prices may -become so competitive that your cost of production may determine whether or not your orchard is profitable. The person who takes advantages of new, practical ideas, is most likely to survive if low prices prevail.

PROVIDE FOR POLLINATION

To insure profitable production, attention must be given to insure a supply of pollen at the time it is needed for pollinating the female flowers to the trees may set a crop of nuts. Only those nutlets that are pollinated can develop into mature nuts. Those not pollinated will shed.

Pecan trees are "monoecious", both male and female flowers being borne on the same tree. The tassel or catkins fall from the trees after the pollen has shed. The tiny nutlets that form in the ends of new spring growth are the female flowers that, if pollinated, may develop into mature pecan nuts.

A given variety does not always shed its pollen at the time its own female flowers are receptive; so some other variety that sheds its pollen at that time must furnish the pollen. According to the chart, in 1972, the Wichita variety shed its pollen from May 16 to June 3, but its nutlets were receptive only from April 8 to May 14; therefore no crop could have been set that particular year without pollen from another variety.

The following data is from information published by Mr. Madden from the USDA Pecan Experiment Station at Brownwood, Texas for the 1972 season. Pollen shedding and nutlet receptivity will vary somewhat from year to year, but the following diagram illustrates the importance of arranging varieties in the orchard so that pollen is available when needed.

For this discussion, I have selected certain pecan varieties and arranged them into four groups:

APRIL MAY

Group 1

SOME VARIETIES that shed pollen EARLY in the season

	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3
CADDO		●	●	●	●																					
CAPE FEAR						●	●	●	●	●	●	●														
CHEROKEE				●	●	●	●	●	●	●																
CHEYENNE					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●							
WESTERN				●	●	●	●	●	●	●	●	●	●													
DESIRABLE ALSO IS AN EARLY POLLEN PRODUCER																										

Group 2

SOME VARIETIES that shed pollen LATE in the season.

CHOCTAW													●	●	●	●	●	●	●	●	●	●	●	●		
GRABOHLS											●	●	●	●	●	●	●	●	●	●	●	●	●	●		
WICHITA									●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
SHOSHONI										●	●	●	●	●	●	●	●	●	●	●	●					
GRABOHLS											●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
TEJAS						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
SHOSHONI										●	●	●	●	●	●	●	●	●	●	●	●					
CHICKASAW SHEDS POLLEN MIDSEASON																										

Group 3

SOME VARIETIES that are receptive EARLY in the season.

CHOCTAW			○	○	○	○	○	○	○	○	○	○														
GRABOHLS						○	○	○	○	○	○	○	○	○												
WICHITA	○	○	○	○	○	○	○	○																		
CHICKASAW	○	○	○	○	○	○	○	○	○																	

Group 4

SOME VARIETIES that are receptive LATE in the season.

CAPE FEAR														○	○	○	○	○	○	○	○					
CHEYENNE																		○	○	○	○	○	○	○		
WESTERN												○	○	○	○	○	○	○	○	○	○	○	○	○	○	

STIGMA (FEMALE FLOWER) RECEPTIVITY ○

POLLEN (MALE FLOWER) SHEDDING ●

The above data is for one season only and it is knowing that pollen shedding and receptivity of a given variety varies from year to year under different growing condition., in varying locations, etc. additional data Is needed and is being assembled.

As I see it, if an orchardist will plant varieties that provide pollen early in the growing season and other, that will supply pollen late in the season, the mid-season needs will be automatically provided for.

The U. S. Pecan Research Station at.Brownwood, Texas and the Louisiana State University at Baton Rouge have come additional data if you wish to write for it.

HOW TO INSURE ADEQUATE POLLINATION

It doesn't seem safe to assume that just because a variety is protogenous (early receptive) it will be pollenized by just any protandrous (early pollen shedding) variety. I believe that if an orchardist will be sure to select some varieties that shed pollen **early** in the **calendar season** and others that shed pollen **late** in the **calendar season**, the two periods that seem most likely to be deficient in pollen, the entire pollination problem will be resolved, especially if a number of varieties are planted or if there are native trees to provide pollen.

Providing early pollen should be of **utmost importance** since there is some possibility that pollen from mid-season varieties may remain viable for some days after shedding to take care of late season needs.

ARRANGEMENT OF VARIETIES IN THE ORCHARD

One satisfactory arrangement is to plant in blocks of nine rows of the same variety for standardizing operations like spraying and harvesting. These rows should run east and west (or across the prevailing wind at pollinating time). Since pollen is carried by the wind, the south row in each block should be a variety (or varieties) that will pollinate the main block. Row #1 on the south side of Block #1 should be the **pollen row**; the next 9 rows of the main variety. Row #11 would be pollen row for the next block, etc.

It has been suggested that pollenizing rows will be effective for a distance of around 500 feet, although it is known that pollen can be carried by the wind for much longer distances (½ mile or more).

If an orchard is surrounded by, or intermingled with native pecan trees, these will usually assist in pollination within the orchard. Native pollen does not affect the size, shape, etc. of the nuts from the orchard varieties.

TRAINING YOUNG TREES

Trees of some varieties naturally form strong framework while those of others tend toward long limbs, weak crotches, etc. that make them highly susceptible to damage from wind, ice, etc.

We have been wisely advised to bring up a child in the way he should go - but we need to be reminded of the importance of "Training A Young Pecan Tree In The Way It Should Grow" and I would like to emphasize the word YOUNG.

Teaching an old dog new tricks would probably be easier than training an old pecan tree. Training pecan trees might be said to begin with young trees when permanent lateral branches are selected.

If the branches all come out at one point, a 'crows foot' is developed, or if they came out of the main trunk at a sharp angle, wide crotches are formed. Too many (actually thousands upon thousands) of orchard trees just grew up like topsy.

WHY PRUNE A TREE

Avoid overcrowding because trees MUST HAVE SUNLIGHT on the leaves or the leaves will turn pale and die; then the shaded limbs will die. You will have little or no production on that part of the tree into which sunlight does not penetrate. We need to prune to maintain tree size and permit sunlight to get to the green leaves.

MECHANICAL PRUNING VS THINNING

My preference for spacing is 30 x 30 ft. that is, 48.4 trees to the acre. For many years in our work we have been recommending a 35 x 35 ft. spacing with the idea after 15 to 17 years we would take out half the trees, leaving a 50 x 50 ft. spacing. Then after 10 more years we would take out another half, leaving trees 70 x 70 ft. because they would have begun to crowd. If I were starting now with a 35 x 35 ft. (or a 30 x 30 ft.) spacing, I don't think I would plan to thin out the trees. I would anticipate pruning the trees with a mechanical pruner and hold those trees to a 35 x 35 ft. (or 30 x 30 ft.) spacing.

If I remove half the trees from a 35 x 35 ft. spacing, I know that I am cutting my production in half and it will take 4 or 5 years for it to come back. Then if in later years I have to remove half the trees in the 50 x 50 ft. spacings, in order to get 70 x 70 ft., I would cut production in half a second time. So it should be better if we can maintain 35 x 35 ft. (or 30 x 30 ft.) spacings by mechanical pruning.

Mechanical pruners are expensive, but I saw one in a large orchard around 30 years old; it pruned trees, two sides and the top for less than 50c a tree.

QUICK RECOVERY FROM PRUNING

It stands to reason that if future High Density (closely spaced) orchard are to be mechanically pruned, they must be planted with varieties that will resume production quickly after pruning. To illustrate: Suppose the trees in the preceding diagram of a theoretical orchard were pruned on a 4 year program - one side each year. If the varieties would not resume production until 4 or 5 years after pruning, production during this period would be almost zero, perhaps 5% or 10% at the most.

One further observation with reference to pruning pecan trees. Some pecan varieties like Stuart, will not resume production quickly after they are pruned. Varieties like Wichita, GraBohls and Western Schley and Cape Fear would resume production within two or three seasons after pruning. **Any variety that will not resume production quickly after pruning has no place in modern high density pecan orchards**.

If it is correct to assume that only part of a pecan tree will be pruned in any one year, say one side is pruned each year in a four year cycle, it should be in profitable production during the pruning process. At this time it is not certain just what the pruning cycle will be, but it does seem that a **quick recovery after pruning** will be a valuable and necessary asset that must be seriously considered in choosing varieties.

Theoretically it would seem that annual pruning (4 year program) would provide evenly distributed annual production, while an 8 year program would promise a larger yield, by about 253/4, due to increased production from the years when no pruning was done, indicating that as little pruning as possible should be done.

WHEN SHOULD PRUNING BE STARTED? AND HOW?

To say that pruning should be started "when the trees begin crowding" may not be a proper answer. If all four sides are pruned at once the orchard will be almost out of production for one year, produce a 10% crop the second year, a 90% crop the third and a 100% the fourth, perhaps an undesirable cropping system, but theoretically an average of 51% crop - the same as the 4 year program of the side per year. So what?

It would be reasonable to suspect that the pruning program should be started (on one side) **before** it is actually needed and gradually carried around the tree in such a way as to eliminate the shock of having to suddenly prune 4 sides of a tree and lose a crop or two.

There is also a possibility that alternate trees only will be pruned and gradually made smaller until they are entirely removed from the orchard.

Another factor that complicates pruning theories is recent data indicates that **tip pruning** (removal of only a few inches of the terminal of new shoots) causes profuse laterals to grow along the length of the shoot, avoids "crow's foot" growth and promotes increased production toward the inside of the tree. Our pruning program will surely be designed to take advantage of 'tip pruning', so far as possible.

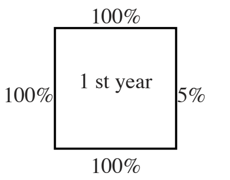
Recently, I was in a discussion group standing in a large orchard where mechanical pruning has been started as a test on 30 year old Western Schley trees. It seems that the trees were pruned alternate rows, two sides and the tops, resuming field production the third season - the foliage was greener, the nuts larger, better quality, etc. The manager said that they had purchased a mechanical pruning machine and intended to "prune everything" the coming winter after harvest.

THEORETICAL 4-YEAR PRUNING CYCLE

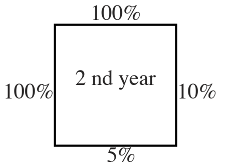
Let us take a tree from an acre of 48.4 trees (30 x 30 ft. spacing), **assuming** it is producing 50 lbs. of nuts and is large enough to need pruning to prevent crowding and to admit sunlight.

Assume a 4-year program - one side per year and that the side currently being pruned will produce a 5% crop, a 10% crop the 2nd year, a 51% crop the 3rd year and a 51% crop the 4th year, completing a 4-year pruning cycle. Before pruning, tree would bear 100% of a full crop, 2420 lbs. per acre. 48.4 x 50 x 100% = 2420 lbs/A.

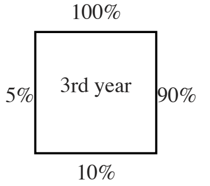
THE SQUARES REPRESENT TREES PRUNED ON FOUR SIDES. THE FIGURES REPRESENT THE % OF A FULL CROP PRODUCED BY EACH SIDE.



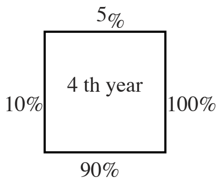
1ST YEAR AFTER PRUNING - ONE SIDE ONLY TREE WOULD PRODUCE 76% OF A CROP. 305 + 4 = 76% (2420 X 76% = 1839)



2ND YEAR AFTER PRUNING - ANOTHER SIDE PRUNED, TREE WOULD PRODUCE 54% OF A CROP. 215 + 4 = 54% (2420 X 54% = 1307)



3RD YEAR - A THIRD SIDE PRUNED. TREE WOULD PRODUCE 51% OF A CROP. 205 + 4 = 51% (2420 X 51% = 1234)



4TH YEAR - A FOURTH SIDE PRUNED, TREE WOULD PRODUCE 51% OF A CROP. 1234 LBS. PER ACRE FUTURE PRODUCTION WOULD LEVEL OFF AT THIS FIGURE

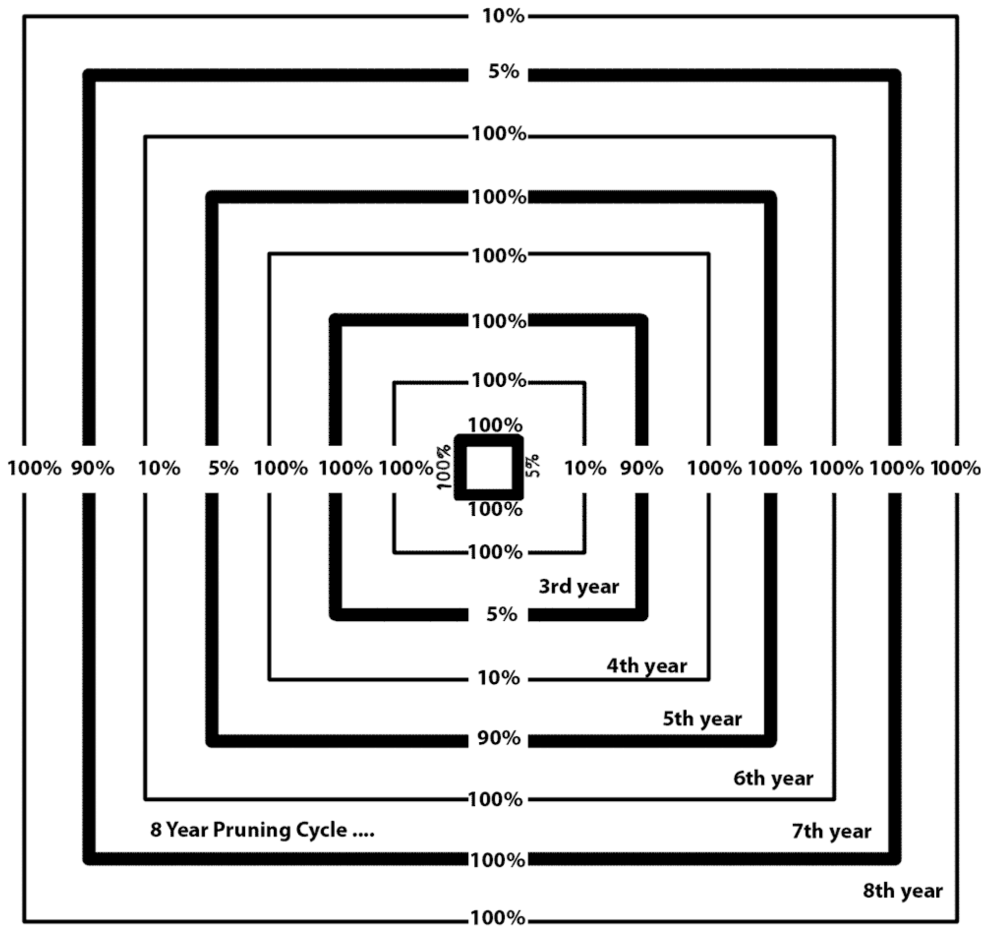
Obviously, these figures are hypothetical, but they serve to give us some idea as to the way pruning might affect production. They also indicate that a 4 year program might not be desirable or profitable.

Theoretical 8 Year Pruning Cycle - The centre square represents the same tree as the upper tree in the 4-year cycle. BUT, instead of pruning one side every year, we will prune (cut back) one side **every other year**. The squares represent the 4 sides of the original tree that is theoretically maintained by pruning to about the same size year after year. The figures in the lines represent the theoretical production of each side for each year.

The theoretical yields from the 4-year and the 8-year cycles are given in the table below. The situations are hypothetical ('Make Believe') and are not intended to be actual but something for us to think about. Experience and common sense will be our guides not a fixed schedule.

STATISTICAL (THEORETICAL) PRODUCTION PER ACRE

	4 Year Pruning Cycle		8 year Pruning Cycle	
Before pruning	100%	2420 lbs	100%	2420 lbs
1st year	76%	1839 lbs	76%	1839 lbs
2nd year	54%	1307 lbs	78%	1888 lbs
3rd year	51%	1234 lbs	74%	1791 lbs
4th year	51%	1234 lbs	74%	1791 lbs



Dark lines represent years in which trees ore pruned. Don't be confused - the larger and larger squares do not Indicate that the trees grow larger each year. At the time prunlng becomes necessary the trees occupy all of the above-ground space. Theoretically, the trees remaln permanently at full size; as large as possible without crowding and shutting out sunlight.

Production levels off

5th year	78%	1888 lbs
6th year	74%	1791 lbs
7th year	78%	1888 lbs
8th year production has leveled off at	74%	1791 lbs

NOTE: The charts indicate production seems to level off on the 4 year pruning cycle at 51%, and on the 8 year cycle at 74-78%. Apparently the 8 year cycle produces 67% more pecans than the 4 year cycle.

DISEASE AND INSECT CONTROL

A good spray program will be a necessity for any profitable pecan operation. It seems that sooner or later, scab disease is likely to attack all varieties as new strains of this disease develop. Even now, progressive growers are finding it possible to use heavy bearing, precocious, scab-susceptible varieties like Western Schley, Cherokee and GraBohis that, without spray protection would be failures in many humid locations. It seems safe to assume that without a good spray program, a pecan grower will be seriously handicapped in trying to produce pecans at a profit.

GOOD MANAGEMENT

Management is always one of the keys to the successful operation of all business enterprises. The manager is the man who coordinates all activities such as cultural and production practices, business decisions, etc., in an efficient and hopefully a profitable pecan growing operation.

SPECIAL NOTE

Much of the foregoing discussion is **speculative** and **theoretical.** It is not intended to be a hard and fast guide to be followed in detail.

It is intended to call attention to some modern, up-to-date thinking about planting new pecan orchards for future production at as great a profit as possible.

The future success (or failure) of a commercial pecan orchard depends a great deal upon decisions that should be made before it is planted.

Clean Cultivation vs Sod

The controversy between these two is still going on. Close clipped, or close grazed sod orchards with a strip down the row kept bare by chemicals seems to be a commonly established practice in the S.E. states. Grazing is questionable because of danger of contamination.

In the far western irrigated orchards, clean cultivation is the commonly accepted practice and so far sod culture has made little headway.

Between these two widely separated areas, clean cultivation has been usual, but some questions are being raised. For instance, under irrigation could some system of sod and herbicides be advantageous.

It seems that for newly planted orchards at least a strip of several feet should be cultivated to control weeds, conserve moisture and perhaps assist in establishing a root system below cultivation depth.

Editors Footnote: It should be remembered that this article is based on American experience and is written for American conditions. For example there is no Pecan Scab Disease in Australia.

ADDRESS BOOK - USEFUL ORGANIZATIONS

This list of useful addresses will be reprinted each year in the Yearbook. It includes Societies, Associations, and Government or Quasi-government departments. Please notify the Editor of errors or omissions.

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

Australia: CSIR0 Horticultural Research Station, Merbein, Victoria 3505, Australia.

Australia: Forestry Branch, Department of Primary Industry, Banks St., Yarralumla, ACT 2600, Australia.

Australia: Rare Fruit Council of Australia, PO Box 707, Cairns, Queensland 4870, Australia.

Australia: Society for Growing Australian Plants, 860 Henry Lawson Drive, Picnic Point, NSW 2213

Australian Macadamia Society, PO Box 445, Caboolture, QLD 4510.

California Macadamia Society, PO Box 666, Fallbrook, California 92028,

USA California Rare Fruit Growers, Fullerton Arboretum.

California State University, Fullerton, California 92634, USA.

Connecticut Nut Growers Association, 27 Baldwin Rd, Manchester, Connecticut 06040, USA.

Costa Rica: Institute Interamericano de Ciencias Agricolas de la OEA (P.G. Sylvain), Turrialba, Costa Rica.

Illinois Nut Tree Association, 1498 Urbandale Dr, Florisant, Missouri 63031.

Indiana Nut Growers Association (Merna Dicoff), 9805 E.100 St., Zionsville, Indiana 46077, USA.

International Association for Education, Development, and Distribution of Lesser Known Food Plants and Trees, PO Box 599, Lynwood, California 90262, USA.

Iowa Nut Growers Association, Stewart Road, RR 6, Iowa City, Iowa 52240, USA.

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

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

Michigan Nut Growers Association, 199 Strongwood, Battle Creek, Michigan 49017, USA.

Nebraska Nut Growers Association, 207B Miller Hall 8N, University of Nebraska, Lincoln, NE 68583, USA.

New South Wales: Department of Agriculture, 157 Liverpool St, Sydney NSW 2000.

New Zealand: Crop Research Division, Department of Scientific and Industrial Research, Private Bag, Christchurch, New Zealand.

New Zealand: Lincoln Agricultural College, Lincoln College, Canterbury, New Zealand.

New Zealand Tree Crops Association, PO Box 1542, Hamilton, New Zealand.

North American Fruit Explorers (Ray K Walker), PO Box 711, St Louis, Mo. 63188, USA.

Northern Territory: Department of Northern Australia, Animal Industry and Agriculture Branch, PO Box 146, Katherine NT 5780.

Northwest: CSIRO Division of Tropical Crops & Pastures, Kimberley Research Station, Kununnura WA 6743.

Ohio Nut Growers Association, 1807 Lindbergh NE, Massillon, Ohio 44646, USA.

Ontario: Society of Ontario Nut Growers (R. D. Campbell). RR 1, Niagara-on-the-Lake, Ontario L0S 1J0, Canada.

Oregon: Nut Growers Association of Oregon, Washington, and British Columbia, PO Box 23126, Tigard, Oregon 97223, USA.

Pennsylvania Nut Growers Association (Albert Magee). RR 3: Box 78, Duncannon, PA 17020, USA.

Queensland: Department of Primary Industry, William St, Brisbane QLD 4000.

South Australia: Department of Agriculture and Fisheries, 25 Grenfell St., Adelaide SA 5000.

South Australia: Woods and Forests Department, 135 Waymouth St., Adelaide SA 5000, Australia.

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

Tasmania: Department of Agriculture, GPO Box 19213, Hobart, TAS 7001.

USA: Agri-Silviculture Institute, PO Box 4166, Palm Springs, California 2263, USA.

USA: Friends of the Trees Association, PO Box 567, Moyie Springs, Idaho 83845, USA.

USA: International Tree Crops Institute USA Inc., Route 1 Gravel Switch, Kentucky 40328, USA.

USA: International Tree Crops Institute USA Inc., PO Box 1272, Winters, California 96594, USA.

USA: Northern Nut Growers Association, RR 3, Bloomington, Illinois 61701.

USA: People of the Trees, 1102 Snyder, Davis, California 95616. USA.

USA: Rare Fruit Council International, 3280 South Miami Avenue, Miami, Florida 33129, USA.

USA: Tree Crops Research Project, 230 East Roberts, Cornell University, Ithaca, New York 14853, USA.

United States Pecan & Field Station, USDA-ARS, PO Box 579, Brownwood, Texas 76801, USA.

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

Victoria: Department of Agriculture, Scoresby Horticultural Research Station, PO Box 174, Ferntree Gully, VIC 3156.

Victorian Nut Growers Association (A.D. Allen), PO Box 69, Wangaratta, VIC 3677.

West Australian Nut & Tree Crop Association, PO Box 27, Subiaco, WA 6008, Australia.

Western Australia: Department of Agriculture, Jarrah Rd, South Perth WA 6151.

Western Australia: Permaculture Association of W.A., PO Box 430, Subiaco, WA 6008.

ADDRESS BOOK - NURSERIES AND COMMERCIAL SOURCES

Please notify the Editor of any omissions or errors, especially where WANA TCA members are involved. (+ + indicates WANATCA Member)

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A. RICHARDS, 1349 Albany Highway, Cannington 6107. Propagation and nursery needs.

+ + DAWSONS NURSERY, Hale Rd, Forrestfield 6058. General garden centre with range of traditional fruits and nuts.

+ + KELMSCOTT AZALEA GARDENS, 41 Roberts Rd, Kelmscott 6111. Retail garden centre with large range of tropical and exotic fruits.

+ + MICROCULTURE, Lot 60, Russell Rd, Landsdale 6065. Tissue culture propagators.

+ + NUTLAND NURSERY, 97 Carabooda Rd, Wanneroo 6065. Plant production, specializing in avocad's, pecans, chestnuts, macadamia, pistachios and others.

+ + NUT TREE AND CONIFER NURSERY, 52 Croydon Rd, Roleystone 6111. Independent propagator producing temperate nuts.

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

PACKSADDLE PRODUCE CO., PO Box 249, Kununurra 6743. New wholesale producer of tropical fruit seedlings.

+ + PECAN INDUSTRIES, PO Box 69, West Perth 6005. Wholesale producers of pecans, jojobas, pistachios, chestnuts. Planting and management services.

+ + SPREADING CHESTNUT, PO Box 27, Subiaco 6008. Retail outlet, has wide range of nut trees and unusual fruits.

+ + WALDECK NURSERIES, Russell Rd, Wanneroo 6065. Large Perth chain of garden centres, stock more popular fruits and nuts.

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

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AUSTRALIAN BLUEBERRY NURSERIES, Boundary Rd West, Narre Warren East 3804.

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

BLUEBERRY HILL NURSERY, Cherrys Rd, Toolangi 3777. Blueberries.

FLEMINGS MONBULK NURSERIES, Macclesfield Rd, Monbulk 3793. Temperate fruit tree wholesaler.

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

HIGH GROVE NURSERY, Mt. Stanley Rd., Stanley 3747. Propagators of grafted chestnuts, walnuts, and layered hazelnuts.

JOHN BRUNNING & SONS, Somerville 3912. Fruit tree wholesaler with large traditional range.

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

MABUHAY GARDENS, PO Box 3, Monbulk 3793. Seed of exotic fruit trees, wholesale only.

W A SHEPHERD & SONS, Mooroodue, 3933. Good range of temperate fruits and berries.

SOUTH AUSTRALIA

BALHANNAH NURSERIES, Balhannah, 5242. Traditional fruits.

+ + FRESHFORD NURSERY. Highbury, 5089. Grafted walnuts, persimmons, and pecans.

PERRY NURSERIES, Kangarilla Rd, McLaren Flat 5171. Avocado, pistachio, quandong, carob, guava tamarillo, chestnut.

STOECKEL NURSERIES, P.O. Box 113, Paringa 5340. Stonefruit and citrus. Wholesale/ retail.

TOLLEYS NURSERIES, PO Box 2, Renmark 5341. Citrus specialists, supply trees, seeds, and budwood.

TASMANIA

+ + SELF-RELIANCE SEED CO., PO Box 96, Stanley 7331. Seeds of useful crop plants.

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BLUE HILLS BLUEBERRY FARM AND NURSERY, Tilba Tilba 2546. Chestnuts and N.S.W, waratahs.

EAST COAST BLUEBERRIES-SECTOR (NURSERIES) PTY LTD. P.O.Box 7, Gosford East.

++HUNTER PECANS, P.O. Box 217, Muswellbrook 2333.

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MOUNTAIN BLUE NURSERY, Waltons Rd, Federal via Lismore 2480. Blueberry specialists.

PREMIER NURSERIES, PO Box 400, Griffith 2680. Wholesale and retail supplier of fruit trees.

RIVERINA NURSERIES, Farm 645, Griffith 2680. Range of fruit trees.

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+ + FITZROY NURSERIES, PO Box 859, Rockhampton 4700. Very good range of tropical fruits and nuts, pecans, macadamias.

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