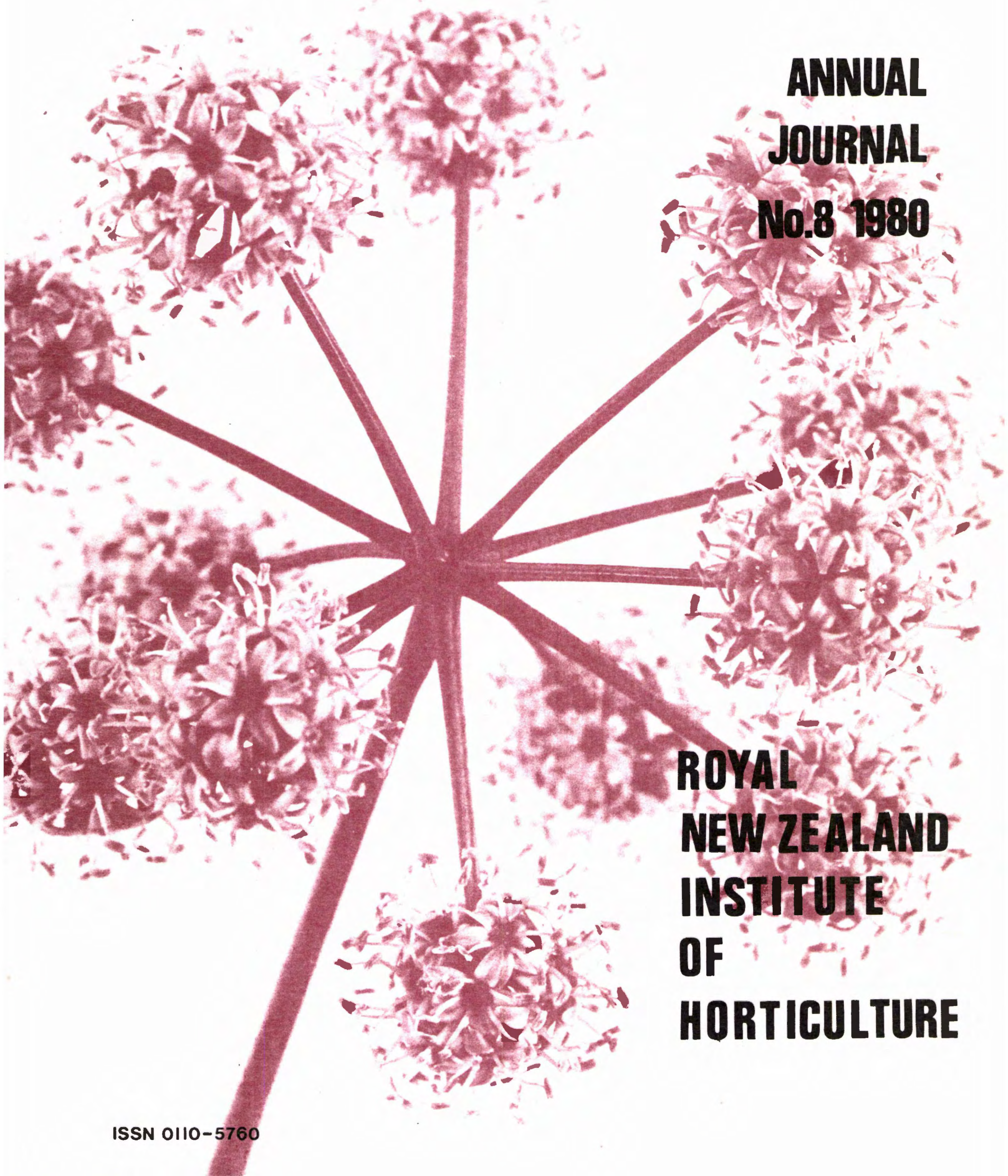

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ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE

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ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE (INC.)

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COVER PICTURE

Pseudopanax laetus inflorescence, on a male plant. *P. laetus* is a dioecious evergreen shrub native to New Zealand. It has large attractive compound leaves consisting of 5 to 7 leaflets from 100-250mm long. This shrub reaches 2-3m in height and prefers a rich moist soil but will withstand quite dry conditions once established. It makes an attractive tub plant.
(Photo - D. Cox)

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Contents

The Banks Lecture, 1980
The Potential for N.Z. to Become a Major Producer of Horticultural Crops

by

E.E. Toleman

Ministry of Agriculture, Private Bag, Hamilton.

When Joseph Banks and Captain James Cook embarked on the "Endeavour" in 1768 they were literally starting on a voyage to the end of the earth. One of their aims was to visit the little known land of New Zealand which they reached in the following year.

The motive power of their vessel was wind and such a journey could be expected to take many months. It is not easy for us today to realise how slow and often difficult and dangerous travelling was then. In the two centuries since, it has become possible to cover the same distance in little over a day by air, a mode of travel then undreamed of. Advances in food storage and transport technology have been such that we can now move large quantities of produce from New Zealand to the centres of population in the northern hemisphere. It is because we can do this that we can contemplate expanding our existing trade in mainly farm products to cover a wide range of horticultural crops as well.

Despite the fact that our major markets are so far away, we do have many advantages which used correctly, will enable us to take part in the highly competitive area of food production and marketing.

New Zealand enjoys over the greater part of its land an oceanic climate varying from cool in the south to warm temperate in the north. We enjoy in most seasons an adequate rainfall, but even when this is insufficient there are usually water sources suitable for irrigation. Being relatively small islands set in a great expanse of sea, winds may be a problem in some parts, but shelter can be given to overcome this. The hours of sunshine, coupled with an atmosphere almost free from industrial and urban pollution gives near ideal conditions for many crops. Compared with many other countries we are indeed fortunate.

We have a work force which is both well educated and intelligent and sufficient in numbers and which despite recent urbanisation is still agricultural rather than industrial in outlook. Our economy is based on primary production from farms and forests, and can be demonstrated to be efficient. Our internal transport system where agriculture is concerned is based largely on feeding the export centres and is thus well suited to being extended to handle horticultural products.

Good transport is a key to success because the topography of the two main islands means that horticulture will most likely develop in areas scattered throughout the whole. Whereas farming can be done in rolling hilly land as well as relatively flat land. Land in New Zealand is classified as 50% steep, 20% moderately hilly and 30% rolling or flat. Included in the latter is the 10% suitable for horticulture. Even all this may not be initially so because of soil types, inadequate drainage, climatic and other factors requiring attention. However, even this 10% should be enough for a very considerable horticultural expansion, in fact if it were all used intensively its productive value would far exceed that of all the land now used for farming. This situation is not likely to eventuate in the foreseeable future and farm production will and must remain our mainstay for a long time yet. Horticulture must be developed to complement, not compete with farm production. The point must be made that although we do have sufficient land for a major horticultural expansion the amount is finite, and we must look to its conservation. In this city of Hamilton, much of which is built on good agricultural land there is a population density of only one fifth of what would be normal in many other countries. We must look to the land as our most valuable asset and not squander the resource which above all enables us to contemplate a greatly increased horticultural production.

Even where the topography is good in many cases the soil is naturally only of medium or even poor fertility, and our husbandry techniques will have to be such that our limited soil resources are both safeguarded and improved. Remember that even in the short time we have what we like to term developed the land many of the mistakes which overseas have turned fertile areas into deserts have been repeated here.

The land is a priceless asset, and as long as we are primarily an agricultural nation only by using it correctly shall we have a future.

A future such as we can contemplate will depend entirely on ourselves making the best and most judicious use of the undoubted advantages we do enjoy. The work force required by an expanding horticultural industry will be considerable numerically. Compared with farming horticulture will always be more labour intensive. Improvements in crop production techniques and the increasing use of mechanisation in horticulture means that the ability and knowledge required of every individual will be of a high level.

Compared with other countries where horticulture makes a major contribution to the national income, such as the Netherlands, Denmark and Israel among others our horticultural man power useage and training resources leave much to be desired.

At tertiary level the supply of horticulturists is currently adequate, and undoubtedly provides a sound base from which to expand to meet our increasing needs.

It is in the area of what can be termed the skilled craftsman that the shortage of trained manpower is occurring and will fast become critical.

Fortunately some steps are being taken to rectify the situation, but we may well have to look at the establishment of a single national training scheme to supply the numbers required. Without the trained and skilled labour force our progress will be curtailed seriously. Because of the inevitable greater use of mechanisation and demands for technical knowledge of a higher level the opportunities in horticulture for the unskilled manual worker will inevitably decrease even if the industry as a whole continues to expand.

We must not overlook the social implications in areas where horticultural production becomes more or less concentrated. Rural depopulation may be checked by the development of small settlements capable of providing those amenities which are currently the reason for the drift of the mainly non-property owning workforce to the towns. In this respect it is encouraging that secondary level school leavers are showing an interest in horticulture as a career - it is vital to encourage this, but to do so will mean looking at the situation as it is today, and realising that what may have been sufficient in the past is unlikely to be so in the future.

When horticultural production existed to meet local demands, or in the case of some fruit an export market as well, those producers involved often regarded it as a pleasant way of life, which in fact it frequently was. It is no disparagement to say that until recently horticulturists knew a lot about crop production but in many cases little about the business management aspect of their occupation. The last few years has seen as influx into commercial horticulture of many businessmen who may be said to know a lot about business but little about horticulture! The abilities of both groups will be complimentary and much needed as we move into the highly competitive field of exports and away from the relatively protected local markets. In many cases the core of experienced growers provides the base from which we can expand, but as we do so then efficient business management becomes of ever increasing importance.

The demand for areas of land smaller than is usual for farms has led to a significant measure of subdivision, especially in areas adjacent to towns. Popularly termed the 10 acre block, and many are in fact of this area (4 hectares), they have been purchased for a number of reasons. The desire for 'a place in the country', an investment which is often a speculation in the rise of land and property values, a tax haven, or a base to establish a rural business are among the many.

It is true that in some cases these smaller units achieve a high level of production, but the numbers which do so is small. The problems arising from subdividing land in this way are many, and we must look closely at this and indeed land tenure in general to see if this is the best way to use our limited land resources. Apart from the land use aspect the proliferation of small holdings raises problems of marketing, which with some crops will not help to achieve the stability so essential. Competition in the form of price cutting from growers selling at the roadside and who are not dependent on such sales for a living can depress returns unnecessarily. Thus it becomes more difficult for the full time grower, who probably has a wage bill to meet, to obtain the returns essential for him to stay in business.

One hears frequently that people are turning to the land in general, and horticulture in particular to escape from the urban 'rat race'. In so many cases time brings the realisation that the horticultural rat is just the urban one in a rural setting. Those people who have become accustomed to the urban way of life should never overlook the change in both outlook and circumstances that is usually involved in entry into horticulture.

The influx of people into horticulture who lack experience poses problems, but in the long run could well introduce a new outlook to the benefit of the industry. A horticultural occupation can be rewarding in many ways, but it is not an easy life, nor is it without worries.

New Zealand undoubtedly has the basic ingredients for success horticulturally but can we in fact sell what we grow. Despite recent events there still lingers the belief that the world beyond our shores is waiting to pay good prices for what we are prepared to let them have. In fact we shall only sell our horticultural produce by competition with the many other producers in the same markets. We must not only produce a high quality article, but maintain this standard at all times. We must also be able to maintain regular supplies at a competitive price and present them attractively. In other words offer for sale what the customer wants not what we may think he should have.

We can do this, and a large part of our current success in marketing apples overseas against fierce competition is due to understanding what the market demands. Although with kiwifruit we had the advantage of initially being the only supplier the realisation of the principle that the 'customer is always right' has played a large part in the profitable disposal of this crop.

Whilst obviously we must look to quantity to achieve substantial returns quality is equally important. The example of the NZ Dairy Board is worth considering - by its efficiency and knowledge of marketing it sells butter successfully against seemingly impossible odds in a market fraught with problems of over-supply and bedevilled by politics. Although many horticulturists will not agree we shall probably have to adopt, and adapt the Dairy Board's concept of co-operation in marketing. The old axiom "united we stand, divided we fall" is still very very true.

We must be able to present an article of consistently high quality to create a reputation of our produce, and this will probably only come about by unified marketing. The NZ Apple and Pear Marketing Board is the best example at present of such unified selling. Despite the criticisms sometimes levelled at it in New Zealand many fruitgrowers in other countries look with envy at the way it handles the ever increasing volume of apples we produce to the benefit of our fruitgrowers. Marketing is a complex procedure, constantly changing, but understanding it is the key to the profitable disposal of our produce.

We do have the major problem of distance from most of our markets, and the most economical use of our energy resources will play a dominant role in marketing.

At present in many sectors of horticultural production there is a degree of instability perhaps inherent in a burgeoning production for which markets are not yet established. There are encouraging signs that many agencies are tackling problems associated with both production and crop disposal, but we must not delude ourselves that the years ahead are going to be easy.

We must remember that before the current surge of interest in horticulture that industry was capable of meeting the demands of the local markets. In some crops, such as pipfruit, latterly kiwifruit, onions and a few others we had established markets overseas. Any further production then means that once local demand is satisfied additional production must be exported, whether fresh or processed. As an example about 80% of the kiwifruit crop reaches the required grade for fresh export. The remaining 20% must be disposed of in other ways, possibly including processing. As the total production increases so the 20% represents a proportionately larger amount, which may become increasingly difficult to sell. The answer may well be in the marketing of fruit juices, wine or preserves and it is for reasons such as this that the growth of industries ancillary to horticulture will have to be encouraged. This will demand more labour, mostly with a high degree of skill. Crop production may be the basis of horticulture, but without efficient associated industries it will not succeed.

If we accept that a vastly expanded horticultural industry in New Zealand is feasible what crops shall we be growing. In Table I are listed what may be termed traditional crops, which are also grown in many other countries, we shall be aiming mainly at the expansion of existing markets. With many of the newer crops we may be entering markets already supplied by our competitors, or in some cases will have to promote a crop which has not yet an established market. With many crops we do have the advantage that we produce them in our summer, which is of course winter in the northern hemisphere where our major markets are. Because production and marketing costs will be high we shall probably have to concentrate on those crops of high intrinsic value relative to bulk, especially where air transport is used. Sea transport will continue to be used for bulkier crops such as onions, and also those such as pipfruit which can be stored for relatively longer periods.

From Table I you will see that in 1979 apples earned us about $NZ70 million in overseas funds with kiwifruit about $NZ30 million. The latter crop in 1972 occupied about 720 hectares of land and in 1980 4200 hectares, with planting continuing and projected to reach by 1985 around 8000 hectares, with an estimated value at today's prices of $NZ124 million, mostly, we hope in overseas funds. If this takes place kiwifruit will be our major export crop then, for apple production is unlikely to increase at a rate sufficient to maintain its current lead. Although admittedly an unique crop, kiwifruit is a good example of the contribution a horticultural crop, occupying a relatively small area of land can make to our national income.

Asparagus is a crop in short supply in most countries, and many parts of New Zealand are undoubtedly suited to its cultivation. However, it is not an easy crop to grow and in the Waikato, where extensive plantings are being made, many are likely to fail to produce profitable crops because unsuitable soils have been used. This emphasizes the basic necessity of relating a plant's needs to the soil and climate, and concentrating growing in those areas where most but preferably all factors are in its favour.

Very large areas of berryfruit including strawberries, brambles, blueberries and blackcurrants have been planted over the past few years. These fruits have problems related to their perishability, but expeditious handling and refrigeration can overcome them. One crop in particular, blackcurrants occupied 63 ha of land in 1970, but it is estimated this area mainly in the South Island, will rise to 1090 ha by 1984. This increase is largely due to mechanisation of harvesting, which has resulted in a reduction of harvesting costs to enable us to sell at more competitive prices. The initial investment in the harvesting machines is considerable but so long as the area cropped is related to their work capacity it is well justified. There appears to be a good demand for the fruit and our crop yields can be high.

Small quantities of blueberries have been exported over the past few years and appear to have potential for considerably greater production. Although relatively new in New Zealand they are an established and important crop in North America. It is hoped that our production will supply the market there and elsewhere during the northern hemisphere winter. Because they are an established commodity there, we have to meet the existing standards and marketing requirements which are of a high level and very competitive.

Boysenberries, with similar cultivars such as marion and others are being planted on a large scale, and the market prospects for these appear encouraging.

In 1972 1500 ha were devoted to grape growing, and this had risen to 4200 by 1979, with further increases likely.

Horticultural exports are by no means confined to food and from very little in 1967 sales overseas of nursery plants had risen in value to over $NZ1 million in 1979, with prospects for further substantial increases in a widening number of markets.

Exports of flowers and ornamental foliage in 1967 were also negligible, but had reached over $NZ1 million by 1979. The increasing production of orchid flowers (mainly *Cymbidium* cvs) is spectacular - in 1978 about 1 million blooms were produced, and exported, this figure is predicted to increase tenfold by 1984, the majority of which will be for export. Although we do have the advantage of an opposite flowering season to the northern hemisphere this is being lessened by the introduction of new cultivars which flower over a longer period. This coupled with a very substantial increase in production in many countries means the world market will become even more competitive.

There are many crops relatively new to New Zealand listed in Table II which may prove valuable additions to our range of horticultural exports. In the markets where we can hope to sell them some will already be supplied from other countries, but with some it will be necessary to promote them as a new product. This is costly and however good the promotion may be the development of a stable and continuing market ultimately depends on whether or not the consumer likes the commodity and if we can compete with competition from other producers.

Avocadoes grow well in parts of the warmer areas of the country and the area planted had risen from 22 ha in 1972 to 153 ha in 1979, with a substantial further increase likely. It appears that this fruit has considerable potential but we shall meet much competition from the large plantings being made in other countries in both hemispheres.

Many hectares of feijoas have been planted, but this is a crop where prior full evaluation of the cultivars used is vital. Some produce fruit of poor quality and flavour and although selections are now being made more carefully many plantings are probably of inferior types. The reception of this fruit on overseas markets varies and if it is to become established good promotion would appear necessary.

Persimmons are another crop where very careful selection of cultivars is essential. They grow well in many parts of New Zealand, but most existing trees are of the astringent unpalatible types and only the non astringent types should be planted. At present these are in short supply, but are being propagated by nurserymen and the shortage should be only temporary.

Nuts are presently receiving a lot of publicity and of these macadamia, if we can grow it successfully, could have a very good potential both on the home and export markets. The spanish or sweet chestnut we know grows well in most parts of New Zealand and there may be a market in Japan and China. Walnuts and pecans, both taking several years to reach full production should also have potential.

With all nuts even if our hopes of an export market are not realised then the local market can be supplied and money saved by not having to import.

A fruit usually grown in the subtropics, cherimoya and the related custard apple can probably be grown in selected areas of the warmest parts of the country.

Asian pears should prove suited to our conditions and there appears to be a promising demand for these overseas.

Recent introductions such as babacco, pepino and casana could also be of value in the warmer areas, but little is known yet what the demand is likely to be both locally and overseas.

Only a few of the plants which we can grow have been mentioned, some will probably prove to be of small value, others may well become of major importance. At present we are on the threshold of considerable change, and with it there is a great challenge. If we are to succeed we must plan to meet the many requirements of commercial horticulture. We must make the best use of our many resources, be prepared to co-operate and above all to set our sights at a level where we can compete in every way, and by so doing bring increasing prosperity to New Zealand.

Sir Joseph noted "... the promise of great returns ..." when he visited New Zealand, but I wonder if even a man with his foresight could have envisaged how great these returns could be. To expand our primary production and become a major producer of horticultural crops is the opportunity offered us, but whether or not we realise this great potential depends in the end on our own ability to meet and overcome the difficulties we may encounter - as we can if we want to.

Acknowledgement:

N.Z. Horticultural Statistics
(New Zealand Ministry of Agriculture
and Fisheries)

TABLE I

TRADITIONAL HORTICULTURAL EXPORTS FROM NEW ZEALAND

(Either/Or Both Fresh and Processed)

Pip Fruit	Apples, Pears
Stone Fruit	Apricots, Cherries, Nectarines, Peaches
Kiwifruit	
Berryfruit	Brambles, Strawberries, Raspberries
Vegetables	Asparagus, Beans, Beetroot, Brassicas, Garlic, Mushrooms, Onions, Peas, Potatoes, Sweetcorn, Tomatoes
Cut Flowers	Carnations, Chrysanthemums, Cymbidium Orchids, Gladiolus, Roses
Ornamental	Trees, Shrubs, Bulbs, and other plants
Ornamental Foliage	
Wine	

In 1979 these exports earned about $NZ150 million in overseas funds, with the major earners being apples $NZ70 million, kiwifruit $NZ30 million, and onions $NZ38 million. In 1980 the total will increase markedly, reflecting both a greater volume as well as monetary inflation. The substantial areas of 'permanent' crops being planted currently, and which take a few years to reach full production will add progressively to our income in the mid 1980's.

TABLE II

HORTICULTURAL CROPS WHICH MAY HAVE AN EXPORT POTENTIAL, EITHER FRESH OR PROCESSED

	Common Name	Botanical Name
	Asian Pear	*Pyrus* spp
*	Avocado	*Persea* spp
	Babacco	*Carica* sp
*	Blackcurrant	*Ribes nigrum*
*	Blueberry	*Vaccinium* spp
	Casana	*Solanum* sp
*	Cape Gooseberry	*Physalis* spp
	Carob	*Ceratonia siliqua*
	Cherimoya	*Annona cherimola*
*	Citrus	*Citrus* spp
	Cranberry	*Vaccinium* spp
*	European Gooseberry	*Ribes grossularia*
*	Feijoa	*Acca sellowiana*
*	Fig	*Ficus carica*
	Guava	*Psidium guajava*
	Hazelnut	*Corylus* spp
	Lychee	*Litchi chinensis*
*	Loquat	*Eriobotrya japonica*
*	Macadamia	*Macadamia* spp
*	Melon	*Cucumis* spp
	Mulberry	*Morus* spp
	Naranjilla	*Solanum* sp
	Olive	*Olea europeae*
*	Orchids	*Cattleya, Dendrobium Paphiopedilum etc.*
*	Persimmon	*Diospyros* spp
	Papaya	*Carica* spp
*	Passionfruit	*Passiflora* spp
*	Paw Paw	*Carica* spp
*	Pecan	*Carya* spp

TABLE II

HORTICULTURAL CROPS WHICH MAY HAVE AN EXPORT POTENTIAL, EITHER FRESH OR PROCESSED

(continued)

	Common Name	Botanical Name
	Pepino	*Solanum* sp
	Pistachio	*Pistacia vera*
	Pomengranate	*Punica granatum*
*	Pumpkin, Squash	-
*	Sweet Chestnut	*Castanea sativus*
*	Tamarillo	*Cyphomandra betacea*
*	Walnut	*Juglans* spp

* Indicates those planted in New Zealand and currently in or near production, some on a significant scale and with limited export at present.

Almost all others are under trial or are being planted commercially but are not yet in significant production. Some may prove to have an export potential, others not, but for most there should be a limited local demand, if only to replace current imports.

Observations on Fruitgrowing in Ecuador and Chile

by

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A visit to Chile and Ecuador earlier this year afforded me the opportunity to have a closer look at fruitgrowing generally, particularly in the types of fruits unknown to New Zealand and others that we know but are grown in very different circumstances in the countries described.

Economically Chile and Ecuador are quite different. In Chile I was impressed by the large enterprises gearing up to produce crops for export production. Traditionally Chile has been famous for its wines. Large areas of fertile valleys around Santiago are devoted to grape growing. A large export industry exists in apple and pear growing. More recently cut flower production such as carnations and chrysanthemums have become important.

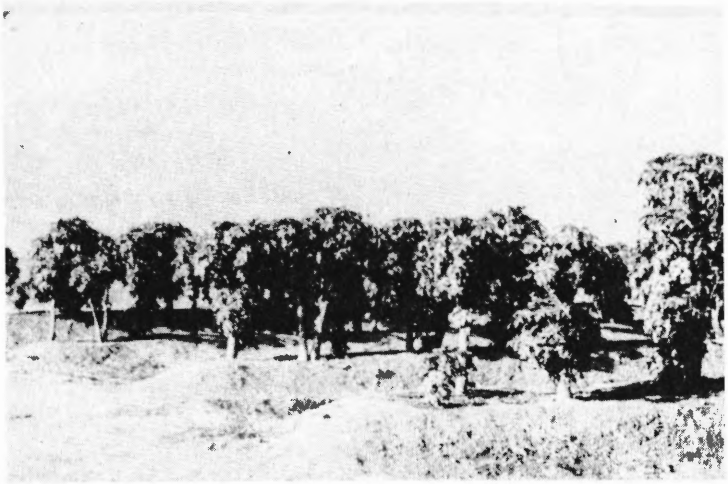
My particular interest was in sub-tropical fruits. In this respect Chile is unique. In this category are crops such as the mountain pawpaw, pepino, cherimoya, lucuma, to mention little-known crops, as well as citrus and avocado.

Ecuador is different. As it is situated in a tropical region one would expect tropical crops, but because this country is intersected by the huge Andean mountain chain many crops are grown high up in the mountains where far colder climates prevail. In the coastal lowlands the main fruit crops are bananas and cacao. These enterprises are carried out on a large scale. In the mountian regions most of the land is divided up into smaller farms or family units. It was in the latter parts that fruits were encountered of particular interest to me.

SUBTROPICAL FRUITS IN CHILE

The mountain paw paw *Carica pubescence*. This fruit needs no introduction in New Zealand as it is commonly found as a backyard tree in the northern parts of this country. It is quite hardy and will withstand a small amount of below zero temperatures. As yet no attempt has been made in New Zealand to commercialise this fruit. In contrast, in Chile this same fruit is now grown on a large scale, with the total harvest utilised for processing. The mountain pawpaw is a fast-growing single-stemmed soft-wooded plant growing to a height of three or four metres. The fruit, five-ribbed, oblong and pointed at each end, develops in the leaf axles on short stalks in clusters of three or four fruits. The plants are monoecious, meaning there are male and female plants, and as well hermaphrodite forms occur. In order to produce fruits both sexes need to be present. In Chile seeds are extracted and sown into boxes, and are later planted out into planter bags in shade house conditions. When about 10 cm high the plants are put into the field on high beds, about 50 cm high, and two metres wide. The young plants are spaced out on a diagonal planting roughly 1.20 metres apart. The climate in which these plants are grown in very dry to semi-desert. Trickle irrigation is laid out at the time of planting. Water is generally available from melting snows in the Andes, carried down in rivers into these dry plains. Soils are heavy, clay like. This appears to be suitable for this crop. At planting time it is impossible to sex the plants, and not until the plants flower at about 14 months from sowing can the sex be

* *Reprinted by kind permission of 'The Orchardist of N.Z.' (December 1979 issue).*



A mature mountain paw paw planting at Longotoma, Chile.

Pepinos ready for harvesting in Chile.

A 100 year old cherimoya tree at Loja, Ecuador.

determined. Male-female ratio in natural seedling populations is about 50/50; for commercial purposes two males to ten female plants is sufficient. The unwanted male plants are grubbed out and replaced by new seedlings which again could be either male or female. This process of elimination is continued until the desired ratio is acquired. The fruit start to mature at two years from sowing and carry on more or less continuously for the following six months. The economic life of the plant is about 10 years. The fruit produced does not seem to vary much in contrast with plants growing in New Zealand which can vary greatly in size and quality. In Chile the fruit is not consumed fresh. The entire crop is canned in syrup, dried or candied. Research is carried out in the utilisation of the by-products such as papain extraction, use of the muculidge substances around the seeds. The mountain pawpaw grows quite easily in New Zealand. There is no reason why no commercial production has been attempted here. In the meantime other promising carica species have been introduced in New Zealand which may have even greater potential than the mountain pawpaw.

The Pepino - *Solanum muricatum*

The pepino is grown throughout the high Andean regions of South America, particularly in Peru and Ecuador. However, in recent years Chile has developed this rather minor fruit into a fruit crop of major importance. In New Zealand this fruit has become increasingly known. Small commercial plantings have been made, but so far no one has been really successful, due to the shy bearing qualities of the plant. The pepino belongs to the *Solanum* family. The shrubby plant, not unlike a potato plant, produces its fruit in one growing season; under favourable growing conditions it will produce for several seasons. The fruits are normally top shaped, somewhat larger than a tamarillo, and when ripe the fruit skin has a translucent pale cream colour with broad purple stripes running from the stem end to the opposite side.

The word pepino is also used for the cucumber in Latin America. The texture of the flesh is somewhat similar. To distinguish between the two plants the pepino as we know it is referred to as pepino dulce, meaning 'sweet'. The fruit is refreshing in flavour, not unlike a rockmelon. It can be eaten raw, cooked or is used in fruit salads.

In Chile the pepinos are grown as an annual crop. Cuttings are made during the month of July, at the time of the removal of the previous season's crop. The cuttings are raised under glass until any risks of frosts are past. During lining in the field the cuttings are planted on raised beds in double rows about 18in apart. From a distance a pepino planting resembles a potato patch. The range of diseases and pests is very similar to the potato; hence a similar spray-programme should be carried out. To preserve moisture, plants are often planted into black polythene mulch. This also helps to prevent fruit from getting soiled.

The fruit begins to mature during April through to mid-June. The fruits are handpicked when the base colour changes. They are then placed on straw beds in a corner of the field and left in the full sun for a few days to improve the appearance and sweetness of the fruit. The purple stripes become darker, the flesh turns a deeper yellow. The fruit is then packed into boxes for the markets, mostly in Santiago (pop. 4.5 million).

The production of fruit is high in Chile. So far it is not understood why production is not adequate in New Zealand. Plant material has been imported from Chile recently, and it is hoped that when it is released we will have commercially important plant material. The pepino can be grown in most fertile areas in the North Island when planted as an annual crop. In Ecuador the pepino is common on all fruit markets. However, the fruit types are very variable in shape and colour, indicating that seedlings are often grown. In Ecuador the plants are tied up to support structure not unlike the way tomatoes are grown, to prevent fruit from touching the ground, like in New Zealand. Slug attacks on the fruit are a problem, but the dry climate in Chile poses no problem with slugs.

The Cherimoya - *Annona cherimolia*

Like the pepino, the Cherimoya is native to Peru and Ecuador. In both countries the fruit is very common in the markets. This fruit is possibly one of the best fruits of South America. It is not as commonly grown elsewhere as would be expected. In New Zealand the fruit was introduced many years ago, but has been shy bearing and susceptible to phytophthora rootrot. The tree requires a frost-free climate and a free-draining site. To my knowledge no commercial plantings exist of any size in N.Z. The potential is there.

In Chile many acres are planted in cherimoyas with about eight different cultivars. Suitable plant sites are found on the higher ground along the broad river basin of the Aconcagua valley. The soils are rather stony and frost-free. The trees are spaced about five metres apart. They are rather sprawly in habit, and to prevent branches from breaking, a support is built around the trees. The trees bear well. It is found necessary to hand pollinate the trees using feather dusters for the purpose. The fruit at maturity is dull green with an average weight of about 3/4 kg. The large fruit, about 13 cm in crossection, is creamy white inside, soft-fleshed and has a delicious sweet flavour. Large black seeds are embedded in the pulp. The fruit is always eaten raw. Once mature, the fruit has only a short shelf life. In Ecuador the fruit is very common. The trees grow wild on roadsides and wasteland. The cool temperatures with high light intensity may be a requirement of the successful culture of the plant.

The Lucuma - *Lucuma abovata*

This unusual fruit I encountered in both Chile and Ecuador. The shape of the fruit differed in each country. However, the taste and characteristics, are the same. The fruit grows on a large tree, in appearance not unlike a karaka tree. The fruits are shaped like a large flat tomato and have a shiny green thin skin. Inside the flesh is yellow dry and sweet and rather nutty in flavour. In the centre are two or three seeds not unlike horse chestnuts polished brown.

In Chile the trees are planted more for decoration, but more recently efforts are being made to commercialise this fruit. This fruit is common in market stalls in Ecuador, which seems to indicate the tree must be grown over a fairly widespread area. Seed brought back to New Zealand may in time introduce a fruit of unusual merit.

OTHER FRUIT GROWN COMMERCIALLY IN CHILE ON A MINOR SCALE.

The Loquat

This fruit is already well know in New Zealand. Again no efforts are being made to commercialise the fruit. In Chile only grafted trees of the variety Golden Nugget are grown. The trees are cared for in much the same way as apples in regard to pruning, spraying, etc. A point of interest was that flower clusters are hand thinned to reduce the number of fruits and increase their size. I did not see many large plantings of loquat, but it does prove to me that we can grow this fruit commercially also.

The Tuna. *Opuntia bonplandii*

This prickly pear type of cactus bears edible fruit. The fruits are about the size of a hen's egg. The fruit appears to be like a modified cactus leaf, including the pores from which the spines emerge. The colour is either pale yellow or rosy pink. The fleshy pulp is pleasantly sweet. Very small seed is scattered through the pulp. The fruits are usually utilised in fruit salads. The tuna is grown in the more dry and arid areas of both Chile and Ecuador. I have never seen these fruits in New Zealand, the reason being that all *Opuntia* spp. are prohibited from entry into this country.

Most of the fruits described so far occur in both Chile and Ecuador. There are a number of other interesting fruits that are important in Ecuador but little known elsewhere, notably the many different species of passionfruit (*Passiflora* spp.) and the Carico family, more commonly known as the pawpaws. The babaco and toronchi are the most important in this group. As the climate in the mountains of Ecuador is like eternal spring, the fruits that grow

A fruit stall in Ecuador. The fruits featured here are lucuma (on left), cherimoya (centre) and tuna (behind).

A toronchi tree - *Carica crysopetala*.

Clusters of ripe capuli cherries.

naturally in these areas are not subject to winter chilling. There are fruits, closely related to our temperature fruits, that thrive in this type of climate. The most notable of these are the Capuli (*Prunus salicifolia*), a cousin of our cherry. This fast-growing evergreen species produces large crops of cherries of excellent quality. A native walnut, *Juglans honorei* has a similar type of nut as the black walnut. Again this tree is evergreen in contrast to other walnut species. There is also a range of raspberries and blackberries that are different from ours. One type of apple grows well in Ecuador. It has obviously been introduced yet crops well in the colder, high-altitude regions. Other introduced fruits, stone fruits, olives, figs etc., have adapted to this unique climate.

A few of these fruits, new to N.Z. yet likely to do well here judging by the plants growing here that were imported recently from Ecuador, will be described in more detail.

The Babaco - *Carica pentagona*

This fruit was earlier described in *The Orchardist*. But to repeat, this plant is of the papaya family. In general appearance it is much like a mountain pawpaw and is equally hardy. The fruits are large, weighing as much as 1 to 2 kg each. About 25 to 30 fruits are produced on each plant. The fruits are used extensively in Ecuador as fruit juice or canned. Large acreages are being planted commercially in recent years to meet the keen demand for this product. This fruit is practically unknown outside Ecuador.

Recently introduced in New Zealand, the babaco has cropped exceedingly well in Auckland, in fact as well as any observed in Ecuador. The fruit is seedless. Hence the plant can only be propagated from cuttings or other asexual means. This has proved to be slow. Several years will elapse before sufficient numbers will be propagated for commercial plantings. This fruit is likely to become an export earner in future years.

The babaco requires fertile soils, a near frost-free climate, and most important, perfect shelter. To make an intelligent guess: areas where tamarillos grow successfully should also support the babaco. In Ecuador successful plantings were observed along alluvial river basins, or in volcanic soils around the high-altitude mountain valleys.

As a point of interest, poultry keeping is often practised in conjunction with the babaco. The poultry manure is utilised to feed the plants.

In Ecuador the babaco is highly lucrative - so much so that growers with only a few acres or so are very well-to-do.

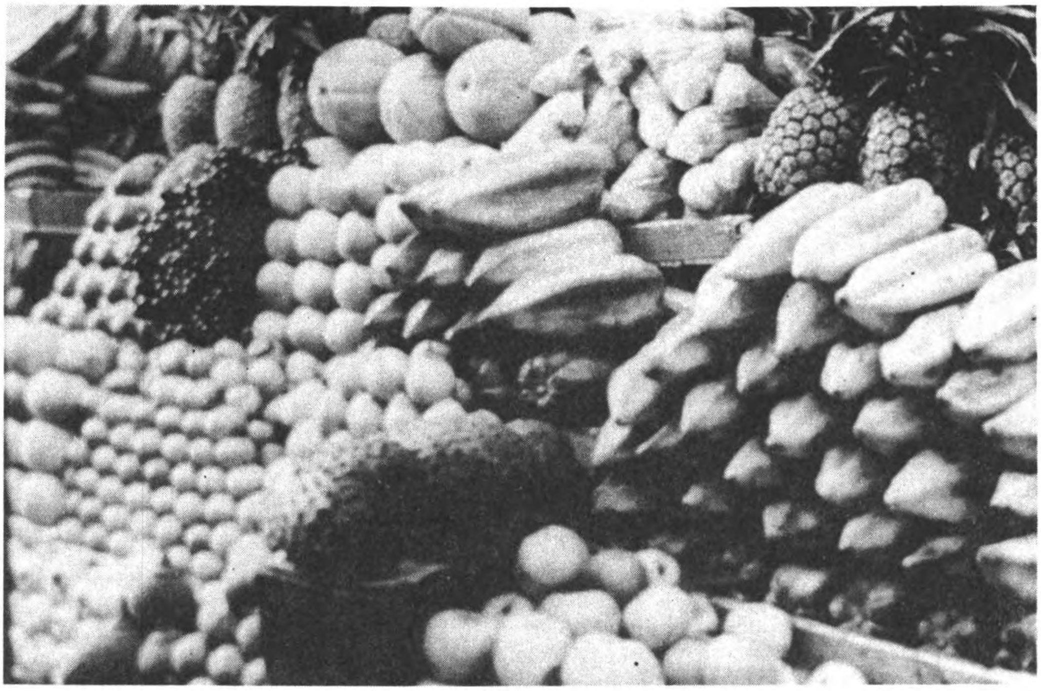
The Toronchi - *Carica crysopetala*

This plant is closely related to the babaco. The flavour is very similar, if not more aromatic. In flavour the fruit is strawberry-pineapple like, and is excellent both as a fresh fruit or presewed. It is not very common in Ecuador.

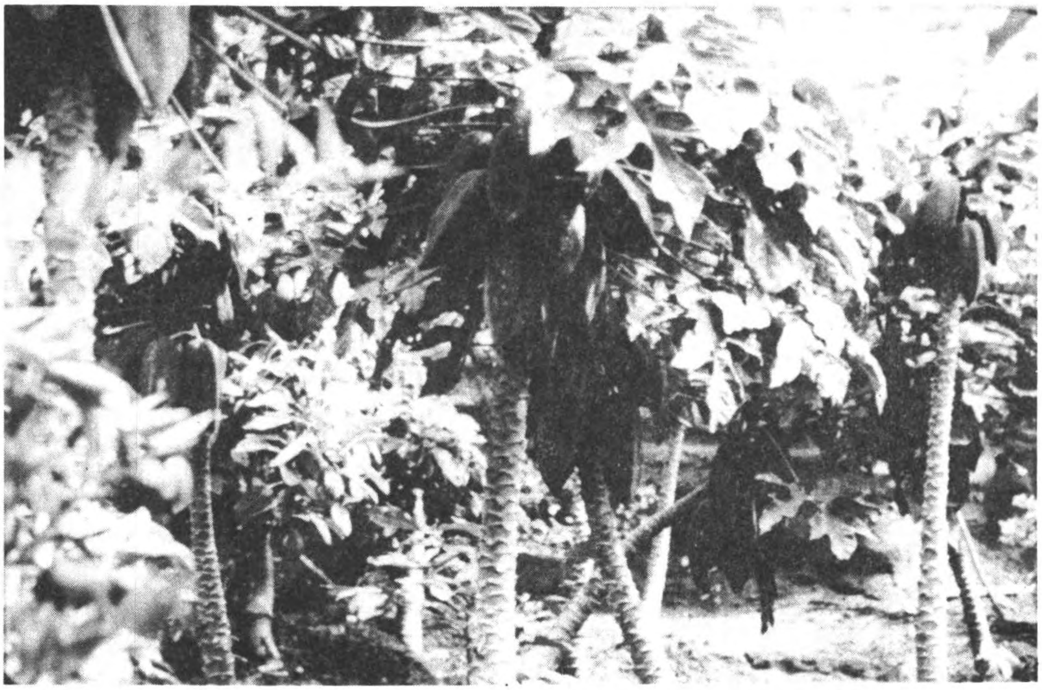
Unlike the babaco, the fruit contains seeds, hence propagation is carried out by raising seedlings. The trees vary considerably, and the fruit produced by individual trees differ. As well male plants develop, and although they are required for pollination the numbers that germinate cannot be regulated. The first toronchi fruits have ripened in New Zealand only recently. The plants crop heavily in Auckland. Future prospects are excellent, but selection will be necessary to find the best type for our growing conditions.

Capuli *Prunus salicifolia*

This is no doubt the most common fruit tree growing in the Ecuador highlands. Capuli grows wild along roadsides and is also seen in most backyards. The tree grows large and tall and is rather willow like in appearance. Trees 50 or more feet in height are not uncommon. The tree is almost evergreen, the old leaves dropping as the new season's foliage emerges. It was unusual to see trees of capuli at various stages of seasonal development. Some were flowering, others had fruit, and yet others were in semi-dormant state. Trees now growing in Auckland show similar characteristics. It is likely that most trees growing in Ecuador are voluntary seedlings, judging by the generally indifferent



A fruit market in Quito, Ecuador, with babacos on right.



A babaco orchard close to harvesting.

fruit produced by the trees. The cherries are carried on racemes in clusters like grapes, not on long stalks as on the common cherry. On the average the fruit is rather small, little larger than blackcurrants. Selection in recent years has resulted in the planting of a few superior varieties. I was fortunate to visit a fruitgrowing area near Ambato where a small number of these superior clones were growing. The fruits on these trees were very large, more like small plums, light red with an excellent sweet flavour. Cropping was extremely heavy. Scion wood was obtained from these trees, but did not survive importation. It is hoped that seed obtained from these small trees will develop the desired characteristics shown by the 'Alobamba' trees.

The capuli appears to be remarkably free of disease. No silverleaf was seen, nor leaf curl. This also applies to the trees at present growing in Auckland. Bird damage does not seem any problem in Ecuador as the trees produce profusely. Lack of chilling requirement would make this tree a valuable addition to the range of fruit crops in the warm temperate region of the North Island.

The *Solanum* plant family is well represented in Ecuador. The pepino, described earlier, is common. The tamarillo is widely grown but only the yellow form was seen. The casana seems to be more widely known in New Zealand than in Ecuador, in spite of some publicity concerning this little-known plant. On my recent trip I still did not see any fruits in the markets. The casana fruited in Auckland for the first time from April until August. Unlike tamarillos, the trees started new growth during August showing a period of full blossom at that time. New fruits have now set which will be a lot earlier maturing than the tamarillo. The fruits produced in New Zealand are of good quality, sweet and pleasant, like passionfruit with a hint of cape gooseberry. The fruit is rather pulpy and soft and does not handle very well. The exotic flavour and appearance will make this fruit popular.

A common nut tree in Ecuador is the Tocte or Ecuadorian walnut *Juglans honorei*. This tree is strikingly beautiful. The large compound leaves are present throughout the year. The nuts are eaten fresh or made into sweets. The nut is black and deeply grooved, like the black walnut, although somewhat larger. The trees are highly valued in Ecuador for their timber. Seeds sown in August 1977 in Auckland have grown into trees two metres high, remaining in leaf during all this time. The continuous growing season of this tree obviously adds to its value as a timber tree in New Zealand. As a shelter tree it may prove useful.

In conclusion, I should mention many other useful fruits such as the avocado, *Mamey sapote*, the many types of bananas, medicinal plants, and the novel use of some minor fruits - for example, the planting of a small fruited peach, much liked by birds, around strawberry plantings, the idea being that the birds prefer eating the peaches rather than the strawberries and this saves the strawberries from bird-ravaging. As yet we have a lot to learn in the growing of these new fruits.

All the fruits mentioned in this article are now established in New Zealand, and it will not be long before they become available to the public.

Phosphorus Response of Proteaceae and Other Nursery Plants in Containers

by

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ABSTRACT

A range of mostly proteaceous shrubs was grown in containers with various P rates. Shrubs in the Proteaceae were generally intolerant of P levels of about 50 g/m^3 but *Grevillea robusta* and *Leucospermum candicans* were not damaged at 120g P/m^3. *Camellia japonica* could tolerate levels of about 125g P/m^3 and this rate appeared optimal for *Erica carnea* 'Springwood White'.

INTRODUCTION

Many of the cultivated Australian Proteaceae come from heathlands where the soils are often extremely impoverished (Specht 1963, Stewart 1959, Wood 1959). Beadle (1962) pointed out that P levels may be below 150 ppm in some soils. South African Proteaceae are also primarily confined to deficient soils in their native habitat (Johnson and Briggs 1974, Wild 1968). Many Proteaceae have adapted to a low P supply (Beadle 1968, Jeffrey 1967). Some can store P and use it in the growing season (Specht and Groves 1966) while others can revert to a semi dormant state when P and N levels are reduced (Wood 1959). The development of proteoid roots has occurred as an aid to nutrient absorption, particularly P (Purnell) 1960, Groves 1964, Jeffrey 1967). This specialised root system is highly efficient at extracting P from the rooting medium (Jeffrey 1967) but can act to the plants detriment if high levels of available P are present particularly within the small confines of a nursery container. Thomas (1974) found that *Grevillea rosmarinifolia* is readily damaged by medium levels of added P in a potting mix.

Phosphorus can be toxic for even such crops as cereals on light lands (Longeragan *et al.* 1966). Many Australian shrubs and trees are grown in New Zealand nurseries plus other species which may be sensitive to added P and the objective of this work was to examine the influence of several P levels on a range of species.

MATERIALS AND METHODS

Plant Species and Growing Conditions

Three separate experiments were carried out each involving from 3 to 5 species and a total of 628 plants. The plants used, trial dates and replicates are given in Table 1. Most plants were raised from seed and pricked out into tubes where they were held with little or no feeding until the experiments began. *Grevillea rosmarinifolia* (Experiment A and C), *Erica carnea* 'Springwood White' (Experiment C) and *Leucospermum candicans* were grown from semi-ripe tip cuttings and held in tubes, as were the seedlings. All experiments were run in a heated glasshouse which was equipped with automatic fan ventilation. The minimum glasshouse temperature was 15^{o}C while the maximum was close to 5^{o}C above ambient temperature. Hand watering was done when required and no further fertiliser applications were made following laying-down.

Media and Fertilisers

A mixture of equal parts of Mataura sphagnum peat and fine grade perlite was used for all experiments. The physical and chemical properties of Mataura peat were described by Goh and Haynes (1977) and perlite by Morrison *et al.* (1960).

Levels of added P varied from 0 to 300g/m^3 (Tables 2-5) and were predominantly supplied from single superphosphate (9% P). Dolomite

TABLE 1

Details of individual trials

Expt.	Plant Species	Reps. (plants/treatment)	Dates Bagged	Dates Lifted
A	*Grevillea robusta* A. Cunn. ex R. Br.	5	30.1.74	28.1.75
	Grevillea rosmarinifolia A. Cunn.			
	Leucadendron adscendens R. Br.			
	Leucospermum candicans Loud.			
	Protea repens (L.) L.			
	Protea scolymocephala Reichard			
B	*Banksia spinulosa* Sm.	10	22.1.74	12.8.74
	Dryandra formosa R. Br.			
	Telopea speciosissima R. Br.			
C	*Camellia japonica* L.	10	1.8.73	7.4.74
	Erica carnea 'Springwood White'			
	Grevillea rosmarinifolia A. Cunn.			
	Hakea laurina R. Br.			
	Protea repens (L.) L.			

and agricultural ($CaCO_3$) limes were used in the ratio of 3:1 (w.w) at 6 kg/m^3. Levels of other nutrients in experiments A and B and were 150g N/m^3 and 75g K/m^3 supplied from 3-4 month Osmocote (26% N) and sulphate of potash (39% K) respectively. The levels in Experiment C were 225g N/m^3 and 125g K/m^3 which were all supplied from 8-9 month Osmocote (18/2.6/10). This meant that in all treatments in Experiment C there was a base level of 32.5g of slow release P with the remaining amount derived from superphosphate. Single superphosphate was the sole source of P in the other two experiments. All treatments also received a basal dressing of the following: 75 g/m^3 'Sequestrene' iron chelate (Na EDTA Fe with 12% iron) and 'Sporumix A' (150 g/m^3) containing 1.14% B, 0.26% Zn, 1.27% Cu, 5.46% Mn, 0.06% Mo, 0.05% Co, 9.78% Mg). The media and fertilisers were well mixed and then transferred to PB 5 (2½l) planterbags just prior to potting.

Data Collection and Analysis

Visual ratings were carried-out on all plants using a grading system based on vigour and foliage quality; with 0 = dead to 5 = very vigorous and healthy.

On completion of each experiment plants were cut-off just above the top of the medium and the foliage oven dried. All ratings and dry weights were statistically examined using Teddybear (now Cryto/Teddybear) computer programme for analysis of variance and F test.

RESULTS

Experiment A

Grevillea robusta and *Leucospermum candicans* failed to respond significantly to any treatment, were unaffected by high P levels, and in fact the latter produced larger plants than the low P treatment (Table 2). *G. rosmarinifolia*, *Leucadendron adscendens*, *Protea repens* and *P. scolymocephala* on the other hand all showed very severe P toxicity symptoms or appeared dead at 3½ months when supplied with 120g P/m^3. This is equivalent to 1.3kg of superphosphate per cubic metre and it clearly had a rapid effect from which there was little

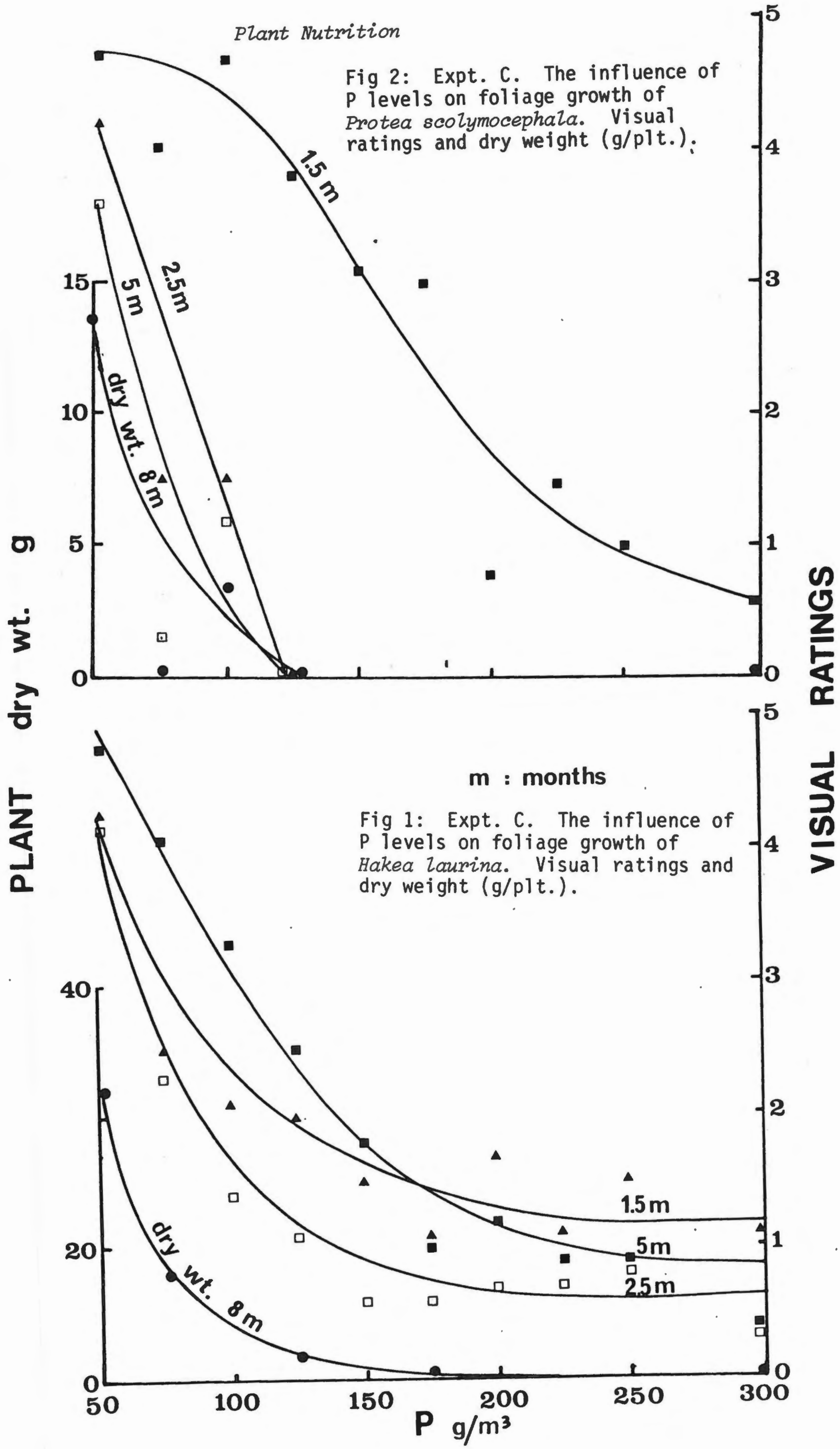


Fig 2: Expt. C. The influence of P levels on foliage growth of *Protea scolymocephala*. Visual ratings and dry weight (g/plt.).

Fig 1: Expt. C. The influence of P levels on foliage growth of *Hakea laurina*. Visual ratings and dry weight (g/plt.).

recovery by these sensitive species. There was no response to the 30g P/m^3 rate by any of the species, nor was there indication of damage by this low rate.

Experiment B

The three proteaceous species in this experiment were all similar in their high sensitivity to added phosphate. Plants receiving 120g P/m^3 were very severely damaged in the first few months of this experiment with many dead before its full duration (Table 3). There was even severe toxicity noticed with 60g P/m^3 after 4 months. This is equivalent to only 0.6kg superphosphate/m^3. Dry weight of foliage of *Dryandra* and *Telopea* plants grown with 60 or 120g P/m^3 was inferior to that for *Banksia*. There was no evidence of a positive growth response to added P in any treatments.

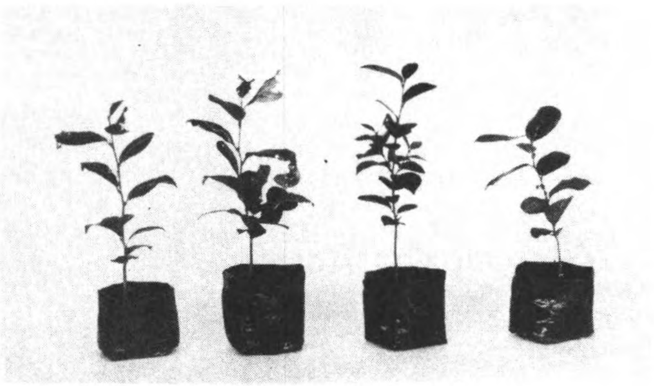
Experiment C

Five species were grown in 10 levels of added phosphate (Table 4). Results with *Camellia japonica* were rather inconclusive but it appears that this species has no high requirement for phosphate and nor is it readily damaged by P at 300 g/m^3 (equivalent to superphosphate at 3 kg/m^3). Phosphate at 50 - 75 g/m^3 appeared to be adequate for this plant. These rates are quite low since the base dressing of 1.25 kg/m^3 of Osmocote 18/2.6/10 would supply 32.5g P/m^3 over 8-9 months (superphosphate was the sole source of P in the other three treatments). The rates of 50 and 75g P/m^3 included 17.5 and 42.5g P/m^3 from superphosphate respectively. *Erica carnea* 'Springwood White' was the other non proteaceous shrub in this experiment and showed no deficiency symptoms at 1½ or 2½ months, however 50 and 75g P/m^3 were inadequate for *Erica* at 5 months and at harvest (8 months), resulting in depressed foliar yields. Added P at 150 - 175 g/m^3 mildly depressed *Erica* foliar growth as indicated by foliar dry weights. The main feature, which started to become apparent at 5 months and in the dry weights was that between 100 - 125g P/m^3 was the optimal level for this *Erica*.

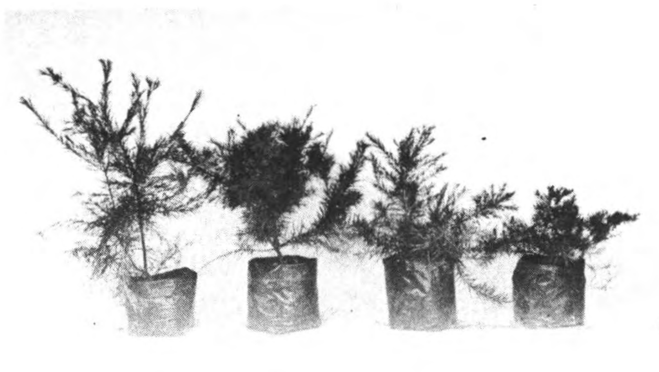
Grevillea rosmarinifolia, *Hakea laurina* and *Protea scolymocephala* were the proteaceous shrubs in this experiment and reacted quite differently to added P than did the previous two species. The lowest rate of 50g P/m^3 was soon observed to be the maximum acceptable level of phosphorus. All data are given in Table 4 along with statistical analyses while Figures 1 and 2 are included to illustrate response curves for significant results for *H. laurina* and *P. scolymocephala* respectively (Table 4, Figure 1 and 2). Rates above 100g P/m^3 depressed growth of all three species after only 1½ months, and the four highest levels caused very severe toxicity in *H. laurina* and *P. scolymocephala* at this early stage. *G. rosmarinifolia* ratings after 2½ months showed a continuing depression of growth but by 5 months plants were recovering, probably due in part to leaching and fixation of available P. The other two species showed no recovery and with *P. scolymocephala* there were only a few plants left alive at 100g P/m^3 with all others dead except for the lowest P level. No positive growth response to P occurred in the latter species, and the results were all unfavourable.

DISCUSSION

Soil phosphate was found to be an important determinant in the development of plant communities in the Australian heath vegetation in early studies by Specht (1963) and in subsequent studies (Heddle and Specht, 1975). *Banksia*, *Grevillea* and *Hakea* often occur together in these communities in various parts of Australia and *Dryandra* may also be present (Lamont 1973). *Telopea speciosissima* occurs in a more restricted habitat on Hawkesbury sandstone but was found here to react in a similar way to the other P sensitive species. The South African proteaceous shrubs were equally sensitive to added P except *Leucospermum candicans*. Eliovson (1967) states that *L. album* and *L. candicans* are similar and that the former grows easily in the garden while both are common in the South Western region of the Cape in South Africa. *L. candicans* appeared to be a robust plant which was easy to propagate and far from difficult to grow in containers. Further work is required to confirm whether this and other *Leucospermum* spp. are similar to *G. robusta* in being able to tolerate high P levels. There was no indication of P toxicity at 120g P/m^3 for *L. candicans* in Experiment A at any stage yet *Leucadendron adscendens*, which is also wide-

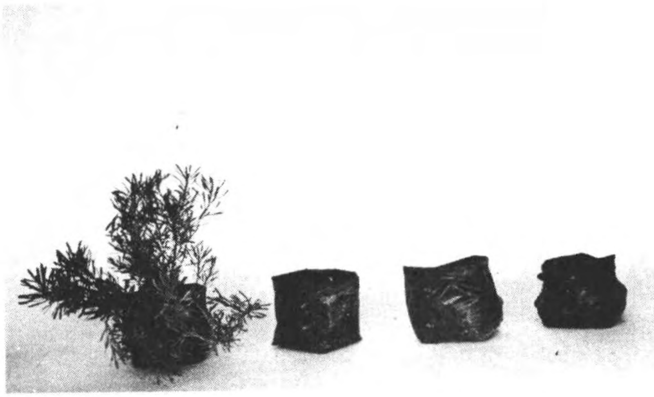


Camellia japonica



Grevillea rosmarinifolia

Hakea laurina



Protea repens

Left to right: 50 100 150 250 g P/m^3

(Experiment C - just prior to harvest.)

spread in a similar habitat, was strongly suppressed by the same P rate.

Camellia and *Erica* are sensitive to high fertiliser levels (Carter 1973, Pearson 1958, Wills 1971) and salinity (Klougart & Bragg Olsen 1969). *C. japonica* growth can be depressed by 300g P/m^3 especially when coupled with high N levels (Thomas 1974). The opposite occurred with *Erica carnea* 'Springwood White' (Thomas 1979) where there was a positive NP interaction. These species are therefore not similar although both are much more tolerant of added P than most Proteaceae. A level of 100g P/m^3 could be recommended (from Experiment B) for *C. japonica* while other unpublished work (Thomas 1979) and Experiment C here would indicate that at least 200g P/m^3 should be basally applied for container grown *E. carnea* 'Springwood White'.

The influence of P additions on the growth of *Grevillea rosmarinifolia* and on *Hakea laurina* in containers was previously noted by Thomas (1979). This *Grevillea* was less sensitive to P toxicity than the latter, and the upper limit for basally applied P is probably close to 100 g/m^3 for *G. rosmarinifolia* and 50 g/m^3 for *H. laurina* There has been little evidence of any benefit from adding any superphosphate (along with slow release fertilisers), indeed with *Banksia spinulosa* in Experiment B foliar ratings and dry weights were inferior with 30g P/m^3 compared to 15g P/m^3. These are low rates and only amount to 333 and 167 g/m^3 of superphosphate (9% P) respectively. It is therefore inadvisable to add any superphosphate to media for sensitive species.

ACKNOWLEDGEMENTS

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REFERENCES

Beadle, N.C.W. 1962: Soil phosphate and the delimitation of plant communities in eastern Australia II. *Ecology 43:* 281-88.

——— 1968: Some aspects of the ecology and physiology of Australian xeromorphic plants. *Aust. J. Sci., 30:* 348-55.

Carter, A.R. 1973: The nutrition of container-grown plants. Proc. 8th Pershore Nurs. Ref. Course: 3-8.

Eliovson, S. 1967: Proteas for pleasure. Timmins, Cape Town. 228p.

Goh, K.M. and Haynes, R.J. 1977: Evaluation of potting media for commercial nursery production of container-grown plants. II Effects of media, fertiliser N, nitrification and inhibitor on yield and N uptake of *Callistephus chinensis* (L) Nees 'Pink Princess'. *N.Z. J. Agr. Res. 20:* 363-70.

Groves, R.H. 1964: Experimental studies on heath vegetation. Ph.D. Thesis, University of Melbourne.

Heddle, E.M. and Specht, R.L. 1975: Dark Island Heath (Ninety-Mile Plain, South Australia). VIII The effect of fertilisers on composition and growth, 1950-1972. *Aust. J. Bot. 23:* 151-64.

Jeffrey, D.W. 1967: Phosphate nutrition of Australian heath plants. I. The importance of proteoid roots in Banksia (Proteaceae). *Aust. J. Bio. Sci. 20:* 403-11.

Johnson, L.A.S. and Briggs, B.G. 1974: On the Proteaceae - the evolution and classification of a southern family. *Bot. J. Linn. Soc.* 83-182.

Klougart, A. and Bragge Olsen, O. 1969: Substratum for container-grown plants. *Acta Horticulturae 15:* 34-6.

Lamont, B. 1973: Proteaceae:ecology of the Australian Proteaceae with implications for their cultivation. *Aust. Plt. 7(54):* 47, 50-1, 54-5, 66-7.

Loneragan, J.F. *et al.* 1966: Phosphorus toxicity in cereal crops. *J. Aust. Inst. Agr. Sci. 32:* 221-3.

Morrison, T.M. *et al.* 1960: Plant growth in expanded perlite. *N.Z. J. Agr. Res. 3(3):* 592-7.

Pearson, H.E. 1958: Irrigation and soil salinity p. 360-6. *In* Tourje, E.C. Camellia culture, MacMillan, New York.

Purnell, H.M. 1960: Studies in the family Proteaceae. I. Anatomy and morphology of the roots of some Victorian species. *Aust. J. Bot. 8:* 38-50.

Specht, R.L. 1963: Dark Island heath (Ninety-Mile Plain, South Australia).

VII The effect of fertilisers on composition and growth, 1950-60. *Aust. J. Bot. 11:* 67-94.

Specht, R.L. and Groves, R.H. 1966: A comparison of the phosphate nutrition of Australian heath plants and introduced economic plants. *Aust. J. Bot. 14:* 201-21.

Stewart, G.A. 1959: Some aspects of soil ecology. p. 303-14. *In* Biogeography and ecology in Australia. W. Junk, The Hague.

Thomas, M.B. 1974: Research on the nutrition of container-grown Proteaceae plants and other nursery stock. *Int. Pl. Prop. Soc. Comb. Proc. 24:* 313-25.

Thomas, M.B. 1979: Nutrition of container-grown plants with emphasis on the Proteaceae. Ph.D. Thesis, University of Canterbury, 291pp.

Wild, H. 1968: Phytogeography in South Central Africa. *Kirka 6:* 197-222.

Wills, R.W. 1971: Delaware nurserymen briefed on camellia culture. *Am. Nurs. 133:* 16, 62-64.

Wood, J.C. 1959: The phytogeography of Australia (in relation to radiation of Eucalyptus, Acacia, etc.). p. 291-302. *In* Keats, A. biogeography and ecology in Australia. W. Junk, The Hague.

TABLE 2

Expt A - Effects of 3 levels of P on the foliage growth (visual ratings and dry weights) of 6 container grown nursery plants.

(*** = P < 0.001; ** = P < 0.01; * = P < 0.05; # = P 0.05 - 0.10)

Plants	P Levels (g/m^3)		Visual ratings 3½ months	Visual ratings 7½ months	Dry Wt. (g/plt.)
Grevillea robusta	15		3.8 a	3.4 a	41.8 a
	30		4.0 a	3.8 a	42.9 a
	120		4.0 a	4.4 a	53.4 a
		(P)	-	-	-
		C.V. (%)	14	25	37
Grevillea rosmarinifolia	15		3.4 A a	4.2 A a	15.0 A a
	30		3.2 A a	4.6 A a	12.9 A a
	120		1.6 A b	1.6 B b	4.6 B b
		(P)	*	**	**
		C.V. (%)	32	29	34
Leucadendron adscendens	15		3.4 A a	3.2 a	14.5 A a
	30		3.8 A a	3.6 a	14.6 A a
	120		1.8 A b	1.8 a	4.7 A b
		(P)	*	-	*
		C.V. (%)	31	50	51
Leucospermum candicans	15		3.8 a	4.0 a	20.2 a
	30		4.0 a	4.4 a	32.3 a
	120		3.8 a	4.1 a	27.9 a
		(P)	-	-	-
		C.V. (%)	27	28	67

TABLE 2 contd.

Plants	P Levels (g/m^3)		Visual ratings 15.5.74 3½ months	23.9.74 7½ months	Dry Wt. (g/plt.)
Protea repens	15		4.0 A a	2.6 AB a	11.7 a
	30		4.4 A a	4.3 A a	16.2 a
	120		0.2 B b	0 B b	7.3 a
		(P)	**	**	-
		C.V. (%)	41	53	140
Protea scolymocephala	15		3.8 A a	3.6 A a	12.9 a
	30		3.4 A a	3.0 A a	10.6 a
	120		0 B b	0 B b	0 a
		(P)	**	**	-
		C.V. (%)	46	51	194

TABLE 3

Experiment B - Effects of 5 levels of P on the foliage growth (visual ratings and dry weights) of 3 container grown nursery plants.

P Levels (g/m^3)	*Banksia spinulosa* Visual rating 3½ months			*Banksia spinulosa* Dry Wt. (g/plt.)			*Dryandra formosa* Visual rating 3½ months			*Dryandra formosa* Dry Wt. (g/plt.)		
0	2.9	AB	ab	3.1	A	a	3.8	A	a	13.5	AB	a
15	3.3	A	a	1.5	AB	ab	3.2	A	a	12.7	AB	a
30	1.8	AB	bc	0.5	B	b	3.5	A	a	20.8	A	a
60	1.5	BC	c	0.1	B	b	1.1	B	b	4.5	BC	b
120	0.1	C	d	0	B	b	1.1	B	b	0	C	b
(P)	***			**			***			***		
C.V. (%)	65			142			44			85		

Telopea speciosissima

P Levels (g/m^3)	Visual rating 3½ months			Dry Wt. (g/plt.)
0	3.7	AB	ab	6.5
15	4.1	A	a	6.5
30	3.0	AB	bc	7.4
60	2.4	BC	c	1.0
120	1.3	C	d	0
(P)	***			***
C.V. (%)	35			53

TABLE 4

Expt C - Effects of 10 levels of P on the foliage growth (visual ratings and dry weights) of 5 container grown nursery plants.

Camellia japonica

P Levels (g/m^3)	Visual ratings 1½ months	2½ months	5 months	Dry Wt. (g/plt.)
50	4.5 a	3.8 A a	4.8 A a	12.3 A a
75	4.4 a	3.2 AB abc	4.4 A ab	11.2 AB ab
100	3.9 a	3.3 AB abc	3.9 A c	7.3 AB bc
125	3.9 a	3.0 AB c	4.4 A abc	8.3 AB abc
150	3.8 a	3.1 AB bc	4.3 A abc	6.4 B c
175	3.9 a	3.2 AB abc	4.4 A abc	8.1 AB abc
200	4.3 a	3.5 AB abc	4.6 A abc	9.5 AB abc
225	3.9 a	3.5 AB abc	4.5 A abc	10.3 AB abc
250	4.0 a	3.7 AB ab	4.7 A ab	12.6 A a
300	3.8 a	2.9 B c	4.0 A bc	8.8 AB abc
(P)	-	*	-	*
C.V. (%)	21	19	16	46

Erica carnea 'Springwood White'

P Levels (g/m^3)	Visual ratings 1½ months	2½ months	5 months	Dry Wt. (g/plt.)
50	3.4 A ab	3.2 a	4.0 AB abcd	18.7 B b
75	2.9 AB abc	3.2 a	3.6 AB d	17.2 B b
100	3.4 A ab	3.1 a	4.6 AB ab	38.9 A a
125	3.2 AB ab	3.3 a	4.7 A a	41.3 A a
150	3.2 AB ab	3.2 a	4.5 AB abc	21.3 B b
175	3.1 AB abc	3.0 a	3.8 AB bcd	15.6 B b
200	3.5 A a	3.2 a	3.7 AB cd	14.7 B b
225	2.6 B c	3.2 a	3.9 AB abcd	21.4 B b
250	2.8 AB bc	3.0 a	3.7 AB cd	19.4 B b
300	2.9 AB abc	2.7 a	3.5 B d	22.4 B b
(P)	*	-	**	***
C.V. (%)	19	23	21	40

TABLE 4 contd.

Grevillea rosmarinifolia

P Levels (g/m^3)	Visual ratings 1½ months	2½ months	5 months	Dry Wt. (g/plt.)
50	4.1 AB a	4.5 A a	4.8 AB ab	39.5 ABC abc
75	4.2 A a	4.5 A a	5.0 A a	45.1 A a
100	4.2 A a	4.2 A a	3.7 BC cd	20.0 DE f
125	3.1 C b	3.3 B b	4.5 ABC abc	21.9 E ef
150	3.2 BC b	2.7 BC bc	4.1 ABC abcd	30.7 BCDE cde
175	2.7 C b	2.4 BC c	4.1 ABC abcd	26.5 DE def
200	3.3 ABC b	3.2 B b	3.8 ABC cd	42.7 AB ab
225	3.1 C b	2.9 BC bc	3.9 ABC bcd	34.6 ABCD bcd
250	3.0 C b	2.2 C c	3.5 C d	31.1 BCDE cde
300	2.7 C b	2.4 Bc c	3.4 C d	27.1 CDE def
(P)	***	***	**	***
C.V. (%)	23	22	23	40

Hakea laurina

P Levels (g/m^3)	Visual ratings 1½ months	2½ months	5 months	Dry Wt. (g/plt.)
50	4.3 A a	4.2 A a	4.8 A a	32.2 A a
75	2.5 B b	2.3 B b	4.1 AB ab	16.2 B b
100	2.1 BC bc	1.4 BC c	3.3 BC bc	8.6 C c
125	2.0 BCD bc	1.1 CD cd	2.5 CD cd	3.8 CD cd
150	1.5 CD cd	0.6 CD de	1.8 DE de	3.3 CD cd
175	1.1 D d	0.6 CD de	1.0 EF ef	1.4 CD d
200	1.7 BCD cd	0.7 CD cde	1.2 EF ef	1.6 CD d
225	1.1 D d	0.7 CD cde	0.9 EF ef	1.0 D d
250	1.5 CD cd	0.8 CD cde	0.9 EF ef	0.4 D d
300	1.1 D d	0.3 D e	0.4 F f	0 D d
(P)	***	***	***	***
C.V. (%)	39	61	46	83

TABLE 4 contd.

Protea scolymocephala

P Levels (g/m³)	Visual ratings 1½ months	2½ months	5 months	Dry Wt. (g/plt.)
50	4.7 A a	4.2 A a	3.6 A a	14.3 A a
75	4.0 AB ab	1.5 B b	0.3 B c	0 B b
100	4.7 A a	1.5 B b	1.2 B b	3.5 B b
125	3.8 AB ab	0 C c	0 B c	0 B b
150	3.1 B b	0 C c	0 B c	0 B b
175	3.0 B b	0 C c	0 B c	0 B b
200	0.8 C c	0 C c	0 B c	0 B b
225	1.5 C c	0 C c	0 B c	0 B b
250	1.0 C c	0 C c	0 B c	0 B b
300	0.6 C c	0 C c	0 B c	0 B b
(P)	***	***	***	***
C.V. (%)	46	102	182	378

Eucalyptus viminalis

by

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INTRODUCTION

Eucalyptus species are the most conspicuous element of the Australian vegetation for they constitute about 95% of the forest trees and dominate the woodlands (Kelly 1969).

Most of the species of *Eucalyptus* are native of Australia and Tasmania with about 6 species extending northward to Northern New Guinea, the Philippine Islands, Timor and Java.

The name *Eucalyptus* was bestowed upon the genus by Charles Louis L'Heritier de Brutelle. It was derived from two Greek words 'eu' meaning 'well' and 'kalypto' meaning 'I cover' and refers to the lid or operculum which seals the flower until thrown off during the process of opening (Zacharin 1978).

The specific epithet *viminalis* refers to long flexible switch shoots like 'osier' (Zimmer n.d.). According to Hortus III (Anon 1976) 'osier' refers to *Salix viminalis* as the common osier, *Salix purpurea* the purple osier and *Cornus alternifolia* as the green osier. *Viminalis* refers to the twiggy nature of the crown (Kelly 1969).

J.J. La Billardiere was the first to discover the species *E. viminalis* in 1806 (Zacharin 1978) whilst on an expedition which set out from France in 1799 to search for the lost explorer La Perouse (Kelly 1969). The first recorded specimen of *E. viminalis* was found in the vicinity of Recherche Bay in South Tasmania, the most southerly occurrence in the natural distribution of this species.

E. viminalis is widely distributed in south-eastern Australia between latitudes 28 and 43°S. It is common in eastern Tasmania, the islands of Bass Strait and southern Victoria. In New South Wales it is found mainly on the tablelands and it extends over the Queensland border. It also occurs in the Mount Lofty Ranges and Kangaroo Island of South Australia. The altitudinal range is from sea level to 1400m with the highest occurrences in New South Wales and the Australian Capital Territory (Turnbull and Pryor 1978).

The most frequently used common name for *E. viminalis* is Manna Gum, Hortus III (anon 1976), as the bark of this species yields a manna eaten by native peoples (Aborigines). Manna is a sugar-like saccharin substance exuded in minute drops with a sugary consistence that later concretes. The bark abrasions from which it exudes in its natural state are due to cicadae. Manna oozes to form thin flakes upon the trunk but when secreted from branches may fall upon leaves or the ground (Zacharin 1978). Other names which are commonly applied to this species are the Ribbon gum , this name referring to the way in which the deciduous bark peels off in long strips and White gum which no doubt refers to the overall colour of the trunk and branches.

CLASSIFICATION OF GENUS

The *Eucalyptus* genus is a large one belonging to the family Myrtaceae. Hortus III (Anon 1976) states that there are over 522 species, 150 varieties and a few hybrids. Other estimates vary depending upon the quoted authority. The reasons for this discrepancy are to be found in the confused nomenclature and the fact that in certain areas where several species grow, a number of natural hybrids have appeared. In the past many of these hybrids were mistakenly described as species (Zacharin 1978).

Many classification systems have been

devised for the eucalypts since their discovery in 1770. The first recorded attempt at a classification system was by Willdenow in 1799 dividing the twelve known species of eucalypts by the shape of the operculum. Willdenow was followed by de Candolle who in 1828 divided eucalypts into two classes based on whether the leaves were opposite or alternate using the shape of the operculum as a secondary characteristic. It was later realized that all species have opposite leaves in the juvenile growth phase and this scheme fell into disfavour. In 1859 von Mueller classified eucalypts by their bark characteristics into six groups. While this classification is not systematic, it is still used today as it provides a useful practical diagnostic character. *E. viminalis* is classified as one of the 'gums' because of its smooth barked trunk. The five other groups are the peppermints, bloodwoods, boxes, stringbarks and ironbarks. The bark of the 'gums' is deciduous whilst that of the other five groups is not.

Bentham in 1866 founded the classification system which formed the basis of what is still widely used. This system was refined by Mueller in 1882, then by Maiden and finally elaborated by Blakely in 1934. Blakely's antheral classification system consists of eight sections and 18 subsections (Penfold and Willis 1961).

Recent revisions of the eucalypts have been made by Pryor and Johnson who have recognised about 500 species and subspecies and in doing so have relegated many of Blakely's 605 species and varieties to synonymy. Pryor and Johnson have divided the genus into seven subgenera that can be defined by the association of many characters and that are believed to be completely reproductively isolated. The subgenera are further divided into sections, series, sub series and super series (Hillis and Brown 1978).

DESCRIPTION OF *E. viminalis*

The deciduous bark of *E. viminalis* flakes off the trunk of the tree in long ribbons often seen hanging in the forks of the branches over the summer and autumn. Most of the trunk is smooth and coloured white or light grey, with pink or brownish tones occasionally showing through. The exception to this is the basal 1.5 to 2m of the trunk which is covered with a persistent and rough stringy bark. As with many species of *Eucalyptus*, the foliage of the adult *E. viminalis* varies considerably from that of the juvenile growth phase.

The juvenile leaves of this species are opposite for an indefinite number of pairs and are 5 to 10cm long x 1.5 to 3cm wide, narrowly lanceolate to ovate lanceolate, more or less cordate (heart shaped) at the base, green, concolourouss and without a leaf stalk. The adult leaves of *E. viminalis* are arranged alternately on the branches, ranging in size from 10 to 20cm long x 1.2 to 3cm wide. The leaves are narrowly lanceolate to lanceolate, slightly falcate (sickle shaped) pale green with a faint bluish grey appearance above and below, with a short petiole. Leaf venation is very faint.

E. viminalis flowers in late February through until about mid April at Lincoln. Kelly (1978) suggests that flowering may occur over much of the year, while Penfold and Willis (1961) state that flowering occurs between February and April. The flowers are a creamy white colour and, as with most members of the Myrtaceae family, produces numerous showy stamens.

Visually the other floral parts are relatively insignificant. Numerous flowers are produced each measuring about 25mm in diameter. The flowers are produced in an axillary three flowered umbel with a peduncle of about 3 to 6mm. Flower buds are 6 to 10mm long x 3 to 5mm wide, either sessile or on short thick pedicels. The operculum is acutely conical, peaked, hemispherical or rostrate (beak like projection), equal in length to the ovoid shaped receptacle. Although the flowers themselves are quite showy they are insignificant compared to the overall size of the tree. Consequently, this species is unlikely to be grown for its flowering qualities.

Heavy seed crops occur at intervals of about three years (Penfold and Willis 1961) and mature seed can be collected during spring and summer. The seed is borne in 3, 4 or 5 locular woody capsules, 6 to 8mm x 6 to 9mm, and may be ovoid or hemispherical.

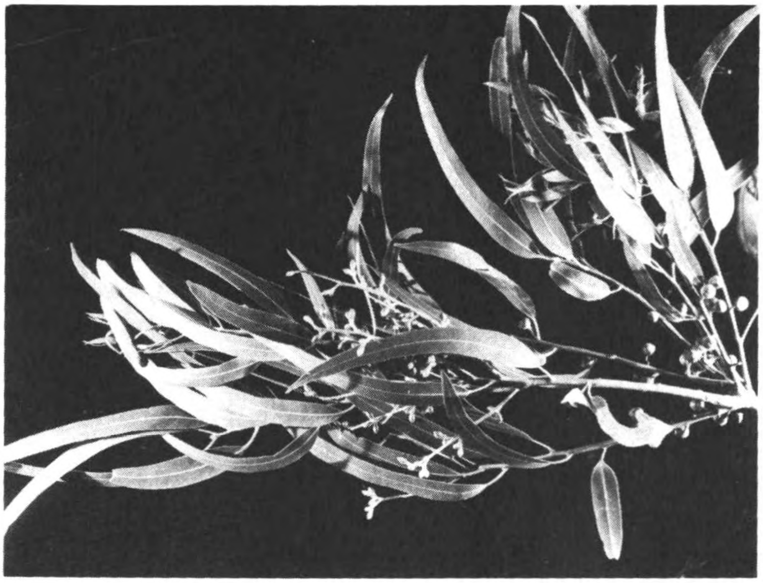
The seeds are tiny, less than 2mm in length and less than 0.5mm wide varying in colour between a reddish and

Plate 1

One of the most dominant and surely the most majestic tree on the campus at Lincoln College (Canterbury) is the *Eucalyptus viminalis*. This tree is situated on the south side of the sports field between the tennis courts and the nursery area.

Although the exact year in which this tree was planted cannot be ascertained, its estimated age is between forty-five and fifty years. It originally grew among a group of trees and shrubs which, when removed from around it about 1958, seemed to provide the catalyst for this tree to grow much faster to its present size (S.A. Challenger, pers. comm. 1980). This tree is 27 metres high with a spread of 21.4 metres, the trunk having a circumference of 4.2 metres (at breast height).

For several years the Ministry of Works nursery staff used this tree as a seed source because of its attractive form and rate of growth. Many trees around the South Island owe their existance to it (T. Gant, pers. comm. 1980). (Photo: E.R. Mangin).



A general view of leaf shape, flower buds and capsules.

A close up showing 4 and 5 locular capsules. Note also the faint venation in the leaves.

golden brown. (Approximately 350,000 seeds per kilogram, Hillis and Brown 1978).

BENEFITS OF PLANTING *E. viminalis*

The ornamental qualities of this tree are evident when it has sufficient room to spread and develop. It is also a useful shade or shelterbelt tree and is widely planted as a hardwood timber tree and a source of pulp wood for the manufacture of paper. *E. viminalis* has been planted in many countries for hardwood timber production but has met with little favour in New Zealand. Other *Eucalyptus* species are thought to produce more durable timber and a list of species suitable for different areas of New Zealand has been compiled (Henry 1952). Along with 10 other species (Zacharin 1978) describes *E. viminalis* as one of the best commercial eucalypt species. Hillis (1978) describes the timber produced by *E. viminalis* as coarse textured with a straight grain while Penfold and Willis (1961) note that the timber of *E. viminalis* is not as durable as many other species of eucalypt. Zacharin (1978) talking about live trees states that the wood of *E. viminalis* can be dangerously rotten on the inside without showing any external signs.

Significant areas of *E. viminalis* have been established in Argentina, Southern Brazil, Italy and the Black Sea coast of U.S.S.R. Other countries which have found this species to be very promising in trials include Chile, Portugal, Spain, Turkey, U.S.A. and parts of Australia (Hillis and Brown 1978).

As a shelter tree *E. viminalis* is very fast growing and wind tolerant. This is exhibited by the specimen growing in an exposed situation at Lincoln College on the Canterbury Plains.

Of lesser importance, as a source of nectar *E. viminalis* produces an amber coloured honey with a distinctive taste. In the autumn the flowers of *E. viminalis* produce large quanities of pollen which can be stored for brood rearing.

In its native habitat *E. viminalis* is the staple diet of the Victorian koala for up to 10 months of the year. There are occasions during the winter months when the young foliage of *E. viminalis* is poisonous (Penfold and Willis 1961).

SOIL

Most eucalypts are not fussy as to their soil requirements, however, few tolerate saline or alkaline soils. Many eucalypts grow naturally on soils of low nutrient status but have the capacity to respond with increased growth rates to more fertile conditions especially to higher levels of nitrogen and phosphorus (Hillis and Brown 1978). A few species will grow well on very shallow soils or conversely on very heavy or poorly drained soils. *E. viminalis* prefers basaltic soils but will tolerate other types with the exception of poor sands.

In its natural habitat *E. viminalis* attains a height of 45m on the deep soils of the valleys up to 1300m in elevation but is much smaller on shallow soils.

PROPAGATION

For most eucalypt species propagation is by seed. Very little success has been had with vegetative propagation techniques, cuttings only striking in some instances and only then with cuttings from the juvenile phase of growth. Some success has been recorded from grafting adult material onto seedlings and by aerial layering of adult eucalypts.

E. viminalis will coppice readily and being a species with lignotubers has the ability to recover from fire damage (Hillis and Brown 1978). Mature seed of *E. viminalis* can be collected in spring and summer. *E. viminalis* is an easy species to raise in the nursery and establish in plantations. Early height growth is rapid and it requires less tending than some other species (Weston 1957).

PESTS AND DISEASES

Damage by fungi is relatively slight and *E. viminalis* is moderately resistant to *Phytopthora cinnamomi* (Marks *et al.* 1973). *Paropsis chrybdis* (chrysomelid beetles) and *Gonipterus scutellatus* (snout beetles) have both have a problem in New Zealand particularly on the faster growing eucalypts such as *E. viminalis*. Research into control of these beetles has largely been directed toward finding suitable predators. *Yungaburra nitens*, a mymarid, was introduced to New Zealand in 1927 to control the snout beetle but has been slow in establishing itself (Penfold and Willis 1961).

Eriococcus coriaceus (gum tree scale) first recorded in New Zealand in 1900 caused damage to *E. viminalis* and more severely to *E. globulus*. The parasite *Rhizobius ventralis* introduced from Australia has relegated scale from a major to a minor pest in New Zealand (Dumbleton 1941).

SUMMARY

Eucalyptus viminalis is one of the most cold hardy species of the eucalypts and combined with its rapid growth, tolerance of wind, attractive form and smooth white grey trunk make this an excellent specimen tree where space allows. Occasional checks should be made on the trunk where branch damage may have occurred to ensure internal rot does not occur.

REFERENCES

Anon. 1976: 'Hortus III' by Cornell University for its L.H. Bailey Hortorium. Macmillan Publishing Co., Inc. New York.

Dumbleton, L.J. 1941: 'Australian parasites of *Eriococcus coriaceus* Maskell.' *New Zealand Journal of Science and Technology No. 1:* 22, 102A-108A.

Henry, J.E. 1952: 'Eucalypts suitable for New Zealand Forestry.' *New Zealand Journal of Forestry, 6:* 309-17.

Hillis, W.E. and Brown, A.G. (Editors) 1978: 'Eucalypts for wood production.' C.S.I.R.O. Australia. Griffin Press, Adelaide.

Kelly, S. 1978: 'Eucalypts' Vol. I. Thomas Nelson (Australia) Ltd., Melbourne.

Marks, G.C.; Kassaby, F.J. and Fagg, P.C. 1973: 'Die back tolerance in eucalypt species in relation to fertilisation and soil populations of *Phytopthora cinnamomi.*' *Australian Journal of Botany 21:* 53-65.

Penfold, A.R. and Willis, J.L. 1961: 'The Eucalypts, botany, cultivation, chemistry.' Leonard Hill (Books) Ltd., Interscience Publishers Inc., New York.

Turnbull, J.W. and Pryor, L.D. 1978: 'Eucalypts for Wood Production.' C.S.I.R.O. Australia. Friffin Press, Adelaide.

Weston, G.C. 1957: 'Exotic Forest Trees in New Zealand.' Statement to 7th British Commonwealth Forestry Conference, Australia, New Zealand, 1957.

Zacharin, R.F. 1978: 'Emigrant Eucalypts.' Melbourne University Press.

Zimmer, G.F. n.d.: 'Dictionary of Botanical Names.' Geo. Routledge and Sons, London.

Biological Control — An Alternative to Chemical Pesticides?

by

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Many of New Zealand's developing horticultural exports are in a cleft stick - the need for products free of evidence of pests yet free of pesticide residues. With ever increasing demands from exporters for high quality produce we find ourselves increasing our use of pesticides. This has been well documented for kiwifruit (Sale, 1980) where from a crop with minimal pesticide input in the early 1960's through to a system with regular pesticide applications today. Have we placed ourselves in the 'pesticide treadmill' so well argued by the late Robert van den Bosch (1978), who was a well-known critic of the pesticide industry in California?

Fortunately a technology for breaking our dependence on the regular use of pesticides is now developing. Integrated pest management is a concept utilising all available control strategies, including pesticides, to manage pest populations to hold them below damaging levels. This is a change from our previous approach of using chemicals to kill all insects. Pesticides are only applied when necessary rather than on a calendar schedule and selective chemicals are used if available. Wherever possible we rely on other techniques to reduce pest density. One such technique, which is often cited as the key to reduced pesticide use, is biological control. Just how viable is biological control, using natural enemies to regulate pest populations, in the context of our horticultural export industries?

Insect populations growing free of chemical controls are commonly regulated by the action of natural enemies. Whether or not the insect populations are held below damaging levels, determines the pest status of the insect. In the horticultural context we can divide the pests into three categories:

1) Primary pests:

These are insects causing direct damage to the consumable product such as leafrollers or codling moth in apples. Failure to apply regular controls will result in virtual complete crop destruction or downgrading of the produce. For these pests we are virtually committed to a pesticide use policy for adequate control. However, by careful monitoring of the insect pests using traps containing attractive substances such as sex pheromones (Fig. 1) and regular surveys of the crop we should be able to reduce the current reliance on calendar schedule spraying. However, in view of strict quality requirements in our overseas markets, we are likely to see natural controls being significant in the control of these primary pests.

2) Secondary pests:

are those that are commonly indirect feeders, found on foliage and stems but not often directly feeding on the saleable product. Generally, we can tolerate more of these pests on a plant than primary pests. Examples of secondary pests would include most pest mite species, some aphids and scales. In unsprayed situations such pests are often held in check by the action of natural enemies. Once chemicals are introduced into the system for control of primary pests, the natural enemies of the secondary pests are destroyed and those pests can subsequently multiply free of controlling influences. High levels, capable of inflicting severe damage to the plant, can be reached so indirectly affecting yield and quality of the consumable product. However, since these pests can be held below damaging levels by natural enemies it is possible that natural control could once more be directed against them. Considerable research in this area is presently being carried out and will be considered further.

3) Tertiary pests:

These rarely reach levels sufficiently large to cause serious damage. Specific controls are not usually directed against these insects. If environmental conditions are suitable, these pests may occasionally break free of their natural regulating agents and inflict damage to plants. Leafhoppers could fit into this category. To date we have not directed much research effort into these insects since priorities must be within the first two categories.

Having established that pesticides must remain the key control stragety against the primary pests in the immediate future, we should direct our attention to the future control of secondary pests. Biological control does offer an alternative to pesticide use for these pests particularly since they do not often directly attack the consumable products so we can tolerate rather higher numbers than with primary pests. This is an important point since for biological control to be effective, a pest density sufficient to permit natural enemy survival is required.

Natural enemies of pest populations are themselves very diverse. Predators are those organisms that consume more than one pest individual in the course of their development while insect parasites complete their development inside a single host. Diseases such as viruses, bacteria, fungi and protozoa also act to regulate pest populations.

Space prevents a complete discussion of biological control but one of the success stories in control of secondary pests has been the re-establishment of biological control of spider mites in orchards. This has seen world wide research efforts since the discovery by Hoyt (1969) that the predacious mites, which, prior to the use of modern broad-spectrum insecticides in orchards had controlled plant feeding mites, had in turn developed resistance to the same insecticides. Thus biological control could be re-established.

Following the initial successes of Hoyt in apples in Washington State, insecticide -resistant predator mites have been found in many parts of the world. A significant programme has been based in Michigan, U.S.A. (Croft 1975) aimed at controlling European red mite. Likewise the discovery of levels of resistance to the insecticide, azinphosmethyl, sufficient to permit predator survival when the chemical is used in apples to control leafroller and codling moth (Penman *et al.* 1976), has lead to the widespread reliance on the predator mite, *Typhlodromus pyri*, for control of European red mite in apples in Nelson (Wearing *et al.* 1978). This programme has lead to a significant reduction in the use of chemicals for mite control. In 1976-77 an average of 4.4 sprays were applied in Nelson orchards with no resistant predator mites, compared with 1.5 applications in orchards practising what is called 'Integrated Mite Control'.

Typhlodromus pyri is only effective in controlling European red mite. Another major pest mite is the twospotted spider mite, common in a wide range of horticultural crops. To attempt biological control of this pest, two predator mites resistant to some insecticides have been imported. Extensive research in New Zealand now suggests that one, *Amblyseius fallacis* from Michigan offers some promise for control of both European red mite and twospotted spider mite (Penman *et al.* 1979).

Mite control using predator mites is, however, still in a precarious state. Predator - prey interactions are complex and further research is necessary to isolate factors which limit the actions of predator mites. In the U.S.A. rust mites, small plant-feeding mites but not major pests, provide an alternative food source for the predator mites when their preferred prey mites are in low numbers. This permits predators to survive to attack the European red mite and twospotted spider mite when they build up again. Rust mites are not common in New Zealand so our predator mites are inclined to die out when prey numbers

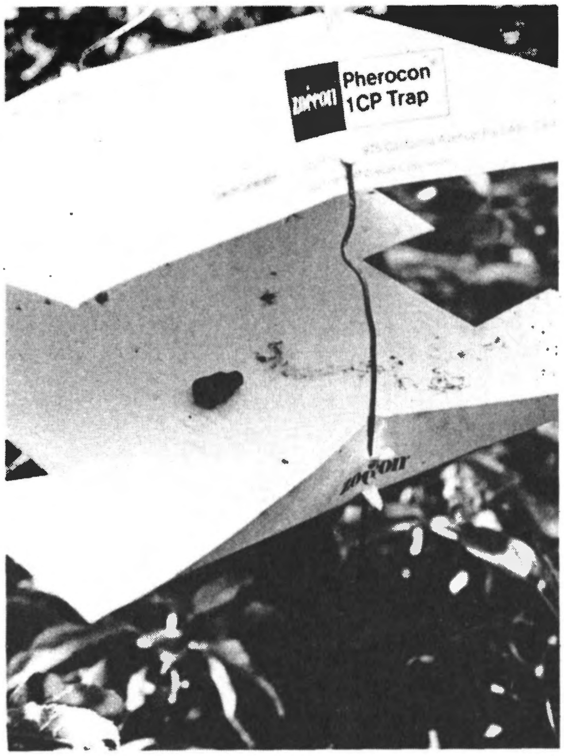

Figure 1. Pheromone trap for attracting male codling moth as a means of more accurately timing chemical sprays, in apples.

are low. This demonstrates the important principle that biological control is likely to be more effective where some alternative food sources are available.

Predator mites are also susceptible to incorrect use of chemicals aimed at other pests and diseases. Only chemicals which show some tolerance towards the predator mites should be used. Compatible spray programmes do exist for apple orchards but the introduction of new chemicals can have a drastic effect on mite control using predator mites. The new group of insecticides called synthetic pyrethroids are particularly potent toxicants against most insects while being relatively safe to mammals. However, these chemicals are very toxic to predator mites while not affecting pest mites (Wong and Chapman 1979). Use of these chemicals leads to death of the predators followed by a rapid build up of pest mites to cause severe damage. This requires use of additional chemicals to control the mites leading to the attendant problems of possible resistance to these chemicals and increasing costs of spray programmes. Until predator mites resistant to the pyrethroids are developed, I cannot advocate widespread use of these insecticides in apple orchards.

Biological control also requires a certain level of crop stability. Annual crops do not lend themselves to successful biological control without the repeated introduction of predators reared elsewhere. The more complex and diverse the cropping system, the more likely we are to achieve successful biological control.

To remove pest control in horticulture away from virtual sole reliance on chemical pesticides will require extensive research and education. Biological control offers a promising approach against secondary pests but should not be regarded as the panacea to our key pest problems. Against these pests we will continue to rely on chemical control but we will move increasingly to spraying by necessity rather than by habit. These factors mean that pest control in the future will become more complex, demanding increasing sophistication in decision-making and planning of control programmes. By not taking steps towards more rational pest control using the concepts of pest management we may never escape the confines of the 'pesticide treadmill'.

REFERENCES

Croft, B.A. 1975: Integrated control of apple mites. *Michigan State University Co-operative Extension Service Bulletin*, E - 285.

Hoyt, S.C. 1969: Integrated chemical control of insects and biological control of mites on apple in Washington. *Journal of Economic Entomology 62:* 74-86.

Penman, D.R.; Ferro, D.N. and Wearing, C.H. 1976: Integrated control of apple pests in New Zealand 7. Azinphosmethyl resistance in strains of *Typhlodromus pyri* from Nelson. *N.Z. Journal of Experimental Agriculture 4:* 377-380.

Penman, D.R.; Wearing, C.H.; Collyer, E.

and Thomas, W.P. 1979: The role of insecticide-resistant phytoseiids in integrated mite control in New Zealand. *In* 'Recent Advances in Acarology, Vol 1', p. 59-69 (J.G. Rodriguez (Ed.)). Academic Press.

Sale, P. 1980: The history of pest and disease control in kiwifruit. *Proceedings 33rd N.Z. Weed and Pest Control Conference*, p. 110-113.

van den Bosch, R. 1978: 'The Pesticide Conspiracy'. Doubleday. 223 pages.

Wearing, C.H.; Walker, J.T.S.; Collyer, E. and Thomas, W.P. 1978: Integrated control of apple pests in New Zealand 8. Commercial assessment of an integrated control programme against European red mite using an insecticide - resistant predator. *N.Z. Journal of Zoology 5:* 823-837.

Wong, S.W. and Chapman, R.B. 1979: Toxicity of synthetic pyrethroid insecticides to predacious phytoseiid mites and their prey. *Australian Journal of Agricultural Research 30:* 497-501.

The Vegetation of Norfolk Island

by

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INTRODUCTION

The small isolated speck of land called Norfolk Island lies at 29°S and 168°E (Fig. 1). The only other land in the vicinity of this Pliocene volcano, built up two to three million years ago (Jones & McDougall 1973), is the tiny limestone Nepean Island about a kilometre to the south, and the small eroded volcanic Philip Island about 4 km further away. The nearest land beyond that is northwards to New Caledonia and the Isle of Pines (about 720 km). To the south is the North Cape Peninsula of New Zealand with the Kings Island (about 740 km), west south west is Lord Howe Island (about 850 km), and due east is Raoul Island in the Kermadec Group (about 1,300 km).

Norfolk is about 7.5 km from east to west, and 7 km from north to south at the widest points, and covers about 3,450 hectares. The highest point of this volcanic mass is the Mt Pitt - Mt Bates ridge rising to about 330 m on the north side. There are many steep cliffs around the coast, but over much of the interior the terrain has gentler contours and except for the restriction somtimes occasioned by dense vegetation, is accessible to the highest points. The central area of Burnt Pine, where most people live, is a level plateau about 100 m, and in the south at Kingston just above sea level there is a low coastal strip bordering the only stretch of coral reef around Norfolk. Here also is the island's main sandy beach, crescent-shaped Emily Bay. The only other sandy beach of consequence is Anson Bay in the west which is bounded by cliffs nearly 100 m high (Fig. 2).

The climate is subtropical without extremes of temperature, the minimum being about 7°C (45°F) and the maximum about 28°C (81°F). Rainfall is generally fairly well distributed throughout the year at 1350 mm (53") annually, but tending to have a winter maximum and with severe droughts somtimes experienced, especially between Christmas and Easter. The small size of Norfolk means that wind is an important factor, and periodically storms do considerable damage, especially by salt-laden wind burning the vegetation. Fortunately, true hurricanes are much rarer. Thus, it is not surprising that wind-pruned shrubs and trees are very evident on many parts of the coast. However, apart from infrequent periods of stress caused by drought and storm, growth occurs in many plants all the year. This is particularly true in areas of fertile soils away from the coast.

HISTORY OF HUMAN ACTIVITIES ON NORFOLK

The story of human activity on the Island begins in the shadowy mists of the prehistoric pre-European period, since although there was nobody on Norfolk at the time of Captain Cook's discovery and landing at Duncombe Bay in 1774 (Fig. 3), and no earlier human remains have been found, signs of human presence have been discovered, e.g. several artifacts have been picked up in recent years. Also, the wild bananas that were there when the first Europeans came to settle must have been brought to Norfolk originally on some early voyage. A beautiful amaryllid, *Crinum norfolkianum*, was described in 1842 as an endemic species from Norfolk, but its whereabouts since seem to be almost as elusive as signs of prehistoric human activity. However, from an early painting it looks as if it could well belong to the

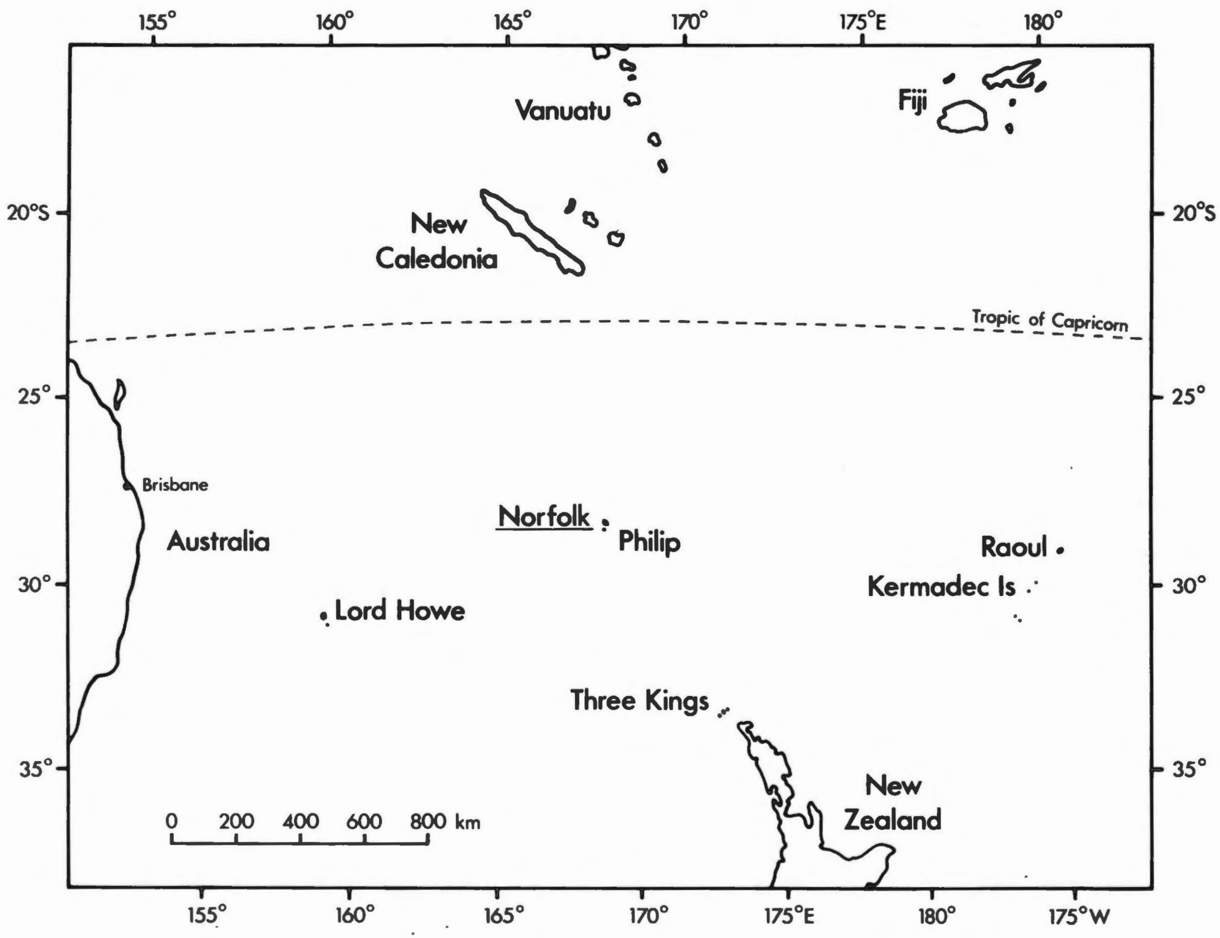


Fig. 1. Position of Norfolk Island in the SW Pacific.

Fig. 2 Anson Bay surrounded by high cliffs and having the second largest beach on the island.

Fig. 3 Duncombe Bay in the north-west, traditionally where Captain Cook's party landed in 1774.

variable *C. asiaticum*, a plant commonly cultivated throughout the tropical Pacific Islands; so it is tempting to wonder if *C. norfolkianum* is not also an ancient introduction.

The first chapter of settlement in modern times on Norfolk begins with the arrival in 1788 of Lieutenant Philip Gidley King with a party of convicts and soldiers. From then on until 1856, except for an interval of 12 years from 1814 to 1826, the island was a penal colony. The second period is notorious as being one of the most bloody and barbaric chapters in British colonial history (Hoare 1979). Such times seemed hardly propitious for botanical exploration, but there were several notable events in this period. During the summer of 1803-1804 the collector and painter Ferdinand Bauer was on Norfolk, and his endeavour enabled Endlicher (1833) to write the first flora of the island. In this work a large number of plants are described as new endemic species. In 1830 the botanist Alan Cunningham visited and collected on Norfolk (Heward 1842). He was able to get to Philip Island from where he was briefly kidnapped by escaped convicts but was fortunately not physically harmed. The convict period is also notable in that a considerable number of plants were introduced for cultivation, and some of the worst weeds on Norfolk today were brought in then, e.g. the two main guava species and African Olive.

Hard on the heels of the departing convicts in 1856 came free settlers. This was the result of an order from London commanding the removal of all the inhabitants from remote Pitcairn Island and their resettlement on Norfolk. Thus the latter came to be populated by the descendants of the Bounty mutineers and their Tahitian wives. Although some later returned to Pitcairn there are still many people on Norfolk who trace their origin back to that island. They constitute the islanders as opposed to the mainlanders, who are mostly people from Australia, and to a much lesser extent, from New Zealand.

Agriculture has been the mainstay of the Norfolk economy until recently, and large areas of the island were soon modified for growing crops, and grazing cattle and horses. The spread of weeds must have greatly increased because of the settlers clearing and modifying the land. This process has continued up to the present; e.g. since the last war the threat to the indigenous forest has increased markedly by the introduction and subsequent rapid colonisation of *Schinus terebinthifolius*, Hawaiian holly, a South American plant originally. This species is also a scourge in Florida and Hawaii, and was likewise introduced to Norfolk for its attractive clusters of red berries (Fig. 4). On the lighter side, the coming of the Pitcairners resulted in the indigenous plants and birds of Norfolk receiving a set of very picturesque common names, a number having a religious flavour as befitted this devout little community.

In 1856 Norfolk Island's link with Van Diemen's Land (Tasmania) was severed, and ever since it has been directly administered from Canberra, being accepted as a territory within the Commonwealth of Australia in 1914. In 1866 the Melanesian Mission was set up on Norfolk, and the subsequent contact with tropical islands to the north resulted in the introduction of Melanesian plants, several of which may still be seen. Since the Second World War duty free businesses have become established on the island, and these attract tourists from Australia and New Zealand. However, this development poses a great environmental threat to this small vulnerable island if not handled carefully.

Australian influence has been evident in the field of botanical research. In November 1902 J.H. Maiden (1903) went to Norfolk and collected extensively. However, he was shortly followed in 1912 by R.M. Laing, who was born in Dunedin but spent much of his life teaching in Christchurch. His account (1915) is the most comprehensive survey of the flora yet published. The only other work to note is the Australian Conservation Foundation booklet of Turner, Smithers & Hoogland (1968). In it the plants and animals are treated together and some of the problems connected with preserving what remains of the indigenous flora and fauna are described, and ways of achieving this was given.

STATISTICS AND COMPOSITION OF THE INDIGENOUS FLORA

Despite these accounts of its flora it

Fig. 4 *Schinus terebinthifolius*, Hawaiian holly, a new threat to the indigenous flora.

Fig. 5 Flowers and fruits in April on *Rhopalostylis baueri* var. *baueri*, Norfolk nikau.

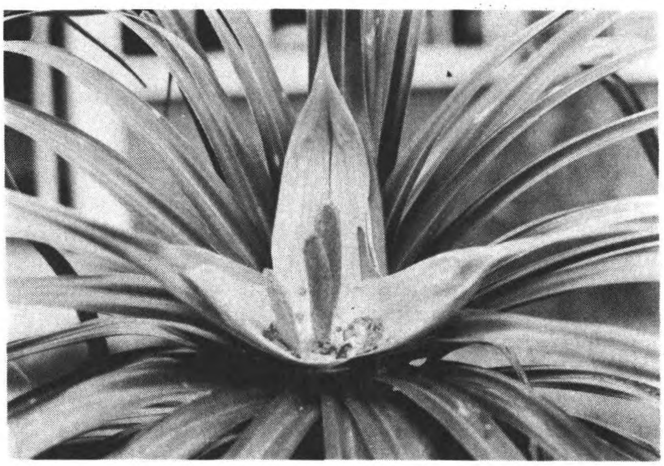


Fig. 6 The attractive, pink-bracted, male inflorescence of *Freycinetia baueri*, ssp. *baueri*, Norfolk kiekie.

is still only possible to give an approximation of the number of indigenous vascular plants on Norfolk. However, I estimate that there are about 165 species in this category, of which about 50, i.e. about a third, are endemic to Norfolk (including Philip). This total is made up of about 85 dicotyledons, 44 monocotyledons, one gymnosperm and 45 pteridophytes. The flora is therefore richer than that of the Kermadecs which has 113 species (Sykes 1977) but is poorer than that of Lord Howe with about 227 species, 127 of which are dicots (Oliver 1917; Recher & Clark 1974).

When one analyses the indigenous flora a little more closely it is evident that there are strong floristic links with New Zealand, and that these are mainly shown by the monocots, excluding the orchids, and the herbaceous dicots. Thus, a New Zealand visitor to Norfolk can feel at home amongst the rushes and most sedges, and high above them are: *Rhopalostylis baueri* var. *baueri*, Norfolk nikau, (Fig. 5), *Cordyline obtecta*, Norfolk cabbage tree, and in a few places climbing *Freycinetia baueri* spp. *baueri*, Norfolk kiekie (Fig. 6), all endemic but very closely related to New Zealand plants. Around the coast the dicots *Lobelia anceps*, *Samolus repens*, and *Tetragonia tetragonioides*, New Zealand spinach, will seem equally familiar as can *Muehlenbeckia australis*, pohuehue, in this and other habitats. Above all *Phormium tenax*, New Zealand flax, on several cliffs, notably at Ball Bay, is almost certainly indigenous despite suggestions to the contrary.

On the other hand, the woody dicots, particularly trees, have strong links with New Caledonia, Lord Howe and, to a lesser extent, Australia. Thus, Norfolk's famous pine and most important tree, *Araucaria heterophylla*, is closely related to *A. columnaris*, Cook pine from New Caledonia and the Isle of Pines. Norfolk Island pine is still the commonest tree (Figs 7 & 8) and it grows from the top of Mt Bates to the coast. Almost as common is *Lagunaria patersonii*, Norfolk Island hibiscus, (white oak on Norfolk). This species is also indigenous to Lord Howe and Queensland, and is well-known in cultivation in the warmer parts of the North Island. A dominant tree in some of the lowland forest remnants on Norfolk is the euphorbiaceous *Baloghia lucida*, aptly named bloodwood because of the sanguinary appearance of the sap. This is also indigenous to New Caledonia. *Elaeodendron curtipendulum*, Norfolk maple, is a common tree belonging to the Celastraceae, again occurring to the north. *Celtis paniculata*, called whitewood because of its whitish trunk, may or may not be endemic, but at any rate has close relatives in the tropical islands to the north. A feature of these two species is the tropical effect caused by the development of large buttresses at the base of the trunk.

In the Rutaceae a species each of *Bauerella* and *Zanthoxylum* are closely related to species further north and west, and in *Euodia* there is an endemic species with a close relative in Australia. A few other endemics are more distinct. The very rare soft-wooded tree, *Achyranthes arborescens*, surprisingly belongs to a genus represented in the tropical Pacific by a few species of herbs or subshrubs, and belongs to the Amaranthaceae. One of the most distinct endemics is an attractive pink-flowered tree in the Sterculiaceae, *Ungeria floribunda*, bastard oak. Along with the presumed extinct legume, *Streblorrhiza* of Philip Island, it represents an endemic genus.

In contrast to the Kermadecs where there is not one indigenous liane or woody climber there are a number on Norfolk. Nearly all are either conspecific with populations to the north and west or are endemics with their nearest relatives in those directions. Prominent are the picturesquely named devil's guts, *Capparis nobilis*, with nasty hooked prickles, and Samson's sinews, *Milletia australis*, a wisteria-like legume with large rope-like stems and dense foliage masses. *Melodinus baueri*, big creeper, and *Tylophora biglandulosa* are two plants with milky latex which belong to the related families Apocynaceae and Asclepiadaceae respectively. *Zehneria baueriana* has surprisingly thick rope-like stems for a member of the cucumber family. *Jasminum volubile* is a common white-flowered fragrant liane, an example of an almost worldwide genus which has failed to reach New Zealand naturally. Even the two species of *Clematis*, one of which is possibly extinct on Norfolk, do not have their closest relatives in New Zealand. The tropical Pacific *Wedelia biflora* comes south-

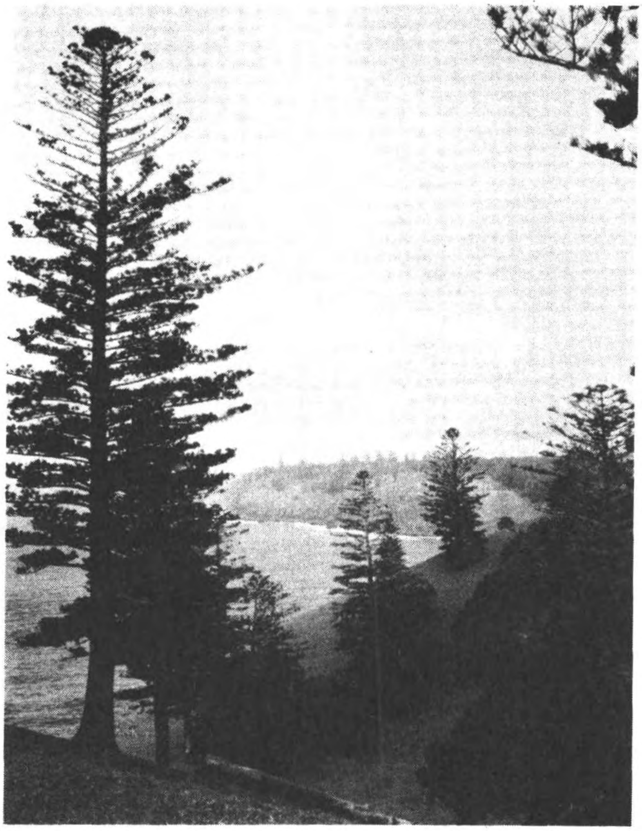


Fig. 7 Coastline near Cascade showing a park-like landscape with scattered *Araucaria heterophylla*, Norfolk Island pine.

Fig. 8 Philip and Nepean Islands from above Kingston and looking across Emily Bay. Note the prominence of *Araucaria heterophylla*.

Fig. 9 *Psidium littorale*, purple guava, probably the worst weed on Norfolk in respect to its effect on the indigenous vegetation.

Fig. 10 Scrub of adventive species in the Cascade Road area. Main weeds are *Psidium guajava*, *P. littorale*, *Schinus terebinthifolius*, *Lantana camara*, and *Polygala myrtifolia*.

Fig. 11 Herbaceous understorey of adventive *Rivina humilis*, coral berry, in the Hundred Acre Reserve.

wards to Norfolk and Lord Howe. Although not really a liane this very common coastal species has a scrambling habit somtimes.

On the other hand, Norfolk has certain woody plants in common with New Zealand, although several are rather rare in the latter area. Good examples are *Nestegis apetala*, ironwood, and *Planchonella costata*, (syn. *P. novozelandica*) tawapou (bastard ironwood on Norfolk), both mainly found on offshore islands now in New Zealand but important trees ecologically on Norfolk. An interesting small tree is our North Island *Pisonia brunoniana* (syn. *Heimerliodendron brunonianum*), parapara or birdcatcher tree, so-named because of the extremely viscid fruits. This species also grows in the Kermadecs, Lord Howe, New South Wales and probably in Hawaii. *Dodanaea viscosa*, ake ake, on Norfolk resembles the New Zealand form of the species more than it does that seen in Tropical Melanesia and Polynesia.

Several other trees and shrubs are doubtfully endemic to Norfolk, and may also grow on offshore islands around North Auckland or in the Kermadecs. Most of them require careful study to ascertain their true status. The large, glossy-leaved *Macropiper excelsum* var. *psittacorum*, kawakawa, is one of the main understorey shrubs on Norfolk, and the now rare *Coprosma baueri*, Norfolk taupata, generally considered to be an endemic species but which is extremely close to *C. repens*, New Zealand taupata. *Pennantia endlicheri*, related to our *P. corymbosa*, kaikomako, is probably conspecific with the single tree on the Three Kings Islands which until recently was called *Plectomirtha baylisiana*. The Norfolk *Myoporum obscurum* seems to be more closely related to the Kermadec ngaio, which I have made conspecific with it (Sykes 1977), than it is to either New Zealand ngaio, *M. laetum*, or the New Caledonian *M. tenuifolium*. The genus *Boehmeria* has an Old World tropical distribution but Norfolk's rare *B. australis* is undoubtedly conspecific with *B. australis* var. *dealbata*, Kermadec nettle tree.

In parts of Norfolk that have not been too severely modified, ferns are a feature and amongst the most striking are the two endemic tree ferns *Alsophila australis* ssp. *norfolkiensis* (syn. *Cyathea australis* ssp. *norfolkiensis*) and *Sphaeropteris excelsa* (syn. *Cyathea brownii*), as well as the giant king fern *Marattia fraxinea*. Ferns often have a wide distribution so most are not endemic, indeed they are likely to have wide distributions which include New Zealand, Australia, Lord Howe, and the tropical high islands to the north. Examples of such ferns are *Adiantum diaphanum*, *Cheilanthes distans*, *Histiopteris incisa*, *Phymatosorus diversifolius*, and *Pteridium esculentum*, bracken. Other ferns are not found in New Zealand proper although they may occur in the Kermadecs, e.g. a very common terrestrial fern in dry forest, *Arachniodes aristata*. But the handsome bird's nest fern, *Asplenium nidus*, the large *Pteris tripartita* and the small epiphytic *Vittaria elongata*, are species which are not in the New Zealand Botanical Region at all. It is not easy to name a fern shared with this region only but probably *Blechnum norfolkianum* is an example. The richest habitat for ferns on Norfolk is in the two or three valleys running down the south side of the Mt Pitt to Mt Bates ridge and the majority of species grow there. Some, such as the three filmy ferns, are almost confined to them.

INTRODUCED PLANTS

Adventive species

Although there are no modern figures for introduced plants on Norfolk there are probably at least as many adventive species (i.e. wild to a greater or lesser extent) as there are indigenous ones. As on Raoul Island it is the woody plants which pose the greatest threat to the indigenous vegetation, and the great majority of the worst ones are of tropical American origin.

Even in the Mt Pitt Reserve, which contains the best remaining indigenous forest, there are only a few parts which have not been, or are not in the process of being, invaded by *Psidium littorale*, purple guava (Fig. 9) and the already mentioned *Schinus terebinthifolius*. Around the forest margins and in clearings or wherever the canopy is open, there is often a dense growth of *Schinus* (Fig. 10). With them is often *Cassia floribunda*, buttercup bush, *Lantana camara*, prickly lantana, *Olea europaea* ssp. *africana*, African olive, *Psidium guajava*, yellow guava, *Solanum mauritianum*, tobacco weed, and last but not least *Eupatorium* *riparium*, its common name William Taylor deriving from the person said to have introduced it. This subshrub is probably the most abundant species on the island numerically, and forms dense stands in and around forest areas, on steep banks and almost all shady places. Surprisingly, the well-known ornamental Australian *Pittosporum undulatum* was almost killed in the severe drought of 1976, but had been a prominent weed prior to this. Seedlings subsequently appeared, of course, and now there are small bushes again.

The extensive pastures, lawns, roadsides, and many seaward slopes where cattle and horses graze cover a large proportion of Norfolk. These grassy areas are almost exclusively dominated by introduced plants with tropical or subtropical grasses predominating, especially *Axonopus affinis*, carpet grass, *Cynodon dactylon*, Indian doab or Bermuda grass, *Pennisetum clandestinum*, kikuyu, *Stenotaphrum secundatum*, buffalo grass, and on slopes just above the sea, *Sporobolus virginicus*. There are many other introduced grasses as well as some introduced sedges on Norfolk, in fact it is often hard to see an indigenous grass. The most likely species in the last category are the small *Cymbopogon refractus* along some coastal cliff tops, and the mat-forming *Microlaena stipoides*. There are introduced temperate grasses like *Briza minor*, quaking grass, *Catapodium rigidum*, *Poa annua* and *Vulpia bromoides*, and a number of other tropical species, among the more conspicuous being *Chloris gayana*, Rhode's grass *Melinis minutiflora*, scented molasses grass, *Paspalum dilatatum*, paspalum, *Rhynchelytrum repens*, the feathery red Natal grass, and in a few places *Sorghum bicolor*, similar to the dreaded Johnson grass, *S. halepense*, but without any rhizomes. The largest grass of all though, because it even dwarfs the occasional cultivated bamboo, is the giant Mediterranean *Arundo donax* of which there is a large stand about 10 m high in the bottom of the valley near the Melanesian Mission.

Arable land, waste places around houses, around fields and on many roadside banks exhibit a curious mixture of tropical and temperate herbaceous dicotyledonous weeds which resembles some weed communities on Raoul Island. Thus side by side with tropical species are well-known European species such as: *Chenopodium album*, fathen; *Euphorbia peplus*, spurge; *Linum trigynum*; *Plantago lanceolata*, ribwort; *P. major*, greater plantain; *Polycarpon tetraphyllum*, allseed; *Sherardia arvensis*, field madder; *Sonchus oleraceus*, sowthistle or puha; *Stachys arvensis*, staggerweed; *Stellaria media*, chickweed, and *Verbascum thapsus*, woolly mullein, a long-time resident at the top of Mt Pitt. With them are more tropical species such as: *Ageratum conyzoides*, *Argemone mexicana*, Mexican poppy; *Bidens pilosa*, devil's needles or beggar's ticks; *Commelina diffusa*, *Desmondium canum*, *Euphorbia prostrata* - only in cultivated ground - *Malvastrum coromandelianum*, *Nicotiana tabacum*, tobacco; *Salvia coccinea*, scarlet sage; *Sigesbeckia orientalis*, *Solanum sodomaeum*, apple of Sodom; *Tagetes minuta*, stinking Roger, and *Triumfetta rhomboidea*. The last two are potentially serious and probably quite recent arrivals. All the temperate species mentioned above have been recorded in the New Zealand Botanical Region, as have the majority of the tropical species, although several of the latter group are uncommon.

Some other introduced plants are naturalised in and around one or two stands of lowland indigenous forest that are partly or completely surrounded by modified communities. In particular, in the Hundred Acres Reserve, near Rocky Point at the south-west corner of Norfolk, a number of species are adventive which are almost unknown elsewhere on the island. Here there is a herbaceous understorey of *Rivina humilis* (Fig. 11), coral berry, in one part of the *Araucaria/Lagunaria*-dominated forest. This small member of the *Phytolacca* family has whitish flowers and little glossy crimson berries. Nearby, grows the New Zealand *Pittosporum crassifolium*, karo, as an understorey shrub to the Norfolk pine on a seaward slope. In the Reserve is *Cinnamomum camphora*, camphor tree, and this has spread extensively from suckers from originally planted trees, and also in the laurel family there was a few wild trees of *Cryptocarya triplinervis* from Australia. The edible *Eugenia uniflora*, Brazilian cherry, is now wild to a limited extent there. Near the Reserve *Ligustrum lucidum*, tree pivet, is occasionally seen, and this species may well prove to be a serious weed if not controlled.

The margins of such small forest stands are inevitably rather exposed, and introduced climbers, as well as indigenous ones, are often prominent. In the former category are the almost ubiquitous *Lantana camara*, and *Asparagus setaceus* (*A. plumosus*), *Impomoea indica* (*I. congesta*), and occasionally *Anredera cordifolia* (*Boussingaultia baselloides*), Madeira vine. In at least one place *Solandra hartwegii*, cup of gold, is now wild. Fortunately, *Caesalpinia decapetala*, Mysore thorn, has remained rare except for the area of the Melanesian Mission, and is not posing the threat to the indigenous forest that it is on Raoul Island.

CULTIVATED PLANTS

A discussion of the vegetation of Norfolk would not be complete without mention of the cultivated flora. It is difficult to know where to begin because there is now such a wide range of plants grown on the island, and more are being imported, for the possibilities are immense in this respect. It seems that most crop and ornamental plants can be successfully grown except for those on the one hand that require a cool or cold temperate climate, (especially a colder winter than Norfolk has), or on the other hand must have a tropical climate with a minimum temperature of around 13°C (55°F). These limitations do not apply strongly for annual crops, because temperate ones can generally be grown in the winter providing that there is not a strict requirement for long days, and tropical annuals thrive in the summer. Apples, apricots and many plums are not very successful and neither are strictly tropical species like *Artocarpus heterophyllus*, jak fruit, *Cocos nucifera*, coconut, or *Delonix regia*, flamboyant.

The most important cash crop on Norfolk now are the nuts from the two Lord Howe Island palms, *Howea forsteriana* and, to a lesser extent, *H. belmoreana*. There are large numbers of trees, and the nuts are harvested in March and exported to Europe. For local consumption there are many edible subtropical fruits: especially *Aberia caffra*, Natal plum, which makes an inpenetrable thorny hedge as well; *Carica papaya*, paw-paw, a summer and autumn crop on Norfolk; *Citrus* spp., a variety are grown; *Eriobotrya japonica*, loquat; *Feijoa sellowiana*; *Musa acuminata*, the name covering most of the bananas there; *Passiflora edulis*, both purple and the better, more tropical yellow (f. *flavicarpa*), passionfruit; *Persea americana* - there are many fine avocado trees - and *Psidium* spp. - guavas are not cultivated now but are still highly esteemed for jam and jelly as well as for consuming when fresh.

For those Norfolk Islanders interested in growing ornamental plants there is plenty of scope for creating a Garden of Eden. As well as all the usual annuals grown in New Zealand, many of our "house plants" such as begonias, succulents, foliage plants, etc., thrive outside and may even become naturalised. Since Norfolk is eight degrees nearer the equator than Auckland, more tropical plants are grown in addition to the usual garden plants of warmer parts of this country. Species in the latter category include some of our indigenous trees, e.g. *Corynocarpus laevigatus*, karaka, *Metrosideros excelsa*, pohutukawa, *M. kermadecensis*, Kermadec pohutukawa, now also spreading naturally, *Pseudopanax discolor* x *P. lessonii*, and *Vitex lucens*, puriri.

Many East Australian ornamental woody plants familiar in New Zealand flourish on Norfolk; e.g. several species of *Acacia*, *Acmena smithii*, lilly pilly, *Brachychiton acerifolium*, Illawarra flame tree, *Casuarina cunninghamiana* - several groves of this sheoke - *Castanospermum australe*, Moreton Bay chestnut, *Ficus macrophylla*, Moreton Bay fig, of which there are several immense buttressed trees, *Grevillea banksii* and *G. robusta*, silky oak - the latter regenerates in the Hundred Acre Reserve - *Syncarpia glomulifera*, turpentine tree, and there are plantations of several species of *Eucalyptus* - one notable one is *E. saligna*. One of the few West Australian species on Norfolk is *Albizia lophantha*, and as in New Zealand this is adventive.

Another part of the world contributing notably to the garden flora of Norfolk is South Africa, with species from the more temperate western Cape and subtropical Natal thriving. Thus, several of the well-known *Pelargonium* hybrids are successful, composites such as *Dimorphotheca ecklonis*, *Gamolepis chrysanthemoides* and a range of *Gerbera jamesonii* colour forms, *Calodendrum capense*, Cape chestnut, *Bauhinia galpinii*, *Strelitzia nicholii* - a large white bird of paradise plant - and there are big rambling hedges of *Tecomaria capensis*, Cape honeysuckle, as there are in New Zealand. Lastly, although it is scarcely cultivated now *Polygala myrtifolia*, sweet pea bush, is naturalised near a number of roadsides where it has escaped from cultivation. From the region from northern South Africa northwards come several successful small herbs or shrubs; e.g. *Hypoestes phyllostachya*, polka dot, and *Pentas lanceolata*, both occasionally more or less adventive. *Ochna serrulata*, Mickey Mouse plant, has escaped from cultivation and is starting to cause concern because of the ease in which seeds from the black berries grow in forest remnants bordering on gardens on the upper side of Burnt Pine.

The subtropical nature of the climate is apparent, for some of the more tropical ornamental trees and shrubs which grow very successfully on Norfolk are only marginal in open garden sites in New Zealand, even north of the Volcanic Plateau. Examples are *Acalypha wilkesiana*, copper leaf, a popular hedge plant on Norfolk, *Bauhinia purpurea*, butterfly bush, *Citharexylum spinosum*, fiddlewood - this could become a nasty weed if not watched - *Ficus altissima* (?), a large banyan with huge buttresses and fairly large oblong figs, *Montanoa hibiscifolia*, an unusual shrubby Mexican composite, *Plumeria rubra* - several cultivars of frangipani are grown - *Spathodea campanulata*, African tulip tree, and *Syzygium jambos*, rose apple. *Malvaviscus arboreus*, Turk's cap, is well-known in New Zealand but here the type variety *arboreus* is the one seen whereas on Norfolk the more tropical var. *penduliflorus* is grown.

Space does not allow for discussion of ornamental species from other parts of the world, such as the warmer parts of Asia and the New World, for in particular, the subtropical and tropical regions of Latin America have contributed many species of Norfolk gardens and, as already mentioned, some have become serious weeds. Thus, it is an eminently sensible precaution to place restrictions upon the importation of plants to Norfolk, and there is now legislation to try and enforce this. A more insidious threat to the indigenous flora of Norfolk is to introduce plants closely related to endemic species, since the danger of genetic pollution from hybridisation will be especially great on such a small island. The most obvious plant at risk is the Norfolk Island pine itself because of the recent introduction of other araucarias for trial in plantations. Fortunately, there are people aware of the dangers of allowing this sort of thing to happen and so one hopes that wiser counsel will prevail.

ACKNOWLEDGEMENT

I gratefully acknowledge the assistance and hospitality given by Beryl and Owen Evans whilst visiting Norfolk. Owen's unrivalled knowledge of the island's flora and fauna has been invaluable to just about every biologist visiting Norfolk for the last 20 years or so.

REFERENCES

Endlicher, S. 1933: Prodromus Florae Norfolkicae. Vienna: 1-100.

Heward, R. 1842: Biogeographical sketch of the late Alan Cunningham Esq. Part I, *Hooker's Journ. Bot. 4:* 231-320 and Part II, *Hooker's London Journ. Bot. 1:* 107-128, 263-292.

Hoare, Merval 1979: Norfolk Island. A history through illustration 1774-1974. Australian Government Publishing Service, Canberra. 73pp.

Jones, J.G. & McDougall, Ian 1973: Geological history of Norfolk and Philip Islands southwest Pacific Ocean. *Geol. Soc. Aust. 20(3):* 239-257.

Laing, R.M. 1915: A revised list of the Norfolk Island flora, with some notes on the species. *Trans. Proc. N.Z. Inst. 47:* 1-39.

Maiden, J.H. 1903: The Flora of Norfolk Island, Part I. *Proc. Linn. Soc. NSW 28:* 692-785.

Oliver, W.R.B. 1917: The vegetation and flora of Lord Howe Island. *Trans. Proc. N.Z. Inst. 49:* 94-161.

Recher, Harry F.; Clark, Stephen S. (Editors)

1974: "Environmental Survey of Lord Howe Island". A Report to the Lord Howe Island Board. Department of Environmental Studies - the Australian Museum. Government Printer, Sydeny. 86 pp.
Sykes, W.R. 1977: Kermadec Islands Flora: an annotated checklist. *N.Z. DSIR Bull. 219*. Wellington. 216 pp.
Turner, J.S.; Smithers, C.N. and Hoogland, R.D. 1968: "The Conservation of Norfolk Island". Australian Conservation Foundation Inc. Special Publication No. 1, Canberra. 41 pp.

The Export Service of Turners & Growers

by

B. Porteous

Turners & Growers Ltd., Auckland.

Over the last 12 months there has been a tremendous amount of interest in growing of Proteaceae and foliage material for export, with many hectares going into production. Turners & Growers have been swamped with enquiries from people from all over the country requesting information on what, and how to grow for export. Although we still do not have nearly enough supplies for export, the situation is quickly changing so we may be faced with an over-supply in the very near future.

Production

We are trying to talk direct growers into producing different types of material for export markets, rather than all growers producing the same type of flowers. As mentioned previously, there may be a danger with over-production of some lines. Most of the material we are able to grow and export from New Zealand has limited markets; and if large quantities of supplies are landed on export markets, the prices could drop to a level when it is no longer economic to grow for export. Israel is facing this problem today with certain fresh cut flowers - how much more real is the factor with flowers from N.Z. that are highly priced, with a high freight content, and with limited markets available.

Marketing

Turners & Growers have developed a highly qualified export team to assist with the marketing of flowers. In addition, we are able to use the services of our field representatives nationwide.

We are continually investigating new market opportunities for growers and are now exporting to many different countries around the world. However, opening up these new markets has not been easy, we have been able to do so by offering our customers a large range of flowers and shipping on a regular all year-round basis.

Many lines we have offered our customers, we have found that there has been no market for. Yet, with their co-operation, we have been able to develop markets for some other lines with considerable market potential. Growers today can now take advantage of this market knowledge that we have obtained.

We have recently spent considerable time in Europe and Japan, looking at markets for proteaceous flowers and foliage from New Zealand. Overall, there was considerable interest in the material we have to offer, but -

1. The exporters must perform,
2. Growers must produce quality,
3. Prices must be competitive.

Nearly all importers in Europe prefer to purchase on a fixed price basis; while in Japan, flowers are sold in auctions, similar to New Zealand. Duty on flowers in Europe is between 17-24 percent while foliage is at 4 percent. We are exporting *Leucadendron* as foliage rather than flowers because of this Japan has a duty of 5 percent on both flowers and foliage.

Growers need to be aware that New Zealand is not the only country in the world producing flowers - many other countries are looking for ways to increase their flower exports also. We are already receiving inquiries for foliage and *Leucadendron* plants from other countries to grow for the cut flower trade, and from countries much closer to the market than we are. We live in a very small world that is changing fast - South Africa and Australia especially, have considerable areas of proteaceous material under production. We must make the best use of our climate, soils, and growing skills and growing the best cultivations if we are going to compete on international markets.

Though it is always our policy to obtain the maximum prices for growers; we are selling on a very competitive market when prices do fluctuate rapidly with supply and demand. Always, growers should strive to obtain the highest quality possible for export.

Normally, growers are paid out within 14-20 days of deliveries of flowers. Turners & Growers accept responsibility for flowers after inspection by M.A.F. for phytosanitary requirements, and checking by our staff. If any flowers are not accepted for export, they will be sold on the local auction under the grower's name.

Air Freight

Growers must realise the following factors concerning the air freight of cut flowers:

1. It will only be feasible to air freight cut flowers and foliage by commercial passenger flights on commodity rates.
2. The economics of using chartered planes to freight large amounts of flowers from New Zealand to markets on the other side of the world are not viable because -
(A) The very high freight rates for chartered planes would make our flowers too expensive.
(B) As our flowers are highly priced, they fill the top-end of a market. They are required to be delivered to many markets in small quantities at frequent intervals.
(C) The logistics of delivering full plane loads of flowers from distant N.Z. is too great to be practical - both in obtaining supplies and selling them.
3. The government's current policy is not to subsidise the air freight business.
4. Air freight rates are going to continue to escalate with increasing fuel costs.
5. The government should be encouraged to allow as many new overseas airline flights into N.Z. as possible; which would increase the air freight capacity available for export, and stimulate competition in the airfreight business.

Growers need to be aware that the development of export flowers from N.Z. on the present scale has only been possible with the introduction of the wide bodied jet. New Zealand at present, has one of the lowest freight rates in the world for cut flowers - a rate that may be faced with a considerable increase in the future. A grower should take these factors into consideration when planting a new crop, and be looking at producing those crops with a low freight content/high re-sale value. The *Leucadendron* for example, would be favoured over the King Protea.

Grading and Packing for Export

There have been a number of problems with the grading and packing of material for export. Growers should observe the following steps when picking and grading their flowers.

1. Foliage should be clean, without marks, blemishes, cuts, broken leaves or insect damage.
2. There should be no pests or diseases on flowers or foliage.
3. Stems must be as long as possible at all times.
4. Flowers should stand in water 2-4 hours before packing.
5. Remove leaves from the lower 10cm of stem.
6. If bunching stems, bunch in lots of ten.
7. When packing, use newspaper in the bottom of carton and around flowers.
8. Foliage will be bought by the kilo or half kilo - this is the method it is normally sold overseas, rather than per bunch as in this country. It does not matter the number of stems per bunch - the weight involved is what is important.
9. Growers are required to pack in Turners & Growers export cartons. There are 2 sizes available from Turners & Growers branches around New Zealand. These are supplied without charge to the growers, except freight charges

for delivery. Growers should take care of these cartons and return them to the branches where supplies were obtained if they decide not to continue exporting.

10. Stems should be secure in boxes, without movement.

11. Growers should advise Turners & Growers agents before the dispatch of flowers; to see which day we can arrange for export. We must receive the exact quantities being sent, the day before dispatch.

12. Picking should be done on day of dispatch. Old flowers will not be accepted.

13. Growers are to use Turners & Growers consignment book when consigning flowers for export. A copy of the consignment note should accompany flowers attached in an envelope to one carton.

14. Growers should write their consignment note on the right hand corner of each carton.

15. Growers to write the name of flowers and number of stems or bunches at the end of each carton.

Our local representatives would be happy to assist you if you require any additional information.

Growers intending to grow for export, should look at what the market requires, and endeavour to produce for that market. Factors to take into consideration when selecting material to grow for export are:

A. Length of stem - material must have a long stem.

B. Flowers are preferred with bright colours, especially reds and pinks.

C. Foliage and flowers should have 14-21 days vase life, without dropping leaves.

D. Purple or red foliage in demand, as with *Lophmyrtus*, for background work in arrangements.

E. There is a limited demand for mixed lines, with a range of material that a florist may use.

Naming of Cultivars

With some new cultivars, there has been some confusion on the naming of material we have endeavoured to maintain the correct botanical names to all species exported, but in some cases, it may be better to establish suitable 'marketing names' acceptable to overseas markets. I have made the following suggestions:

Leucadendron salignum red cultivars
Including 'Mrs Stanley', 'Fire Glow' - all to be called 'Fire Glow'.

L. 'Red Gem'
To remain the same

L. 'Safaria Sunset'
To remain the same

L. 'Safaria Gold'
To be called 'Red Gem'

L. cordifolium
Pin Cushion (mainly U.S.A. and Japan)

Lophomyrtus 'Kathryn'
Common name required.

Phormium
Commercial names could be required.

Protea barbigera
Queen Protea

P. cynaroides
King Protea

Telopea
Waratah

We would welcome suggestions on the naming of material.

Summary

We are now entering a very exciting stage of development for New Zealand flower export industry. The future looks promising if growers concentrate on producing quality material that is in demand overseas - especially material that is new and different. As long as freight costs do not escalate too much, that the freight capacity is there, and other producing nations do not undercut us, we should be able to market considerable quantities of material from New Zealand.

Those lines of special interest overseas are:

Leucadendron salignum
Lophomyrtus 'Kathryn'
Telopea
Phormium

Drawings of N.Z. Native Plants

by

H. Young

Department of Horticulture, Landscape and Parks, Lincoln College, Canterbury.

<u>Fuchsia</u> <u>excorticata</u>

Kotukutuku

Kotukutuku is the largest fuchsia in the world being easily recognised from its shaggy appearance as the outer bark peels away. The flower is not that significant in size but the colour of the pollen, blue, is quite rare. As the flower opens its colour changes from purple to deep red. The fruit is a black juicy berry for which the maori name is konini.

Clematis paniculata

Puawananga

In maori it means 'the sacred flower' and be it true when in spring this climber produces its starry blossoms. The staminate flower is larger and seemingly more showy than its female counterpart. The clematis has no petals and so it is the elegant white sepals which gives the flower its showiness.

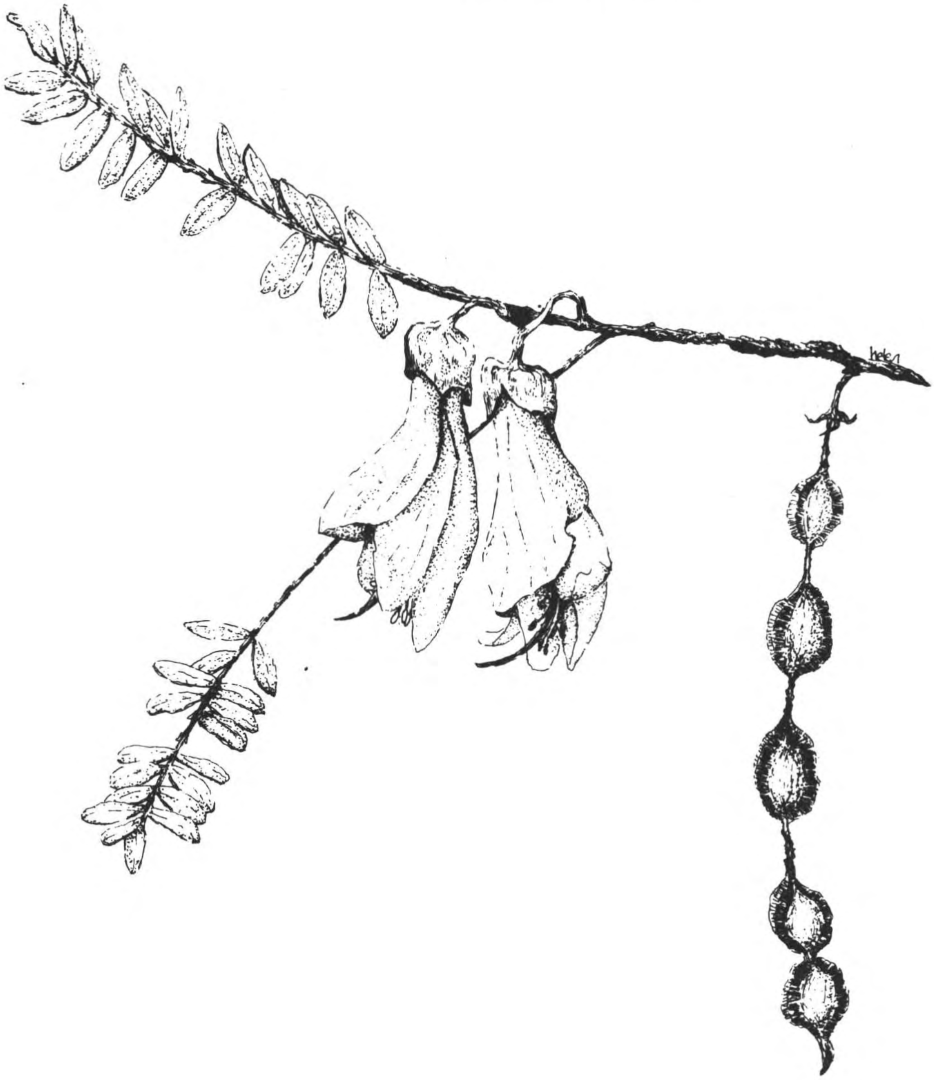
Hoheria populnea

Houhere

The common name 'lacebark' is derived from the pattern of the inner layers of bark.
The tree has a very delicate appearance, particular when in flower. The slender branchlets, bearing the perfect white flowers in profusion, give the tree an almost poplar-like appearance.
Several garden cultivars have also been developed.

Pittosporum eugenioides
Tarata

Commonly called 'lemonwood' due to the strong lemony smell emitted when the leaves are crushed.
The maoris mixed the flowers with fat for annointing their bodies or used the sap as a scent.
The flowers are very small, bell shaped, and occur in large corymbs. The leaves have a very light green midrib and an undulating margin.



<u>Sophora tetraptera</u>
Kowhai

Could it be debatable that the kowhai is our most beautiful tree? When the pendulous golden flowers abound in spring bringing a richness into any landscape, home or wild, it can be understood why this tree has been chosen as a national emblem.

The nectar of this flower is a favorite food for many native birds.

Loder Cup Award 1979
Mr and Mrs R.A. Sutton

This is the 50th award of the cup since its inception and marks a milestone in the history of the award.

The Loder Cup Award is made annually by the Minister of Agriculture to encourage the protection and cultivation of the native flora of New Zealand. The Cup was presented for competition within New Zealand by the late Gerald W. Loder, late Lord Wakehurst of England, the first award being made in 1929.

Mr and Mrs Roger A. Sutton of Lorneville, Invercargill were jointly nominated for the Loder cup award, by the Southland Branch of the Royal Forest and Bird Protection Society.

For many years Mr & Mrs Sutton have collected seeds and cuttings from native trees and propagated them in their own garden. Originally the idea was to raise the trees to suitable size for planting out, then to gain permission from Local Bodies to beautify selected road-side areas with them.

As a member of Invercargill Conservation Committee, Mr Sutton realised their supply of small trees could be an appropriate way of raising funds for Conservation Week activities and at the same time result in the planting of many native trees around Southland.

This was the small beginning, some fifteen hundred trees being sold the first year and which has grown each year since. In May 1977 the trees were not only sold in Invercargill, but throughout Southland wherever there was a Ranger Guide company to help out. A conservative estimate shows that since its beginning in 1974 the scheme has distributed about fifteen-thousand (15,000) native trees to interested people. The plants are healthy and grow well, customers arriving back year after year for further supplies.

All the proceeds from sales have been used for financing conservation week activities in Southland. (Expenses for guest speakers, Estuary Seminar, hall hire, advertising pamphlets, essay and poster prizes.)

Though Mr & Mrs Sutton gratefully acknowledge the help of the Ranger Guides in the sales department, the amount of work they have done to prepare the trees to the sale stage is prodigious. Each year they have gathered and cleaned seeds and taken cuttings, then planted them in seed boxes. As the seedlings develop they are potted into containers. The potting soil has to be mixed and sieved and thousands of cans (soft drink, beer and food) collected and tidied up ready for use. As the small trees grow, they have to be weeded, watered and sprayed. Tribute to the care and attention given them is the very small failure rate and the beautiful trees produced.

From seed Mr & Mrs Sutton grow: *Dodonaea viscosa*, *Aristotelia serrata*, *Carpodetus serratus*, *Clianthus puniceus*, *Podocarpus spicatus*, *Pseudopanax crassifolius*, *Metrosideros umbellata*, *Clematis paniculata*, *Parsonia heterophylla*, *Myosotidium hortensia*, *Hoheria* spp., *Phormium* spp., *Cordyline* spp., *Sophora* spp. and *Pittosporum* spp. From cuttings: *Hebe* spp., *Olearia* spp., *Senecio* spp. and *Fuschia* spp.

Mr Sutton is well known in Southland for the excellent talks he gives (about 20 a year) to schools, youth groups and other organisations on planting native trees to attract native birds. As a keen ornithologist this is a subject most important to him. Mrs Sutton cannot be persuaded to speak publicly, but puts in many extra hours at home instead tending the young trees.

Mr Sutton also conducts nature walks through the Waituna Wet land Management Reserve. His knowledge of the flora and fauna of this area is second to none because he and Mr Owen Marshall were instrumental in having the area gazetted as a wet land reserve in the first place. Subsequently it has been given world status.

This year (1977) Mr & Mrs Sutton have realised part of their ideal. After ploughing their way through much formality and red tape, they have been allowed to plant a good selection of their trees on the embankments of the road railway bridge at Lorneville near their home.

Citations for the Award of Associate of Honour A.H.R.I.H. (N.Z.) 1980

Edward Hugh Latimer

Hugh Latimer was born in Timaru in 1926 and after attending Timaru Boys' High School and Nelson College, joined the Treasury Department, Wellington, as a clerical cadet.

Upon completion of this cadetship, he returned to South Canterbury to work on various farms as a prerequisite for the diploma of agriculture course at Lincoln College which he completed in 1949 being awared the College gold medal.

After spending 4 years with the extension division of the Department of Agriculture, he transferred to the Justice Department as Farm Supervisor of the 1200 ha Waikeria Prison Farm and it was here that his interest in horticulture developed since, in addition to the extensive farming operations, he was also responsible for production of all vegetable requirements for the upper North Island prison institutions, a 7 ha mixed orchard, institution gardens, shelter planting and general beautification.

In 1959 he joined the Cornwall Park Trust Board in Auckland as Park Director responsible for the maintenance and development of the 162 ha area of urban parkland.

He commenced his N.D.H. in 1962 and completed it in 1966 and during this time and in later years held the offices of secretary, chairman, president and executive member of the Auckland District Council R.N.Z.I.H.

His interests in the Institute have been maintained over the past 20 years and he has rendered much assistance to examination students.

His work at Cornwall Park has been responsible for the conversion of a once poorly maintained and patronised area into the primary parkland area of greater Auckland which is the centre of both active and passive recreation for large numbers of people.

In 1965 he was appointed, in addition to his duties at Cornwall Park, as a consultant to New Zealand Steel Limited, Glenbrook, responsible for all agricultural and horticultural operations.

His work here continued until 1973 during which time he re-developed ten dairy units into one sheep and cattle unit so consolidating the 200 ha area into a green belt surrounding the steel mill.

All shelter belts, ornamental and roadside plantings and plantations on the green belt as well as lawns, roadside verges, playing areas and tree and shrub plantings on the adjacent staff housing areas, were established under his guidance and control to give an area which is today a much admired industrial complex in a parklike setting.

In 1968 he was responsible for the extended development of the park nursery to initiate and implement a scheme to grow trees and shrubs for free distribution to all local bodies, charitable organisations and some schools in the Auckland area.

This distribution now totals an average of 20,000 plants annually with 75% of these being native species, the use of which he has fostered.

He has maintained an advisory service to many of the smaller local bodies and numerous other organisations who do not have parks officers or horticulturists planning their plantings, horticultural development and maintenance work.

In 1965 he was elected a fellow of the Institute for his services to the Auckland

District Council.

Mr Latimer's horticultural interest and activities in the Auckland area are thus extensive and varied and he is highly regarded as a professional park officer and horticulturist.

He has been a member of the executive committee of the New Zealand Institute of Park and Recreation Administration for the past 12 years representing the Auckland zone.

We have much pleasure in nominating him for the award for Associate of Honour and I am sure that his work, both for the Institute in general and parks and horticulture in the Auckland area in particular, will continue for many years.

Mrs Daisy Alice Hardwick

It would be no exaggeration to say that when ornamental or domestic horticulture in the Tauranga area is mentioned the name of Mrs Daisy Hardwick is the first one to come to mind.

The essential facts of Mrs Hardwick's life are simple. Married and having raised a family, Mrs Hardwick and her husband were developing a large property on the Minden Hills overlooking Tauranga Harbour. Widowed in 1961, she has continued to live on the Minden property. With an interest in and love of horticulture from childhood, she has devoted much of her life to the spread of horticultural knowledge in the whole Bay of Plenty area. She was employed for 15 years in the retail nursery trade, and through that channel became very well known as a dispenser of sound horticultural advice. From 1952 she gave fortnightly talks on gardening on Radio 1 Y D, Rotorua. After Radio 1 Z D, Tauranga, opened in 1961 she conducted her own weekly gardening session. She wrote the gardening notes for the Bay of Plenty Times for 16 years. More recently she has written fortnightly gardening notes for the Bay Sun.

However, this is only one side of Mrs Hardwick's activities. Although with no horticultural examinations, she has studied horticulture extensively, she has a substantial library, and has attended refresher courses and seminars at Massey and Ruakura. She has given freely of her horticultural knowledge in a wide number of ways. Over a period of 28 years she has been a regular speaker, shower of slides, and dispenser of horticultural advice, invariably authoritative, to Garden Clubs, other horticultural groups, Country Women's Institute Groups, etc., not only in Tauranga, but as far afield as Reporoa and Paeroa. She has not turned down a request she could possibly fulfil, even at short notice when a scheduled speaker has failed to recompense. She has invariably given assistance at horticultural shows and has been a regular judge of cut flowers. She has also a sound knowledge of garden landscaping, and has guided landscaping projects such as various aspects of the Tauranga Historic Village, and has not hesitated to get in and do some of the physical work herself.

Mrs Hardwick has been Patroness of the Tauranga Federation of Garden Clubs since its inception approximately 15 years ago (12 constituent clubs), and has actively supported all Federation projects. She has been a member of the Royal New Zealand Institute of Horticulture (Inc.) for about 20 years and a Fellow since 1966. When the Bay of Plenty District Council was formed in 1973, she early accepted the position of Secretary, which position she still holds, and has been at the centre of all District Council activites.

Richard John Nanson

Richard John Nanson was born on 16 April 1937. He was apprenticed to Duncan and Davies Ltd., New Plymouth for 2½ years before transferring to Christchurch Parks and Reserves Department for a further 2½ years as an apprentice.

During his apprenticeship he studied and passed all N.D.H.N.Z. examinations apart from the Thesis which he completed in 1966 gaining the Cockayne Gold Medal for that year.

After the successful completion of his apprenticeship he travelled overseas to gain further experience and held the position of Head Gardener for the late Constance Spry for 20 months before taking the year's course at "The Grotto" in Public Park Administration. On completion of this course he travelled through Holland and Belgium for a time to observe horticultural practices in both countries. On return to Britain he completed a term of nearly a year with John Waterer & Sons and Crisp as a Landscape Foreman undertaking both commercial and private projects in southern England.

On his return to New Zealand he was appointed Assistant Superintendent of Parks in Hamilton, a position he held for five years prior to his appointment to his present post as Deputy Director of Parks and Reserves in Wellington.

While in Hamilton he took a keen interest in the Institute's affairs and was an active member, with particular emphasis in the landscaping of the Waikato University, the preservation of portions of bush reserves and the establishment and formation of a Civic Trust for Hamilton.

He has been a member of the Royal New Zealand Institute of Horticulture since 1954 when he first started his career as a full time horticulturist, and has been an executive member for the last 17 years in Hamilton and Wellington. In 1970 he was elected a fellow of the Institute.

In Wellington he has taken an active part in the Institute's work as an executive member and served as chairman of the Wellington District Council for three years, also an examiner for the N.D.H. for some 12 years. He has devoted a great deal of time in advising and co-operating with progressive associations, schools, sports groups and churches. He has given innumerable talks and lectures, promoting interest in horticulture and assisting with many weekend working groups. At present he is co-ordinating the activities of the Adult Detention Centre and Wellington College in the clearing of gorse and replanting of the hills above the college.

His duties as Deputy Director of Parks have involved him in the extensive landscaping and planting associated with the Wellington Motorway and the many beautification schemes in the city and suburbs.

Mr Nanson was a foundation member of the New Zealand Association of Landscape Design. He served as President and was a member of the executive for five years. For two years he conducted a Gardening Programme on Wellington TV 1 and also participated on a radio talk back programme.

The Institute and other bodies interested in horticulture are indeed fortunate that this dedicated horticulturist is prepared to contribute such a vast amount of time and effort to promote horticulture outside his busy hours of work associated with the position of Deputy Director of Parks for Wellington.

Gunnera hamiltonii

by

C.J. WEBB

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Gunnera hamiltonii was first collected from coastal Southland, and later recorded for Stewart Island. Apparently only one population of this attractive species now survives in the wild, and this is the coastal dunes of Mason Bay, Stewart Island (Fig. 1). The leaf blades and petioles are red-tinged, and the leaves are arranged in rosettes of up to 10 cm diameter. The species is perennial and strongly stoloniferous forming mats of up to 1 m across at the dune edges.

G. hamiltonii is sometimes cultivated, as its vigorous growth makes it an excellent tub or rockery plant. It establishes readily from single rosettes, and it often flowers (Fig. 2) in cultivation but seldom, if ever, produces good seed.

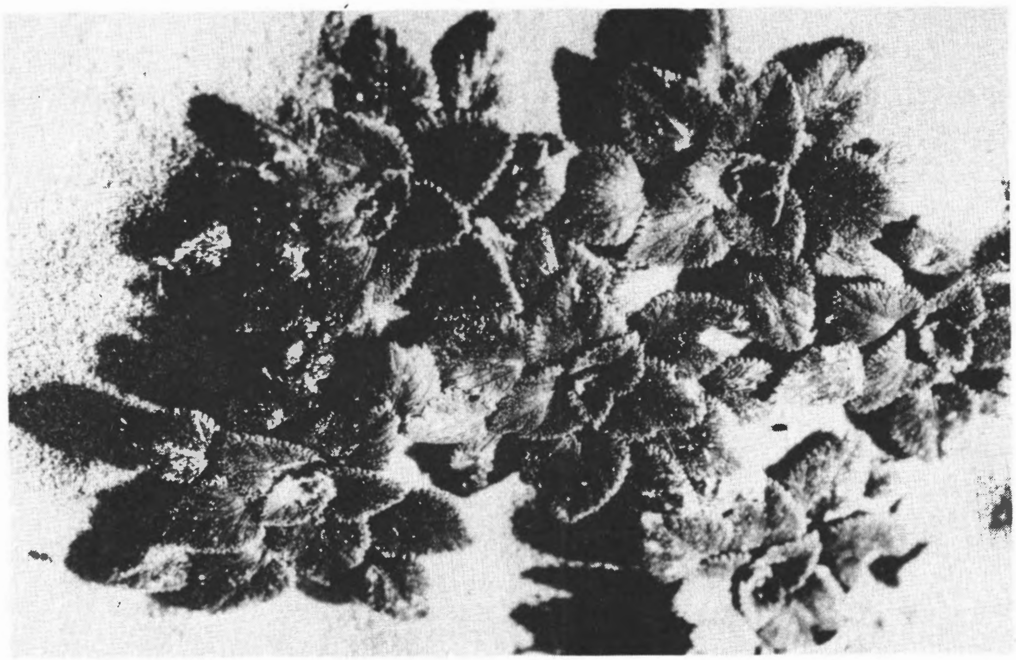

Fig. 1 *Gunnera hamiltonii* growing in sand dunes, Stewart Island (reprinted with permission from *N.Z. Journal of Botany 14:* 362).

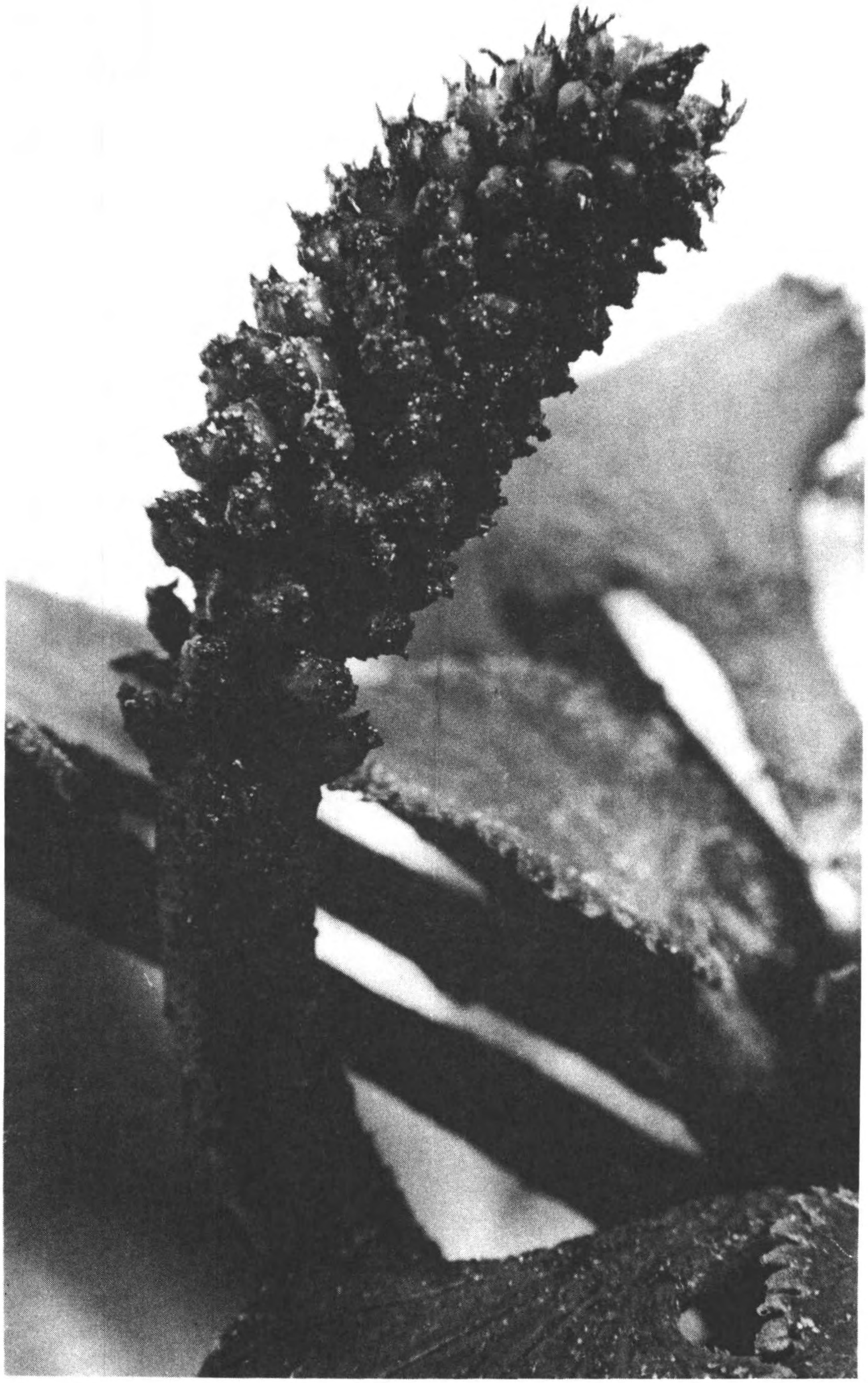

Fig. 2 *Gunnera hamiltonii*; spike of female plant showing immature fruit. (Photo - M. Hargest)

Seed Coat Dormancy in *Passiflora* Species

by

M.J.S. Morley-Bunker

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Seed germination success and failure

Seeds which fail to germinate immediately must have attracted the attention of the earliest agriculturists. When conditions are present for normal plant growth (and presumably also seedling growth) seed dormancy appears paradoxical. Such behaviour suggests an inherent constraint due perhaps to evolutionary and ecological forces. It is commonly held by investigators that dormancy mechanisms have a survival value for a species but it is also held that the agriculture environment removes the ecological requirement for dormancy. Nevertheless experience indicates that rapid simultaneous germination in high percentages is not the invariable situation for many horticultural subjects.

A large number of conditions affect germination success. At the most basic level germination is the result of a favourable external environment and a favourable seed constitution. The arrested development of the seed caused by unfavourable environmental conditions is termed quiescence. Seed dormancy is the condition of arrested seed development where the structure or chemical composition of the seed prevents germination. Either a counter stimulus or degradation of the inhibiting mechanism is required before germination may continue. A number of seed dormancy categories can be identified including; embryo immaturity, after ripened seeds (dry or imbibed), induced and secondary dormancy, and hard coated seeds.

Hard coated seeds

Hard coated seeds are sometimes referred to as "impermeable seeds". The dormancy mechanism of "hardseededness" is the interference with aqueous and gaseous substances communicating with the seed. There have also been suggestions from investigators that seedcoverings may physically resist germinating structures but measures of resistance to applied forces need not be proof of seedling restriction.

A number of plant families contain plant species with hard seed coats. Ballard (1973) lists Convolvulaceae, Gerianiaceae, Leguminosae, Malvaceae and Solanceae in addition to this there is Liliaceae, Cannaceae, Convallariaceae and Passifloraceae. Regulating germination by the interposition of a seed coat between environment and embryo suggests itself as a simple approach and therefore an obvious mechanism to be found in many plant families. Agronomic practice has often included seed coat treatments to improve germination for "hard" and "soft" coated seeds (see Table 1). In subtropical crops the removal of the shell and/or seed coat is sometimes practised as in avocado, *Persea americana* and mango, *Mangifera indica*.

Seed coat breakdown mechanisms

The presence of a hard impermeable seed coat would appear to be an imprecise "all-or-nothing" means to limit germination. Therefore it is not unreasonable to find that the anatomy of the seed coats of cotton and several forage legumes indicates that there are mechanisms by which the coat may become permeable. These mechanisms rely on seed coat structure. At specific locations inbuilt weakness in the coat may be found.

Both cotton and the forage legumes

Trifolium spp, *Medicago* spp and *Desmondium* spp are grown in semi and tropical and subtropical environments. Dessication of the seed is an environmental hazard. Similarly germination is hazardous when a consistent moisture occurrence is not found. A mechanism that acts as a hygroscopically sensitive valve is required. In some legumes coat softening in a moist environment occurs at random sites but in many others the hilum and strophiole act as a valve. Quinlivan (1968) showed that in some legumes in fluctuating temperature and moisture regimes the strophiole would rupture allowing moisture penetration. In cotton, moisture penetration occurs between the chalazal cap and lignified palisade region of the coat. Both the cotton and forage legumes have been investigated because of their status as crop plants. It would seem reasonable that other examples of coat mechanisms exist, especially in the tropical and subtropical plants, which have on the whole been least investigated, and frequently endure adverse conditions.

A study of passion fruit seed germination

With the previous comments in mind I now propose to report a study, now six years old, concerning passion fruit seed germination. The study was suggested for two reasons. The first, an experience, and the second practicality when faced with the need to prepare a short dissertation for a masters degree. Seed investigations provide very convenient small scale projects for both student and private investigator. For the horticulturists the establishment of plants often starts with the transformation of a seed placed under the soil to a seedling thriving above and below the soil. How many times do we hear the complaint "the seed was dead" when the transformation fails to occur? Successful seed germination in the ground depends on both the soil and seed condition. Both need study but there is a danger that seed investigations concentrate only on the seed behaviour to the exclusion of consideration of the soil environment. Predictably great advances have been made with maintaining the seed in a viable condition. For the horticulturist the information gained about the seed's germination behaviour needs to be followed with the description of how to attain successful germination in the field. In this respect the study which follows is deficient and field tests of passion fruit germination in conjunction with soil condition and soil environment are still required.

Seasonal germination responses observed

Many years ago the author spent an afternoon on his hands and knees holding a block of wood. Between this and a piece of rough concrete were some passion fruit seeds. The object was to rub the seed over the concrete, it was (a crude attempt at scarification). Physical scarification was recommended as a second best option in place of acid and the author had no sulphuric acid in his cupboards at the time! The passion fruit seed did not germinate within a month and the seed box was placed to one side. Three months after, the box had still not been thrown out, when some seeds started to produce seedlings. The time, in Swaziland, Southern Africa, was early October, late spring (if the name is appropriate) just after the start of the rains. A chance remark at a later time caused the author to recall the scarification incident and look for a time to investigate the matter further. The remark came during a visit to Burgershall, South Africa, where Frans Kuhne, a leading expert in subtropical fruit crops, commented that germinating passion fruit seed for rootstocks was always more successful in the spring. The question posed was, did spring provide conditions that were best in breaking seed dormancy?

The scope of the investigations

The study began with acquiring seed of various passion fruit from a range of geographical locations: South Africa, Ghana, Hawaii, Malawi, Swaziland and Kenya. A number of seed coat treatments were tested under various temperature conditions. In supplementary investigations the use of tetrazolium (1% triphenyl tetrazolium bromide) was used to test seed viability and the seed coat was examined under a microscope.

Fig. 1 Effect of 4 coat treatments and 4 environments on passion fruit seed from Malawi (seed P).

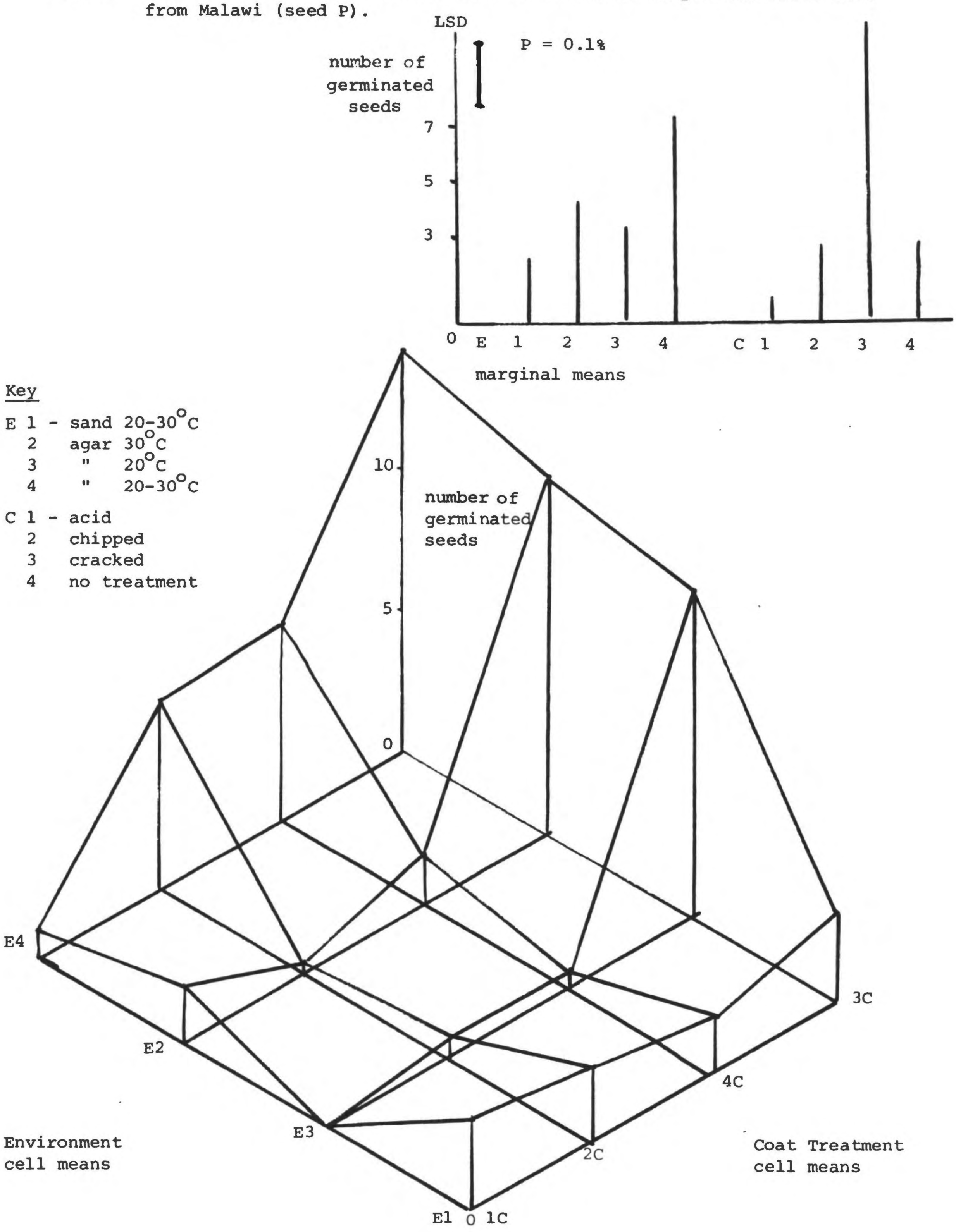
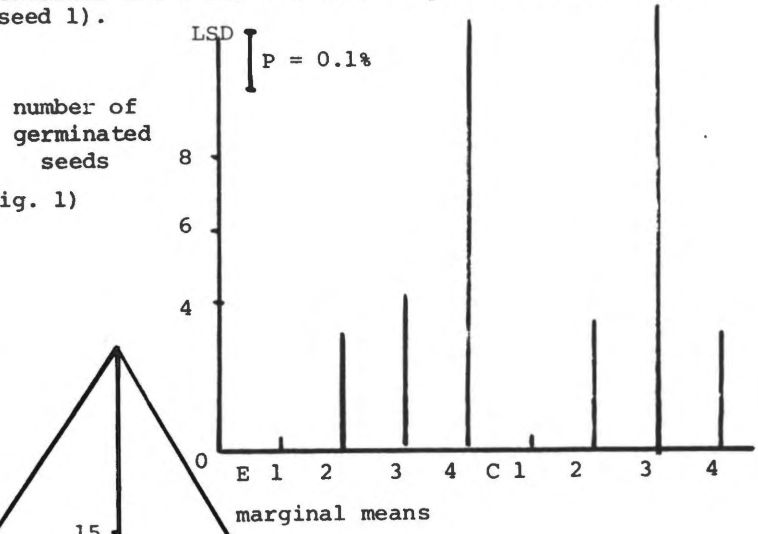
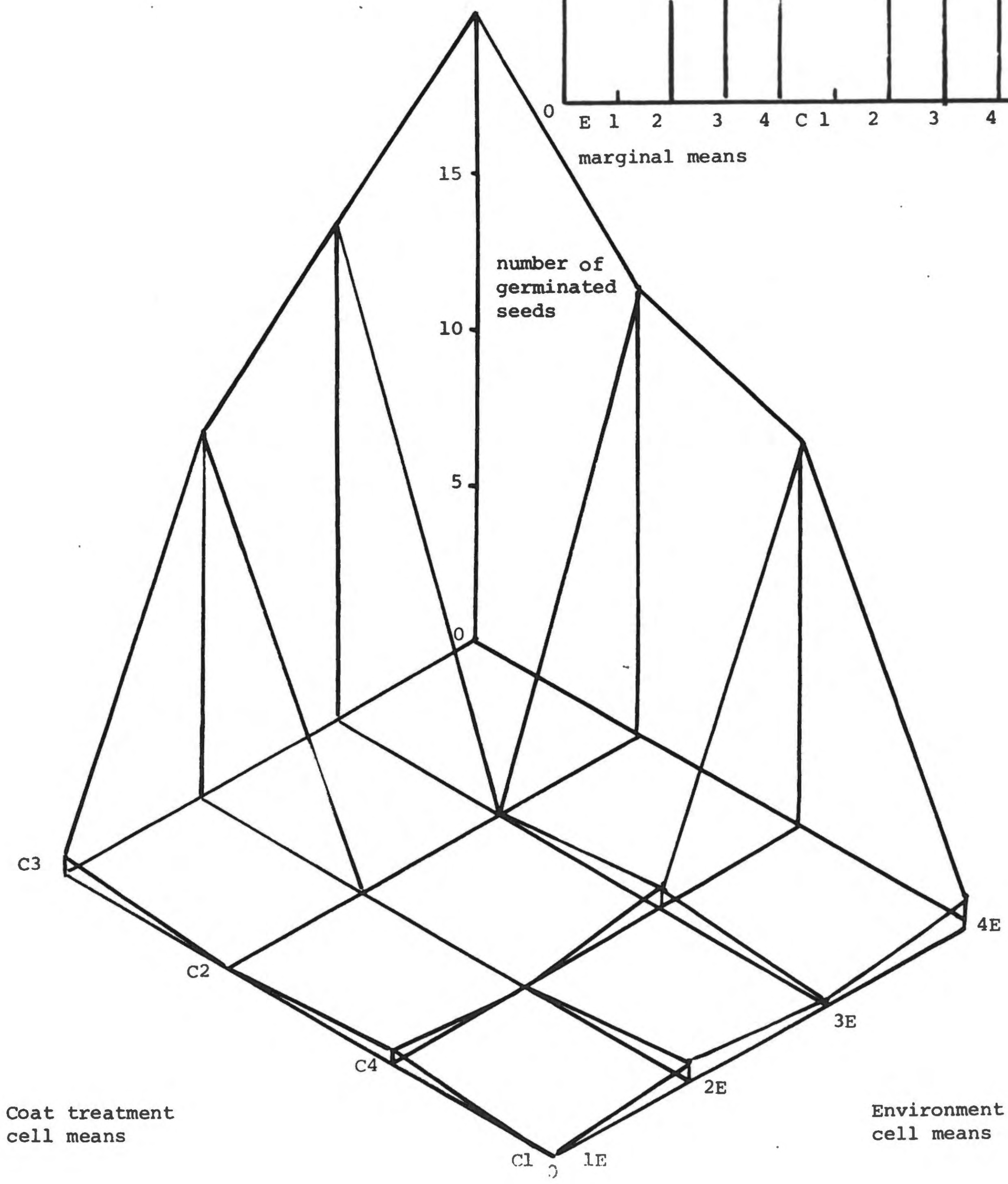


Fig. 2 Effect of 4 coat treatments and 4 environments on passion fruit seed from South Africa (seed 1).

(For key to treatments see Fig. 1)





Seed coat treatments

Initially, with seed from South Africa and Malawi, a comparison of seed coat treatments with different germination environments was made. The seeds were treated with either 75% H_2SO_4 for six hours, or chipped with a scapel blade, or placed in a vice and the seed coat gently fractured, or left untreated. The seeds were then sown either in agar or sand and kept at 20°C or 30°C, or alternated every 12 hours between 20°C and 30°C. There were four replicates for each treatment of 35 seeds, of which 30 seeds were sown and five tested for viability.

Germination in the agar dishes began after 7 days, most radicals emerged between 7 and 14 days - however, germination did still continue 28 days after sowing. Seeds sown in sand were much slower in emerging. Fungus and bacterial infections affected many of the treatments especially where the coat was chipped. After 28 days ungerminated seeds in the agar dishes were tested for viability. Whereas at sowing the stain indicated approx. 100% viability, the stain after germination treatments indicated low viability.

The results are shown in 3-dimensional graphs in Figure 1 and 2, and clearly show that germination increased with cracking and fluctuating temperatures. Statistical analysis was made difficult by the small number of replicates, and sample size being disrupted by fungus and bacterial infections. However bar charts indicating LSD values for main effects (marginal means) accompany the graphs.

Further seed coat treatments were tested in two temperature regimes, 30°C constant, and fluctuating 20°C and 30°C. The treatments were scarification with sand paper, fermentation for 24 hours, use of the snail enxyme cytase, and a no coat treatment for control. Germination was very low for all coat treatments in all temperature conditions (germination percentages 1-9%).

Comparison of seed source with germination behaviour

The range of plant material was compared for germination performance. The seeds came from a range of localities, and represented a number of species and hybrids being considered for commerce (see Table 3). Four treatments were used examining two variables, fractured seed coats and alternating temperatures. The results shown in Table 2 show that fractured seeds for sources (H) (I) (L) (P) and (Q) performed best with notable contrary responses from (J) (M) and (R) (see Figure 3 and 4). Fluctuating temperatures definitely enhanced germination for seed samples (K) and (O) and to a lesser extent (H) (L) (N) and (R).

Hormone and coat restriction investigations

Consideration was then given to the effect of exogenous hormone application and seed coat restriction. In the experiment to examine hormone application gibberellin was added to the agar before sowing and the variables fractured seed coats, gibberellin and fluctuating or constant temperature were examined. The results in Figure 5 indicate the main effect, fracturing the seed coat was most effective in both temperature regimes. No noticeable enhancement occurred with the presence or absence of gibberellin. In the experiment designed to consider seed coat restriction, comparison was made of naked seed, seed with half the seed coat and the fractured seed grown with constant or fluctuating temperature. Unfortunately this experiment suffered badly from bacterial and fungal contamination. Observations showed initially, after seven days, the naked seeds at constant 30°C were most successful germinating, but after 14 days the fractured seed was more successful with no temperature regime favoured.

Seed coat description

The series of experiments was concluded with a microscopic examination of the seed coat where seeds had been soaked in an eosin solution for three days. The seed coat has a thick wall, mechanically very strong and with a wax like outer surface. Internally the coat has fingerlike projections. The coat has two fused halves and at the funicle end a tissue plug passing through the seed coat that presumably connects to the ovary wall. Seed from

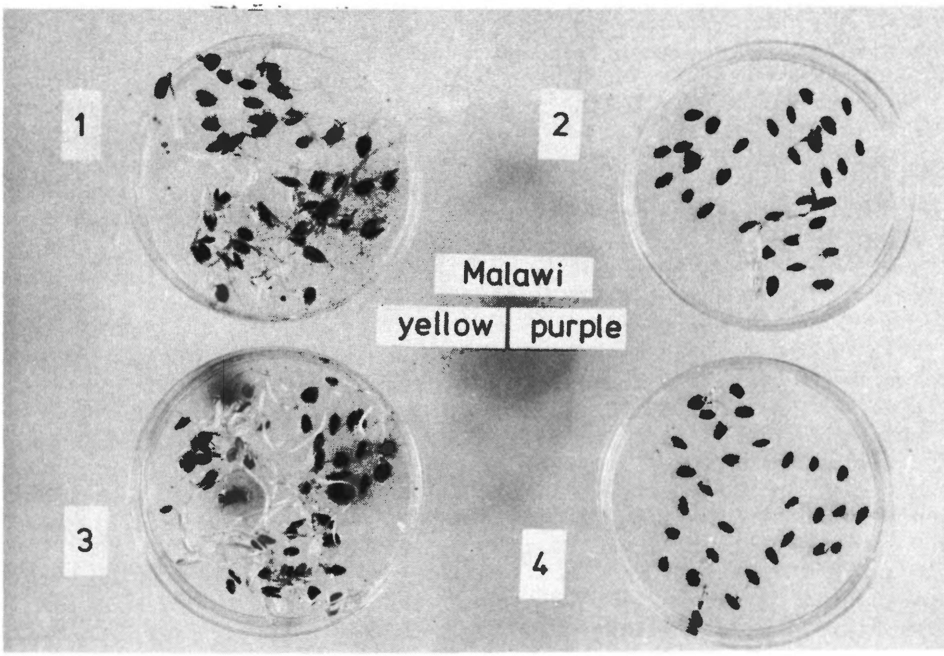


Fig. 3 Effect of coat fracturing and fluctuating temperature conditions on passion fruit seed from Malawi (seed P)

Key:

1. fractured seed coat, fluctuating temperature 20-30°C
2. untreated seed coat, fluctuating temperature 20-30°C
3. fractured seed coat, constant temperature 30°C
4. untreated seed coat, constant temperature 30°C

Ghana had in the previous experiments shown an ability to germinate readily, without fracturing the coat or keeping the seed under fluctuating temperature conditions. In this sample the eosin stain readily passed through the coat to stain the contents. The tissue plug was heavily stained. By contrast seed from other sources did not admit the stain.

Discussion

In the series of experiments the best treatment mean was only 67% germination within 28 days, which does seem rather low. Fletcher (1952) considered good germination 13000 seedlings from one pound of fresh dry seed, this is about 43%. Passion fruit viability does decrease rapidly with storage. Certainly raising passion fruit from seed is not without inefficiencies. In all probability the range of treatments for extracting, storing, and pretreating passion fruit seed before sowing, reflects empirical attempts to improve germination. The experiments suggest two general observations, firstly that fluctuating temperatures may enhance germination performance, and secondly moisture penetration through seed fracturing was the most effective coat treatment. The observations of the eosin stain showed that the seed coat was not necessarily breached either by chipping or by the acid treatments to reduce coat thickness.

In legumes Quinlivan (1971) suggested that with fluctuating temperatures a fracturing of the coat as well as softening occurred. He reported that at least 15^{o}C fluctuations were necessary. Passion fruit originates in the tropical Americas, in the higher altitudes where duirnal temperature variation is the usual condition. It would seem likely that germination could proceed normally under these conditions whereas in the lowland areas, where temperatures are more uniform, germination would be limited. In subtropical and Mediterranean climates, temperature fluctuations are greatest with the shift from a seasonal cool to hot period, the brief intermission period may be termed 'spring-like'. It is this period which coincides with the appearance of passion fruit seedlings in the naturalised habitats, woods and forests, in Southern Africa. To confirm this hypothesis a study of soil temperature and moisture levels in conjunction with the emergence of passion fruit seedlings is required. A simple recreation of fluctuating conditions could be produced with the use of black plastic sheeting over a seedbed. The inference of the fluctuating temperature treatment is that the seed coat then fractured. What also needs clarification is whether the processes of germination, as distinct from the coat breakdown, requires constant or fluctuating temperature conditions. Three seed samples showed a readiness to germinate without the need for fracturing the coat. Two came from the same source Ghana, the other was a related passion fruit species, *P. maliformis* and this seed did not appear to have a hardcoat of the same strength as *Passiflora edulis*, the passion fruit species most used commercially. Fluctuating temperatures did enhance the germination count in all three samples.

It does seem a unique feature that the Ghanian seed should have behaved contrary to the other sources. The storage for eight months in polythene bags was at a lower temperature than other samples (5^{o}C). The seed was also fumigated with carbon disulphide for 24 hours before dispatch. No other seed was treated in this way. However the explanation for this behaviour difference can only really be guessed.

Postscript

The story about passion fruit seed germination ends with one further puzzle. Towards the end of the experiment series a further seed sample was obtained from the London store, Harrods. It was thought that the fruit came from Kenya. The seed and pulp was scraped out onto a muslin bag, washed, squeezed free of juice and pulp and blotted dry. The tetrazolium stain test indicated a high germination potential in the sample. However no treatments with sandpaper, sulphuric acid, cytase, fluctuating or constant temperatures produced any germination at all. Perhaps some further inhibition mechanism is present? Certainly the old adage "one question answered is another two questions asked" would appear to be true!

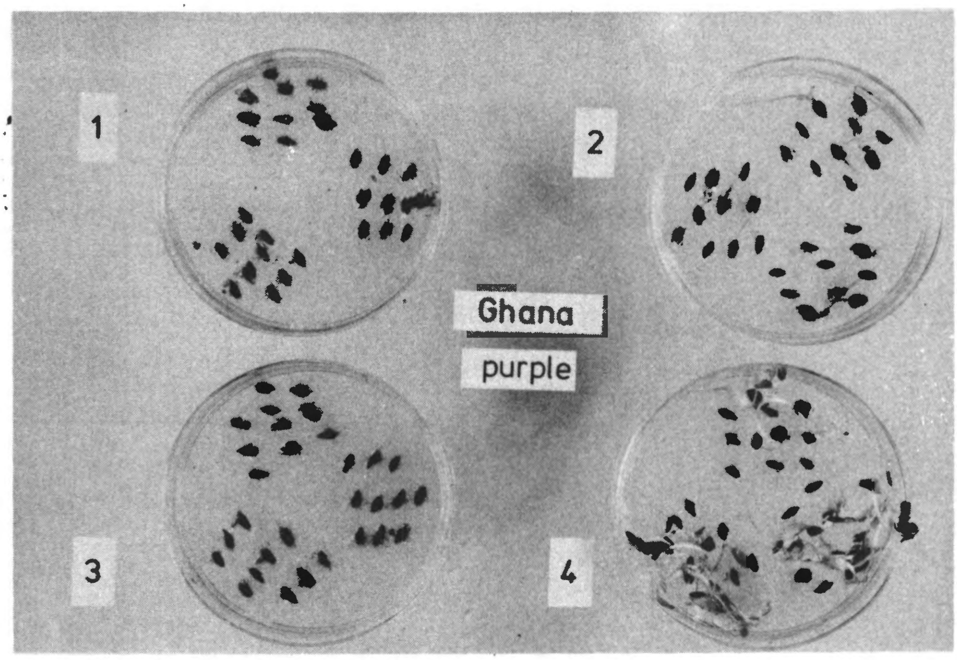
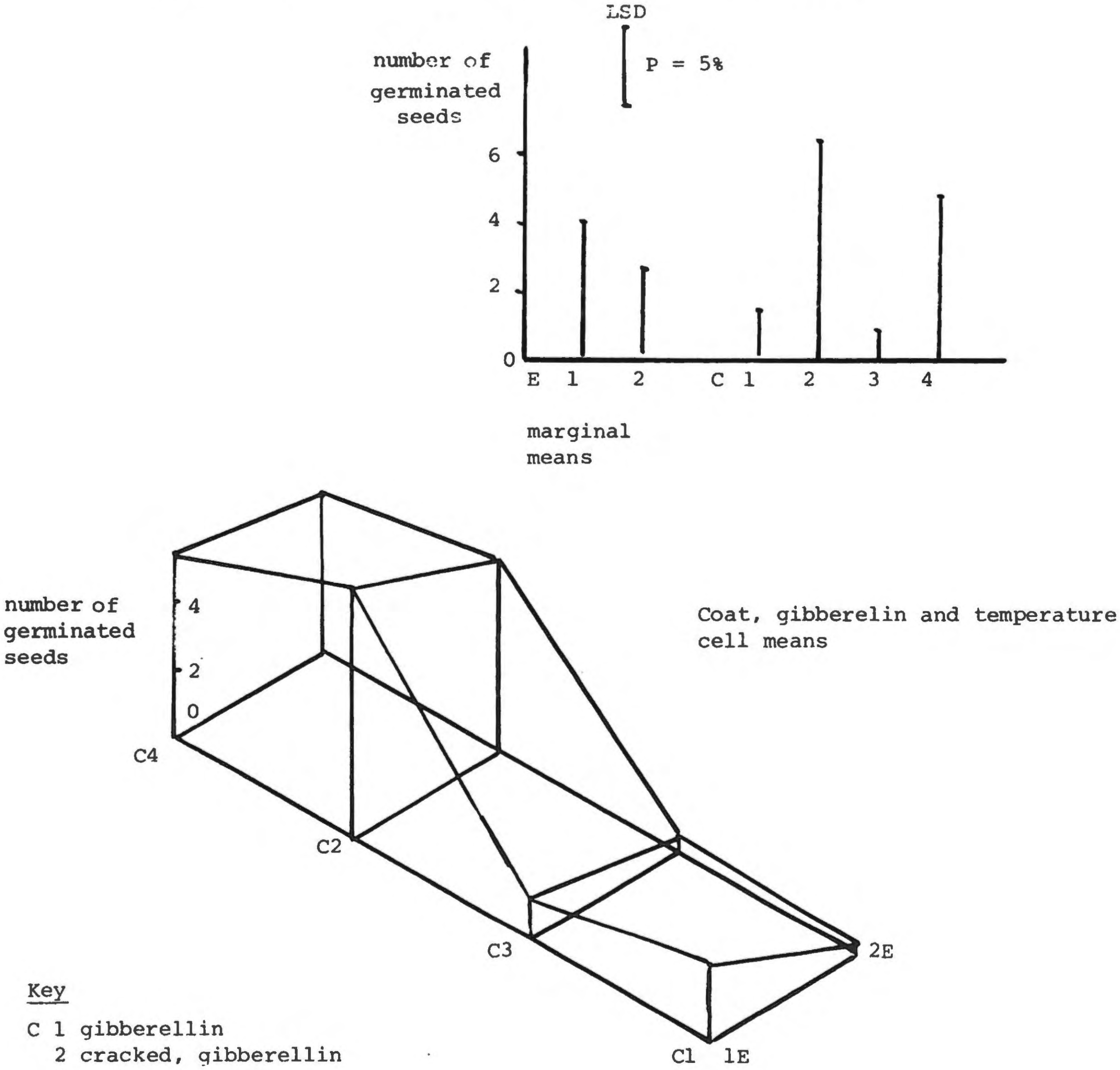


Fig. 4 Effect of coat fracturing and fluctuating temperature conditions on passion fruit seed from Ghana (seed J).

Key:
1. fractured seed coat, fluctuating temperature 20-30°C.
2. untreated seed coat, fluctuating temperature 20-30°C
3. fractured seed coat, constant temperature 30°C
4. untreated seed coat, constant temperature 30°C

Fig. 5 The effect of gibberellin and seed coat fracture in two temperature regimes on passion fruit seed from South Africa (seed H).



Key

C 1 gibberellin
  2 cracked, gibberellin
  3 no treatment
  4 cracked

E 1 20-30^{o}C fluc
  2 30^{o}C const

REFERENCES

Ballard, L.A.T. 1973: Physical barriers to germination. *Seed Sci. & Techno. 1:* 285-303.

Barton, L.V. 1965: Dormancy in seeds imposed by the seed coat. W. Ruhland ed. Encyclopaedia of Plant Physiology Vol. XV/2. Springer Verlag Verlin: 727-745.

Bums, R.E. 1959: Effect of acid scarification on lupin seed impermeability. *Plant Physiol. 34:* 107-108.

Christiansen, M.N. and Moore, P.R. 1959: Seed coat structural differences that influence water uptake and seed quality in hard seed cotton. *Agron. J. 51:* 582-584.

Fletcher, W.A. 1952: Passion fruit Culture Bulletin. N.Z. Department of Agriculture 135, revised 1952. pp. 11

Gladstone, J.S. 1953: The influence of temperature and humidity in storage on seed viability and hard seededness in the West Australian blue lupin *Lupinus digitatus* (Forsk). *Aust. J. Agric. Res. 9:* 171-81.

Hambly, D.H. 1932: Softening of the seeds of *Melilotus alba. Bot. Gaz. 93:* 345-75.

Kuhne, F.A. 1968: Cultivation of granadillas. Farming S. Africa 1968 43(11): 29-32.

Purseglove, J.W. 1968: Tropical Crops. Dicotyledon Longmans London 2 Vol. pp. 719

Quinlivan, B.J. 1968: The softening of hard seeds of sand plain lupin (*Lupinus varius* L). *Aust. J. Agric. Res. 19:* 507-15.

Quinlivan, B.J. 1971: Seed coat impermeability in legumes. *J. Aust. Inst. Agr. Sci. 37:* 283-95.

TABLE 1

Some treatments used to overcome hardcoatedness.

Treatment	Examples of Material Treated	Notes
HEAT TREATMENT		Prolonged exposure may cause damage.
(1) Immersion in hot water	*Gossypium* spp. (Christiansen and Moore 1959)	Disrupts chalazal cap seal in seed coat (1 min at 80°C).
	Legumes (Purseglove 1968)	
(11) Dry heat	Legumes (Rincker 1954)	220°F for 4 min.
FREEZING AND LOW TEMPERATURE		
(1) Immersion in liquid air, nitrogen or oxygen	*Trifoliam* spp. *Melilotus* spp. *Lotus* sp. (Barton 1965)	
(11) Diurnal Fluctuation	*Trifolium subterraneum* (Quinlivan 1971)	Fluctuation of at least 15°C up to 60°C day temp.
ELECTRICAL IRRADIATION AND HIGH PRESSURE		
(1) Pressure up to 60,000 p.s.i.	*Medicago sativa* *Melilotus alba* (Barton 1965)	Decrease sample hard seed content but increase dead seeds.
MECHANICAL SCARIFICATION		
(1) Filing or sand paper	*Passiflora edulis* (Kuhne 1968)	Breakage may occur if rubbed hard.
PERCUSSION		
(1) Shaking or impaction	Legumes (Hambly 1932)	Coats may be cracked or loosened from the contents.
CHEMICAL TREATMENTS		
(1) Alcohol	*Caesalpinoideae* (Ballard (1973)	Remove wax culticle
(11) Sulphuric acid	*Lupinus augustifolius* (Burns 1959)	Eroded pits and palisade tissues.
	Legumes including *Desmodium* spp. (Purseglove 1968)	In general use for most hardcoated seeds.
STORAGE TREATMENTS		
(1) High humidity storage	*Lupinus cosentini* (Gladstone 1953)	To prevent the drying out of the seed epidermis and acquisition of impermeability.

TABLE 2

The effect of coat fracturing and fluctuating temperature with 11 different seed samples, expressed as % germination (to nearest figure).

Seed H purple (SA)		Seed I purple (SA)		Seed J purple (Ghana)	
42	13	29	13	5	52
44	0	35	18	3	42

Seed K purple (Hawaii)		Seed L purple (Malawi)		Seed M yellow (Ghana)	
47	51	41	4	5	51
31	0	28	5	10	34

Seed N yellow (Hawaii)		Seed O yellow (Malawi)		Seed P yellow & purple (Malawi)	
23	40	22	21	26	19
28	19	6	3	43	5

Seed *P. liguiaris* (Hawaii)		Seed R *P. maliformis* (Hawaii)	
19	0	14	26
15	3	4	27

KEY treatments

(1) fractured fluctuating 20°C 30°C	(2) not fractured fluctuating 20°C 30°C
(3) fractured constant 30°C	(4) not fractured constant 30°C

TABLE 3

Seed Type	Country of Origin	Date of Harvest	Notes concerning source, extraction and storage.
Purple			
H) *P. edulis* f. *edulis*	South Africa	Dec. 73	)Collected from same source, plants reported to show fair degree)of uniformity. Extracted by removing pulp and seed, washing over)a fine sieve. Seed dried in a cool dark room 7-10 days. Storage
I) "	"	Oct. 73	)at room temperature in brown paper bags.
J) "	Ghana	Aug. 73	Extracted, dried (not washed) stored at 5°C in polythene bags. fumigated 24 hours carbon disulphide (10ml/cu.ft) before sending. Dispatched in polythene bags.
K) "	Hawaii	June 72	Storage in refrigerator 7°C, 70% humidity. Dispatch in paper packets. No further information.
L) "	Malawi	Jan. 74	Local selection planted March 73. Extraction of seed and pulp, dried in shade, washed and re-dried. Dispatched in brown paper packets.
Yellow			
M) *P. edulis* f. *flavicarpa*	Ghana	Aug. 73	See (J) Ghana purple.
N) "	Hawaii	not known	See (K) Hawaii purple.
O) "	Malawi	Jan. 74	Plants sown Dec. 68. Germinated in one week. Started bearing 1970. Extractions etc. as in (L) Malawi purple).
P) *P. edulis* f. *edulis* x P. *edulis* f. *flavicarpa*	Malawi	Jan. 74	Reported as "purple" hybrid. Planted 1970 and germinated well. Began bearing 1971. Extraction etc. see (L) Malawi purple.
Q) *P. ligularis* (Sweet Granadilla)	Hawaii	May 73	Seed treated with "Captan" fungicide. Also see (K) Hawaii purple.
R) *P. maliformis*	Hawaii	Jan. 71	See (K) Hawaii purple. This sp. described by Martin and Nakasone (1969).
T) *P. edulis* f. *edulis*	East Africa (probably Kenya)	Aug. 74	Fresh fruit brought on London market. Pulp and seed extracted, washed in muslin bag, and sown after treatment.

Table 3. Seeds used during course of experiments and appropriate information.

Medicinal Herbs

by

J. Palmer

Crop Research Division, D.S.I.R., Private Bag, Christchurch.

Plantago ovata. The seed of this plant forms the ispaghula of commerce. This has been used for centuries in India as a treatment for dysentery and like complaints. Now its usage is becoming more common as a treatment for many gastronomic complaints and at least two proprietary brands are sold in New Zealand. The mucilagenous husk surrounding the seed swells and forms bulk to the gut content and at the same time lubricates the wall epithelia. *(Photo by R. Lamberts)*

Plantago psyllium. A Mediterranean species with similar properties to ispaghula. This species is winter hardy in Canterbury and generally more suited to cultivation in temperate regions. *(Photo by R. Lamberts)*

Digitalis lanata. The source of the glycoside Digoxin, used in almost all cases of heart disease. The extract from the leaves of this species is nearly twice as active as that obtained from the common foxglove, *D. purpurea*. *(Photo by R. Lamberts)*

Chamomile, *Matricaria chamomilla*. Commonly used in herbal teas in Europe. It is now widely sold in 'tea bags'.

The evening primrose, *Oenothera biennis* and the hybrid *O. erythrosepala* (syn. *O. lamarkiana*) has recently been found to contain a long chain fatty acid in their seed which could be of use in the treatment of multiple sclerosis. One Christchurch based company has a contract to supply several tons of this seed at prices of around $3,000 per ton. *(Photos by R. Lamberts)*

Nutrition of container — grown Trifoliate Orange Rootstocks *(Poncirus trifoliata)*

by

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ABSTRACT

The response of container-grown trifoliate orange seedlings (*Poncirus trifoliata*) to five levels of N, P, K and lime were studied. A strong response to N was obtained, with an optimum medium rate of 450g N/m^3. Response to P was moderate with the optimum at 2-300g P/m^3, while added K failed to promote growth and induced foliar chlorosis thought to be due to Mg deficiency. The only interaction was between K and lime. Good growth was obtained at nil amounts of K and lime and at high levels of both combined: 332kg K/m^3 and $12kg/m^3$ of lime.

INTRODUCTION

Trifoliate orange rootstocks (*Poncirus trifoliata*) are widely used in New Zealand for oranges, mandarins, grapefruit and Lisbon lemons on most soils except alkaline ones (Jackson 1974). Citrus plants in New Zealand are quite often grown in containers for periods of up to two years particularly where cutting-graft techniques are used (Cowan 1974). Increased sales of container-grown plants produced in Florida, have been noted in the U.S.A. and Canada (Anon 1972; Bridges and Youtsey 1977).

Trifoliate orange rootstocks offer advantages of hardiness and disease resistance but they are more susceptible to zinc and iron deficiencies than other rootstocks used for citrus (Kahdr *et al.* 1965; Warner 1979). They also suffer in conditions of high P and K, and are less tolerant of low magnesium supply than other species. Nitrogen levels influence development of dormancy (Kahdr *et al.* 1965). Dickey (1977), in a review of nutritional deficiencies of woody ornamentals in Florida, noted that citrus suffer from a wide range of deficiencies. It can be readily concluded that citrus in the nursery, and in particular *P. trifoliata*, need a careful nutritional programme especially when container-grown.

A preliminary experiment revealed that the growth of trifoliate orange seedlings is very sensitive to added nutrients when grown during normal winter daylengths. At low levels of N, added P and K induced severe chlorosis and death in many cases. These failures were considered to be caused by Mg deficiency aggravated by high K, plus possibly Fe deficiency due to high P and K, or alternatively to the onset of dormancy (results unpublished). Warner (1971; 1979) had reported that trifoliate orange seedlings are responsive to photoperiod: short days in the winter reduced growth to almost zero. Supplementary lighting to give long day treatments would ensure continuous growth over the winter.

This paper describes the response of container-grown trifoliate orange seedlings, grown under long day conditions, to five rates of N, P, K and lime mixed into the potting medium. The objective was to evaluate the influence of individual added nutrients using response surfaces to describe any interactive effects.

MATERIAL AND METHODS

Experimental Design

A four factor response surface Box-Hunter design, of Cochran and Cox (1957), of the central composite second order type with incomplete blocks was used. It involved N, P, K and lime additions with 30 treatments arranged in 10 blocks each consisting of 3 sub-blocks and 10 replicates per treatment.

Fertiliser rates and potting media

The fertiliser sources used in the experiment for N, P and K were Osmocote (26%N), superphosphate (8%P) and sulphate of potash (39%K) respectively. Lime was applied as a mixture of dolomite and agricultural lime (3:1) as recommended by Bjerkestrand (1969) for liming of peat to provide the necessary magnesium. In addition trace elements were applied in the form of 'Sporumix A' (containing 1.14%Zn, 1.20%Cu, 5.46%Mo, 0.05%Co and 9.78%Mg) at 150g/m^3 and 'Sequestrene' iron chelate (Na EDTA Fe with 12%Fe at 75g/m^3. All the fertilisers were mixed as a basal dressing in the potting mix, although N was given as two equal applications, with half being applied initially and the other half five months later as a top-dressing (lightly worked into the surface).

The medium used was equal parts (1:1, vv) Hauraki sphagnum peat and coarse sand (crushed shingle grit - particle size 40%: 3.6-2.00mm, 22%: 2.0-1.0mm, 38%: 1.0-<0.1mm). Containers used were PB 5 (2.5*l*) polythene planterbags.

Plant Material

Ten month old bare root trifoliate orange seedlings were root trimmed and potted-up on 12th July 1978. The stems, which were up to 30cm tall, were then trimmed to 20cm above the medium.

Growth Environment

The experiment was carried out in a thermostatically controlled glasshouse with a minimum temperature of 8°C. The glasshouse was equipped with automatic fan ventilation with fans operating when the temperature exceeded 21°C that maintained the maximum temperature at approximately 5°C above ambient temperature. Supplementary lighting with 100 watt incandescent lamps 2m above floor level at 1.5m centres was given to increase photoperiod to 16 hours in order to minimise dormancy and produce growth equivalent to citrus growing areas of the North Island of New Zealand. Lighting started before dusk and was 6½ hours on the shortest day and 1½ hours on the longest day to provide equal total photoperiods. The seedlings were watered by hand when necessary.

Data Collection

Media samples were taken 8 months after commencement from 8cm deep cores and analyses carried out by Analytical Services Limited, Cambridge, N.Z. Analyses were based on saturated extract to measure available nutrients. NO_3-N was analysed using the colorimetric salicyclic acid/sulphuric acid method (Cataldo *et al.* 1975), Phosphorus by the colorimetric molybdovanadate method and K, Ca and Mg by Atomic Absorption/ Emission using a IL 251 spectrophotometer. The pH was based on 1:2.5 soil water ratio using glass electrodes.

Plant growth was assessed 9 months from commencement, for height, visual rating, extent of chlorosis and stem diameter. Visual ratings were obtained using a score of 0 for dead to 5 for very vigorous high quality plants. Chlorosis ratings were obtained using a score of 0 for no leaves (completely defoliated) to 5 for normal (no chlorosis, green). Height growth index was calculated from the stem diameter squared x height as used to evaluate the quality and size of pine seedlings (Chavasse, C.G.R., pers. comm.).

Plant tops were harvested at 11 months and oven dried. Foliage samples were then randomly selected from each replicate, aggregated together and ground to give composite samples. Sub-samples were analysed to determine the concentrations of N, P, K, Ca and Mg by the methods described by Parkinson and Allen (1975).

Data from this experiment were statistically analysed for analysis of variance and F test using Boxhu computer programme. Data presented in graphic form in this paper were computed from the equations of the response surfaces.

RESULTS

The constants and coefficients of the equations of the fitted surfaces of yield components for all main effects and the

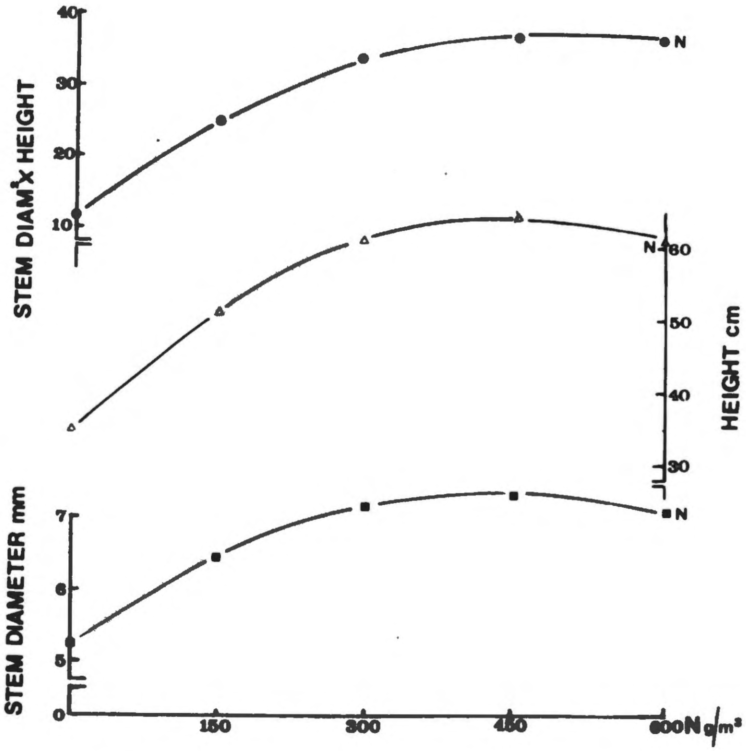

Fig. 1: Influence of N fertilisation on the foliar height and stem diameter characteristics.

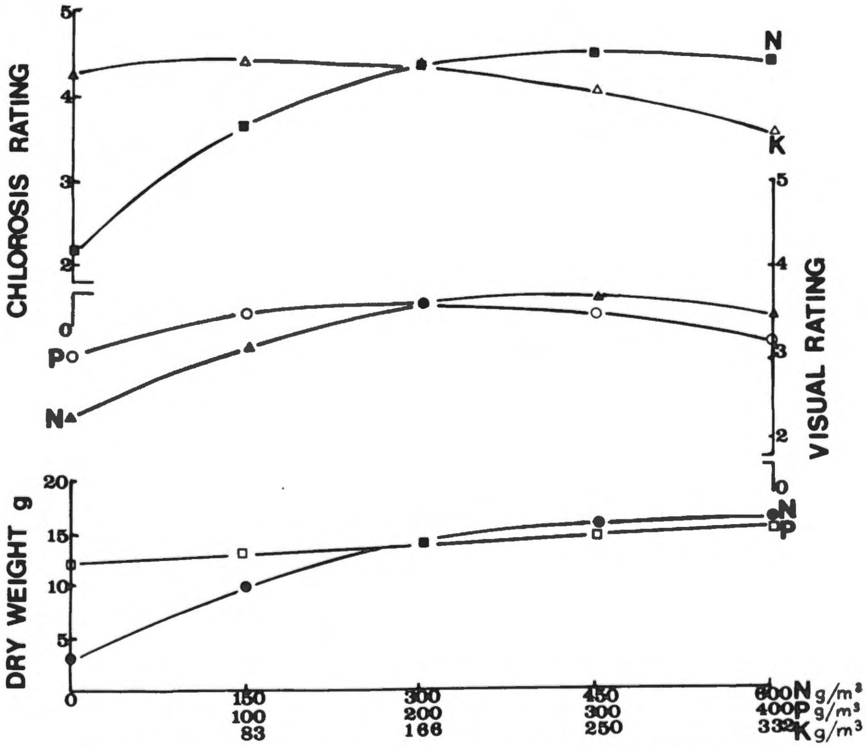

Fig. 2: Influence of N, P and K fertilisation on foliage greenness, quality and dry weight.

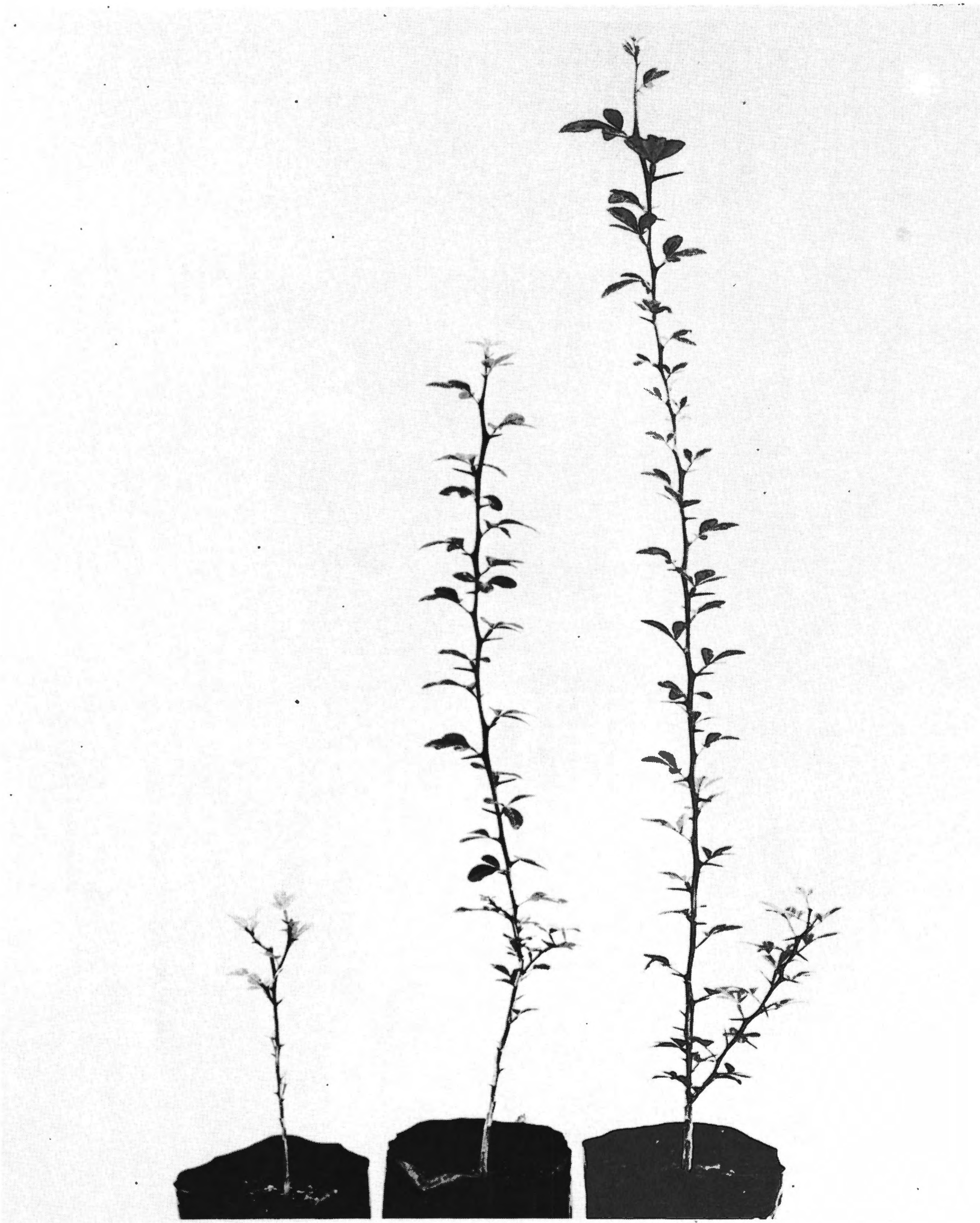

Fig. 3 Plants photographed just prior to harvest indicating a strong response to nitrogen. These plants all received the middle rate of P, K and lime, and total N from left to right at 0,300 and 600 g/m^3.

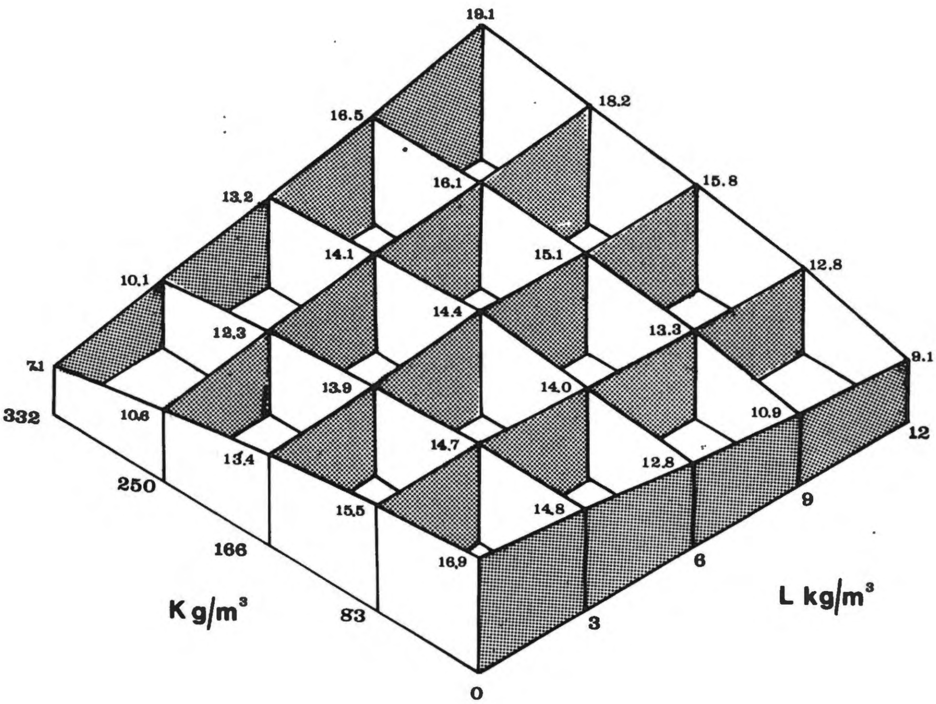

Fig. 4: Interaction of K and lime additions on foliar dry weights.

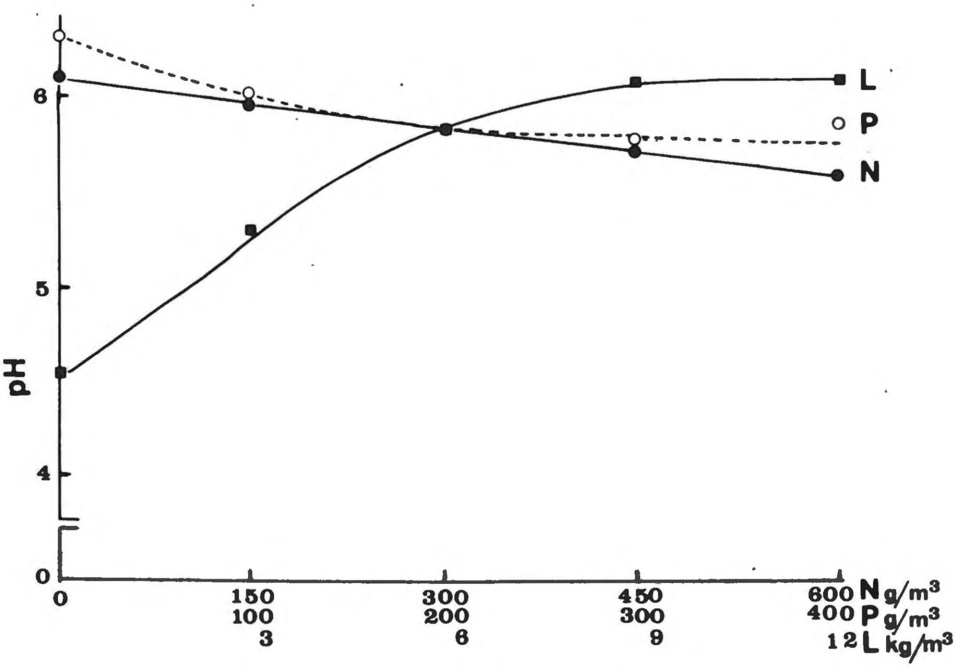

Fig. 5: Influence of added N, P and lime on media pH.

one significant interaction are given in Table 1.

Influence of nutrient levels on growth

Fig. 1 shows the effect of the five levels of N on height, stem diameter and height growth index (stem diameter^2 x height). Each of these parameters increase with N level to an optimum around 450g N/m^3, i.e. (41g N/m^3/month). Similarly, the optimum accumulated dry weight and visual rating (Fig. 2) were obtained with about 450g N/m^3. Foliar chlorosis due to low N levels was apparent below the middle N rate indicating that rates of 300g N/m^3 or less were inadequate. Apparently, this plant has a medium to high N requirement. There was no obvious interaction between N and the other applied macronutrients. The size of plants photographed just prior to harvest indicated the importance of N (Fig. 3).

Added P had a moderate influence on plant quality (visual rating) and foliar dry weights (Fig. 2). The optimum was at about 200g P/m^3 with no interactions with other nutrients.

Lime levels strongly influenced the response to K (Fig. 4). Chlorosis occurred at above 166g K/m^3 (Fig. 2). Increasing K additions depressed foliar dry weights at 3kg/m^3 lime, especially at nil lime (Fig. 4). However, high dry weights occurred at nil K and lime at a pH of close to 4.5 (Fig. 5) while the highest dry weight yields were when both were combined at any of their two highest rates. For example, 332g K/m^3 and lime at 12kg/m^3 gave the greatest foliar dry weight. Lime had the greatest influence on pH (Fig. 5) and there was a P x lime interaction where the maximum pH of 6.7 was reached at nil P and 12kg lime/m^3 (data and response surface not shown).

Media and Foliage Analyses

The avaiable nutrients present in the media were in a similar proportion to the rates of incorporated fertilisers (Table 2). Small but significant amounts of NO_3 - N, P and K were recorded in the medium - as indicated by their presence in treatments where the relevant fertilisers had been left-out. Nutrient levels in the foliage (combined stems and leaves) showed a fairly close relationship with added nutrients (Table 2). The increase from nil to the highest rate of incorporated nutrients increased foliar levels of N, P, K and Ca by 34, 125, 41 and 21% respectively. The source of Mg was primarily dolomite lime and this increased from nil to 9kg/m^3 (900-1800g Mg/m^3 plus 3kg/m^3 $CaCO_3$ lime) yet the foliar Mg levels dropped 6%. An additional 15g Mg/m^3 would be derived from the Sporumix trace element mix but is considered a comparatively insignificant Mg source.

DISCUSSION

Results of this study indicate that trifoliate orange seedlings responded well to N. This agrees with other container culture studies that N nutrition is generally of dominant importance (Thomas 1979 a,b,c). Similarly, *Boronia* and *Choisya*, which are in the same family as Citrus (Rutaceae), have shown a very strong response to N (Thomas 1981). Studies with container-grown citrus species including trifoliate orange seedlings, in a modified - U.C. mix indicated that increasing N promoted growth and produced high fresh weights (Nauer *et al.* 1967). In a similar experiment foliar N in the leaves of Valencia orange seedlings were reported to increase with high N fertilisation (Labanauskas *et al.* 1967) and in the work reported here, foliar levels rose to 1.5%N at the highest N rate. The work reported here indicated a medium N rate response, with an optimum of about 450g N/m^3, i.e. 41g N/m^3/month which is less than the recommendations made for Florida citrus nurseries, where a higher N requirement was suggested (Anon 1972).

A moderate increase in plant growth with added P was revealed in this study. Foliar ratings indicated an optimum response at 200g P/m^3, i.e. 18g P/m^3/month. However, dry weight continued to increase slightly with additional P, and at the high P level of 400g P/m^3, no toxicity was observed. This characteristic of trifoliate orange parallels that of *Choisya*, which appeared very tolerant to high P (Thomas 1981). *Boronia*, on the other hand, showed depressed growth at high P. High P can induce iron deficiency symptoms, (DeKock and Wallace 1965) or depress zinc translocation in trifoliate orange seedlings

(Kahdr *et al.* 1965). However, no such deficiency symptoms were observed in this study at high P. Other research with container grown trifoliate orange and Valencia orange seedlings in modified - U.C. mix had indicated significant increase in fresh weight and foliar P, with P fertilisation (Labanauskas *et al.* 1967; Nauer *et al.* 1967). No significant interaction between P and other macronutrients was found in the work discussed here.

In this study trifoliate orange seedlings showed no benefit from K fertilisation. However, high K application produced plants that were in poor condition, and showed symptoms of chlorosis. At low to medium K, the plants were greener and better looking than those supplied with high levels. The association of Mg deficiency with high K in citrus and trifoliate orange seedlings has been discussed by Chandler (1958) and Kahdr *et al.* (1965). High K appeared to greatly reduce magnesium content of trifoliate seedlings and this could partly be overcome by high Mg application (Kahdr *et al.* 1965). High K also depressed foliar Mg level in *Boronia*, as in the trifoliate orange (Thomas 1981). These workers also reported that high P could severely decrease the calcium content of leaves of trifoliate orange. This interaction between K, Mg and Ca appears to be important in this present study where lime was the source of Mg and Ca. Dry weight was greatly depressed by high K at low lime and high lime at low K. By calculating the ratios of K:Mg application rate, it could be seen that high dry matter yield was obtained at ratios of 1:3 and above. For example, the best yield or growth was at 332g K/m^3 and 12kg lime/m^3 (i.e. 332g K/m^3 : 1095g Mg/m^3 = 1:3.3). However, when this ratio falls below 1:1 such as at the 250g K/m^3 : 3kg lime/m^3, dry weight falls to 12.3g. At low lime or Mg, yields of 10g and below were obtained at ratios of 1:0.9 or below. The worst growth or yield of 7.1g was at the ratio 1:0.04. This indicated that high potassium antagonises magnesium uptake. It therefore seems important that high K fertilisation must be accompanied by high magnesium application to overcome this potassium effect.

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REFERENCES

Anon. 1972: Florida container-grown citrus. Will it replace bareroot stock? Nursery Business. July/ August 1-2.

Bjerkestrand, B. 1969: Liming and fertilising of sphagnum peat for container plants. Acta Horticulturae 15: 11-16.

Bridges, G.D. and Youtsey, C.O. 1977: Cultural practices in Florida citrus nurseries - 1976. Proceedings of the International Society of Citriculture 1: 121-124.

Chandler, W.H. 1958: Evergreen Orchards. Lea and Febiger, Philadelphia. 535p.

Cochran, W.G. and Cox, G.M. 1957: Experimental Designs. John Wiley & Sons, Inc. 617p.

Cowan, J. 1974: Cutting-grafts of citrus with *Poncirus trifoliata* roots. The International Plant Propagator's Society Combined Proceedings 24: 294-5.

De Kock, P.C. and Wallace, A. 1965: Excess phosphorus and iron chlorosis. California Agriculture 19(12): 3-4.

Dickey, R.D. 1977: Nutritional deficiencies of woody ornamental plants used in Florida landscapes. Florida Agricultural Experiment Stations, Institute of Food and Agricultural Sciences, University of Florida, Gainesville. Bulletin 791, 63p.

Jackson, D.I. 1974: Temperate and sub-tropical fruit production. Lincoln College Department of Horticulture Bulletin 15, 97p.

Kahdr, A.H.; Wallace, A. and Romney, E.M. 1965: Mineral nutritional problems of trifoliate orange. Californian Agriculture 19(9): 14-5.

Labanauskas, C.K.; Nauer, E.M. and Roistacher, C.N. 1967: Initial soil-mix and post planting liquid fertilisation effects on nutrient concentrations in Valencia orange seedling leaves. Hilgardia 38: 569-577.

Nauer, E.M.; Roistacher, C.N. and Labanauskas, C.K. 1967: Effects of mix composition, fertilisation, and pH on citrus grown in U.C. - type potting mixtures under greenhouse conditions. Hilgardia 38: 557-567.

Parkinson, J.A. and Allen, S.E. 1975: A wet oxidation process suitable for the determination of nitrogen and mineral nutrients in biological material. Communications in Soil Science and plant analysis. 6(1): 1-11.

Thomas, M.B. 1979a: Nutrition of container grown plants with emphasis on the Proteaceae. Ph.D. thesis. Lincoln College, University of Canterbury, New Zealand. 207p.

Thomas, M.B. 1979b: Nutrition of container grown *Grevillea robusta, Protea repens, Camellia japonica* and *Lycopersicon esculentum* 'Best of All' 'Tomato'. Royal N.Z. Institute of Horticulture Annual J. 7: 39-53.

Thomas, M.B. 1979c: Nitrogen response of Proteaceae and other nursery plants in containers. International Plant Propagator's Society Combined Proceedings 29: *In Press*.

Thomas, M.B. 1981: Nutrition of five species of container-grown *Acacia, Boronia, Choisya* and *Eucalyptus*. Sci. Hort. 14(1): 55-68.

Warner, R.M. 1971: Vegetative response of citrus rootstocks to photoperiod. Proc. International Plant Propagator's Society 21: 125-126.

Warner, R.M. 1979: Rootstocks for Hawaiian Citrus. The Plant Propagator 25(1): 5-8.

TABLE 1

Constants and Coefficients of Response Surfaces of Growth Components.

(*** = P<0.001; ** = P<0.01; * = P<0.05: # = P 0.05-0.10)

TERMS		Chlorosis rating (9 months)		Visual rating (9 months)		Height (9 months)		Stem diameter (9 months)		Stem diam^2 x ht (9 months)		Foliar dry wt (9 months)	
Constant		4.38		3.57		60.93		7.21		34.21		14.42	
Linear	N	0.53	***	0.31	***	6.57	***	0.43	***	6.52	***	3.45	***
	P	0.03		0.03		0.23		0.02		0.68		0.93	*
	K	-0.18	*	-0.08		0.12		-0.01		0.44		0.10	
	Lime	0.13	#	0.03		2.06		0.13		2.00		0.61	
Quadratic	N	-0.27	***	-0.19	***	-3.24	*	-0.27	**	-2.32	#	-0.96	*
	P	-0.09		-0.10	#	0.72		-0.05		0.03		-0.19	
	K	-0.09		-0.00		-1.06		0.03		-0.52		-0.35	
	Lime	0.00		-0.00		1.54		0.11		1.40		0.05	
Significant Interactions		none		none		none		none		none		K x Lime 1.28	*
CV (%)		29		27		40		23		67		51	

TABLE 2

Media and foliar analyses from composite samples taken at 8 months and at harvest respectively.

Added Nutrients				Nutrients in Media (mg l^{-1})					Foliar Nutrients (%)				
g/m^3			kg/m^3										
N	P	K	Lime	NO_3-N	P	K	Mg	Ca	N	P	K	Ca	Mg
0	200	166	6	0.1					1.10				0.25
150	100	83	3	0.6	2.1	7	17	34	1.17	0.17	0.93	0.84	0.20
300	200	166	6	6.4	2.6	10	24	64	1.02	0.17	0.87	0.85	0.17
450	300	250	9	16	4.5	18	38	110	1.02	0.17	0.88	0.95	0.17
600	200	166	6	29					1.47				0.19
300	0	166	6		0.3					0.08			0.16
300	400	166	6		10					0.18			0.17
300	200	0	6			2.6					0.74		0.21
300	200	332	6			20					1.04		0.18
300	200	166	0				21	56				0.88	0.17
300	200	166	12				30	85				1.06	0.16

Leonard Cockayne : Horticulturist

by

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Cockayne's early contributions to botany and especially to horticulture are reviewed; his contributions to the latter culminated in his election as President of the New Zealand Institute of Horticulture in 1924. Aspects of Cockayne's teaching career in Otago, impetus for his resolve to study New Zealand plants, and initial interest in and attitude to horticulture are discussed mainly from evidence in the published record. Cockayne maintained an extensive correspondence with colleagues overseas and examples are cited. His link with the Christchurch Beautifying Association as Secretary from 1897 gave rein to his practical views on horticulture. Examples are given of Cockayne's interest in applied botany and horticulture, including his advocacy of plant breeding and experimental research stations. The conference of fruitgrowers and horticulturists in Dunedin in 1901, which Cockayne attended, was a milestone in the development of horticulture in New Zealand; some of his contributions to the conference are noted.

INTRODUCTION

Extracts from Chapter I of M.J. O'Sullivan's "History of the Royal New Zealand Institute of Horticulture" (1955) were reproduced in the *Annual Journal of the Royal New Zealand Institute of Horticulture No. 5* (O'Sullivan 1977). This detailed history of the Institute commences with the year 1903. However, the genesis of the Institute can be traced much further back, and as a further contribution to the history of horticulture in New Zealand, the present article traces the important role played by Leonard Cockayne (1855-1934), especially in the years before 1903. Emphasis is also placed on the importance of a conference which Cockayne attended of fruitgrowers and horticulturists in Dunedin in June 1901 (Anonymous 1901) as a step in the development of the Institute of Horticulture.

There are many sources of information about Cockayne and reviews of his work; the two best recent reviews are by Moore (1967) and Godley (1967). The present article provides additional biographical details about Cockayne and is more specifically directed to his interest in horticulture and includes data not in the earlier reviews.

ASPECTS OF COCKAYNE'S EARLY DAYS IN NEW ZEALAND

I would like to digress somewhat and refer to Cockayne's early career in New Zealand. Although he became New Zealand's foremost botanist his initial interests were directed more to horticulture which in a way provided a foundation for his later botanical studies.

Cockayne emigrated from England to Australia in 1876 and spent from 1877 to 1880 teaching in Tasmania and Queensland before coming to New Zealand in 1881 (Scholefield (1932)). He had a temporary teaching position at the Tokomairiro District High School (January to March 1881), then from March 1881 to 1883 taught at the two-teacher Greytown (now Allanton) School. These data on Cockayne's teaching career come from the records of the

* Reprinted with a minor change from *N.Z. Journal of Botany 16:* 397-404, 1978.

Otago Education Board and are at variance with data in Scholefield & Schwabe (1908) and Scholefield (1924, (1932)). Incidentally, Cockayne's wife Maude (nee Blakeley) taught at the Balclutha North School when it opened in 1879 and in the following year taught at George Street School, Dunedin.

These early days in New Zealand, after he arrived from Australia, must have been most significant in Cockayne's resolve to study New Zealand plants. I believe the initial impetus came from his association with Peter Goyen. Goyen was one of the inspectors of the Otago Education Board (Anonymous 1905, pp. 162-3). It is recorded in the *Orchardist of New Zealand* (Anonymous 1934) that Cockayne's "... first knowledge of our flora came when he questioned the late Mr P. Goyen about two native plant specimens, and was told they were *Aristotelia racemosa* (wineberry), and Angelica (aniseed)". However, Cockayne himself recorded in an obituary notice to his old colleague G.M. Thomson (Cockayne 1933), "... it was the coming into my possession of his little book on ferns (G.M. Thomson's "The Ferns and Fern Allies of New Zealand", 1882) which led me to commence the study of New Zealand plant life ...". This view was also recorded earlier (Anonymous 1919, 1925a) in articles which appear to have been written by Cockayne or else he provided the data: "In 1887 a copy of the Hon. G.M. Thomson's little book on ferns came into his hands, and, armed with this, he commenced collecting and studying these plants. This quickly led to an investigation of the higher plants. These, in the first place, he approached from the standpoint of horticulture".

COCKAYNE'S INITIAL INTEREST IN HORTICULTURE AND APPLIED BOTANY

Cockayne's studies were initially from the standpoint of horticulture and his property "Dilcoosha" at Styx, Canterbury, where he purchased 15 acres 6 perches on 27 October 1885 and in 1886 bought another 7 acres (Godley 1967, p. 252), contained "... an extensive collection of herbaceous and bulbous plants" including "... indigenous alpine plants he had collected in Canterbury, Westland, and Otago ..." (Anonymous 1919). He lived at "Dilcoosha" until 1892 (Godley 1967, p. 252) and then moved to 4½ acres near New Brighton where he established his Tarata Experimental Garden (Fig. 1) and decided to "... devote his life to horticulture and New Zealand botany" (Anonymous 1919). After leaving "Tarata" in 1903 (Scholefield (1932)) Cockayne lived at several locations in Christchurch and Wellington before making his final home at Ngaio, Wellington. Table 1 indicates Cockayne's various addresses between 1903 and 1934 and was compiled from addresses given on his correspondence to colleagues.

Cockayne lectured to the Philosophical Institute of Canterbury in 1896 on "The Improvement of wild flowers by artificial selection" and the address was "... illustrated by a very large number of exhibits of cut and pot plants" (Anonymous 1897, p. 623). In 1897 he exhibited specimens of winter-flowering iris and hybrid hellebore at the Institute (Anonymous 1898, p. 569). Cockayne's first public lecture was entitled "The daffodil" and was given as a popular lecture in the Art Galley, Christchurch on 22 September 1897 (loc. cit., p. 572); it was illustrated by "... photographs, diagrams, and lantern-slides, and a magnificant collection of Narcissi ...". The manuscript of this lecture is retained by the Auckland Institute and Museum Library (MS74). In his lecture Cockayne envisaged a host of daffodils when he said, "Just think of it! The banks of our river (Avon) one waving mass of these golden flowers to which this evening is dedicated. Think of the effect of this and kindred sights upon our minds. Think of the moral influence of such surroundings upon our children! But my weak words fail, let me turn to Wordsworth Nature's grandest preacher, than whose poem can I find no peroration so fitting my theme" (Cockayne 1897, p. 33).

Some data on Cockayne's Tarata Experimental Garden have been recorded (Anonymous 1919, 1925a): "The New Brighton garden grew apace, thanks to a series of exchanges instituted with forty or more of the leading botanical gardens of the world, so that the collection rapidly increased to thousands of herbs, alpine plants, trees, and shrubs. Also a considerable correspondence began with many of the famous botanists of the day, and herbaria in Great Britain and abroad received many botanical acquisitions. In addition to sowing the seeds of exotic plants (about 2000

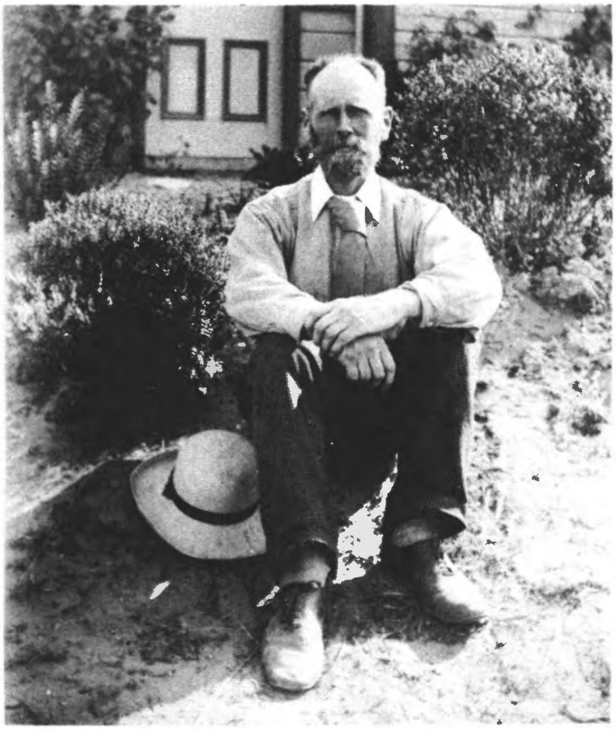

Fig. 1. Leonard Cockayne in his garden at New Brighton, Christchurch (probably in 1890's).
Photo: Auckland Institute and Museum.

Fig. 2 Leonard Cockayne's certificate of Honorary Life Membership of the Christchurch Beautifying Association (original 24 x 20cm).
Photo: National Museum, Wellington.

species yearly) received in exchange for those of New Zealand, Dr Cockayne also sowed many of the latter, and, seeing how greatly a considerable number differed from the parent plants, he commenced studying these seedlings and instigating experiments therewith". Cockayne (1900, p. 98) earlier described his garden as "... in the coastal region, situated partially on the older sand-dunes". Another comment about "Tarata" was noted in Cockayne's letter of 2 January 1905 to Sir Joseph Hooker: "In my former garden, on the Canterbury Plains near the sea, I grew a number of Himalayan alpine plants, several species of Primula being very luxuriant and growing side by side with cultivated Celmisias and *Ranunculus lyallei*" (Cockayne 1905). In 1934 Allan wrote, "Cockayne's New Brighton garden of those days will long be remembered as the seat of fundamental studies in plant-life, of the greatest horticultural as well as botanical value" (Allan 1934).

The correspondence and exchange of seed referred to above provided a method for the dissemination of New Zealand plants and information about them to many parts of the world. The Cockayne manuscript collection (MS74) at the Auckland Institute and Museum Library (summarised by Arthur 1971) includes a list of some 445 of Cockayne's overseas correspondents from the end of the nineteenth century (loc. cit., pp. 7-20). An attempt is being made to obtain copies of all extant Cockayne correspondence from many botanical institutions, archives, and libraries. Since this retrieval programme commenced in July 1976 copies of holograph letters from Cockayne to the following botanists have been received: Willis Linn Jepson (1867-1946), 5 letters from 6 July 1900 to 11 April 1922; Edward Charles Jeffrey (1866-1952), 1 letter of 24 February 1929 (Thomson 1976b); Frederick Orpen Bower (1855-1948), 8 letters from 20 September 1911 to February 1917; Karl Ritter Eberhard von Goebel (1855-1932), 39 letters from 3 August 1892 to 11 June 1931; John Ramsbottom (1885-1974), 1 letter of 5 October 1930; William Arthur Sledge (1904-), 1 letter of 24 January 1932; Sidney Frederic Harmer (1862-1950), 1 letter of 14 January 1929; Royal Botanic Gardens, Kew, 59 letters from 15 August 1899 to 13 August 1928 (obtained by E.J. Godley). The Cockayne correspondence provides an important insight into botanical history and some information contained in it is relevant to present-day botany. An annotated summary of the correspondence is being published in the *N.Z. Journal of Botany* (Thomson 1979). An inventory of all extant Cockayne correspondence will be published in due course in a bibliography of Cockayne's work.

Cockayne's affection for "Tarata" and some further data on the garden are given in a letter he wrote on 9 August 1918 to C.E. Foweraker (1886-1964) while the latter was convalescing in England from World War I; Foweraker was later head of the first School of Forestry at the University of Canterbury. The letter refers to a visit made by Cockayne and Arnold Wall (1869-1966) to "Tarata" in 1918: "... and we visited the wrecking of my former garden and I saw the dismantled glasshouse where juvenile Discaria was born and where indeed my Botany first shaped its career. Here had been Old Brown-the wonderful, the comic-here Dendy many times-here Goebel and later Diels-here Petrie-here many of our Christchurch friends-here Truby-King, Judges Chapman and Struiger, the Hon. Stevens, Michael Murphy all in New Zealand highest in the gardening world and I know not who besides. Now the trees are cut down, the hedge of Galician roses is up-rooted, cows and fowls roam at will-but still here and there are old friends. A Mediterranean daffodil was in bloom; there was still the Chatham Island Sophora and S. grandifolia of the East Cape. There were Eucalypti on the way to becoming majestic and a splendid Mexican pine, away by itself on the sandhills, raised from seed sent to me in the long-ago by Baron Sir Ferdinand von Mueller" (Cockayne 1918).

Photographs of the Tarata Experimental Garden are extant, e.g., Cockayne (1907, p. 373; 1924b, p. 660), Cockayne ((1923), fig. 18), and photograph H1095 in the Archives of Botany Division, DSIR. Cockayne's old house and the site of his garden were photographed in May 1963 by C.J. Miles (see Godley 1967, fig. 2).

COCKAYNE AND THE CHRISTCHURCH BEAUTIFYING ASSOCIATION

It is recorded (Anonymous 1919, 1925a)

that "In 1903 Dr Cockayne, in order to devote all his time to pure science, sold his New Brighton property, giving the contents of his garden to the Christchurch Beautifying Association. At the present time many of the plants adorn the banks of the River Avon".

Cockayne was a founder of the Christchurch Beautifying Association which was formed in 1897. He was the first Honorary Secretary (Chilton 1924) and became an Honorary Life Member (Fig. 2) in 1903 (Scholefield 1924). Chilton (1924) in reviewing the history of the Association noted that the first Annual Report is dated 31 August 1898 and is signed by Cockayne, "... and was in all probability drawn up almost entirely by him". Thus the aims of the Association reflected Cockayne's views, and were "In the first place are to beautify, by suitable landscape gardening, the various waste or partially improved spots within our city and its immediate suburbs, and in the second place (and this we take to be one of its most important functions) to influence by example, suggestion and assistance, others to help in making our city beautiful and attractive, as for instance, through the better and more artistic cultivation of their gardens, or the removal or masking of unsightly objects" (Chilton 1924).

Chilton (1925b) refers to the Sixth Annual Report for 1903, "In the previous April the Hon. Curator, Dr L. Cockayne, had presented to the Association the whole of the very valuable collection of plants and shrubs which were growing in his garden at New Brighton and had himself supervised the work of removal and transplanting during the winter". Chilton (1925a) had earlier noted that Cockayne presented the Association with several varieties of flowering cherry trees and "Among them were several fine flowering cherry trees, white, pink, yellow and red. These were planted on the river banks between Hereford and Worcester streets in front of the Public Library and the Canterbury Club" (Anonymous 1926). Additional contributions by Cockayne to the beautification of Christchurch are described by Lamb (1972).

It can be noted here that Cockayne's attitude to ornamental plants was probably reflected in his comment at the 1901 Conference of New Zealand Fruitgrowers and Horticulturists (Anonymous 1901, p.130): "Mr Cockayne said it was just the single varieties (of roses) in which he took most interest. His garden was like a garden of weeds, but those weeds were appreciated in the shows"; and in the following incident recounted by Chilton (1925c) in his history of the Christchurch Beautifying Association: "Mr H.G. Ell (1862-1934) recommended that the daffodils on the river (Avon) bank be taken up and arranged in beds ... On the other hand, Dr Cockayne strongly disapproved of any interference with the daffodil bank".

FURTHER ASPECTS OF COCKAYNE'S INTERESTS IN APPLIED BOTANY

The first research item published by Cockayne was on humble-bees; it was sent as a note to the first *New Zealand Journal of Science* (Cockayne 1891) and is introduced (probably by the Editor, G.M. Thomson) thus: "Mr L. Cockayne of Dilcoosha, Styx, near Christchurch, who is well known as a collector of Alpine plants, and a cultivator and introducer of European Alpines, sends the following notes of plants visited by humble-bees ...". Cockayne's initial interest in horticulture and applied botany in general is reflected in his first major research publication which was entitled "On the freezing of New Zealand alpine plants: notes of an experiment conducted in the freezing-chamber, Lyttelton" (Cockayne 1898). As mentioned by Thomson (1975a), Cockayne had no qualms about recognising and emphasising the applied aspects of his researches, and with regard to his work on the freezing of alpine plants he noted that the aim was "... in the first place, add possibly some facts of importance to our scanty knowledge of the physiology of New Zealand alpines, and, in the second place, furnish some information which might be of commercial value". He entertained the possibility of shipping dormant rhizomes of *Ranunculus lyaleii* to England in September for flowering in the English spring.

Some aspects of Cockayne's contribution to horticulture were briefly referred to in the Cockayne Memorial Number of the *Journal of the New Zealand Institute of Horticulture* (Anonymous 1938) which includes tributes from L.H. Bailey (1858-1954), Carl Skottsberg (1880-1963), and Sir W. Wright Smith (1875-1956).

Cockayne's early interest in applied botany is also reflected in his campaign to establish biological research stations in New Zealand to study aspects of agriculture and horticulture, e.g., the improvement of plants by selection and breeding (Moore 1967, Thomson 1975a). He was the prime mover in the project to establish a biological station at Cass in Canterbury and an early report (Anonymous 1907) of Cockayne's view on this subject is not recorded by Percival (1958, pp. (41-50)) in "The Flora of Cass" or by Gardner *et al.* (1973). This report in 1907 refers to a meeting of the Canterbury College Board of Governors on 27 May 1907 at which a letter from Cockayne was read; in it he gives reasons for advocating an experimental station: "The rapid development of botany on the side of experimental morphology and physiology has made it desirable that opportunities should be afforded university students of studying primeval vegetation and conducting experiments with plants at various altitudes under natural conditions. In other words, the indoor laboratory, which until quite recently has everywhere reigned supreme, must be supplemented by that of the open air". *The Plant World* for November 1907 (F.E.L. 1907) records, "At the instigation of Professor L. Cockayne, the well known New Zealand botanist, the Board of Governors of Canterbury College has decided to establish a sub-alpine station in the Southern Alps of New Zealand where the mountain flora can be studied under natural condition". Support for Cockayne's views on the importance of research stations was voiced by others; T.W. Kirk was a strong advocate for better facilities, especially for horticultural research (*see* Thomson 1976a, p. 20), and in 1901 was urging that "... small well-equipped horticultural stations be established without delay", he envisaged the possible direct participation of growers, and recommended that the Department of Agriculture "... be authorised to subsidise qualified persons owning orchards or gardens to carry out specified experiments under the control of departmental officers" (Kirk 1901, pp. 323-4).

From the data available about Cockayne's emphasis on the need for applied as well as basic biological research, and the need to establish research stations, it is evident that his views must have given impetus to the campaign which resulted in the formation of the Department of Scientific and Industrial Research. During the Jubilee celebrations of the Department in 1976 emphasis was placed on the 1926 Heath Report (Atkinson 1976, pp. 9-18). However, the foundations for a government research organisation were laid many years earlier, especially by Cockayne and his colleague from Dunedin G.M. Thomson, although the earlier name suggested, Department of Scientific Affairs (Anonymous 1917), did not eventuate. Hoare (1977b) in his Third Cook Lecture 1976 emphasised the contributions of G.M. Thomson (1848-1933) and his son J.A. Thomson (1881-1928), but fails to note (except in poetic form, loc. cit., p. 31) the immense contribution of Cockayne to the development of New Zealand science and, indirectly, to the formation of the Department of Scientific and Industrial Research. Hoare (1977a, p. 30) in his Second Cook Lecture 1976 does state in a footnote on p. 30, "In my view more attention must be given to this seminal pre-Heath debate on N.Z. science than has been the case hitherto".

1901 CONFERENCE OF NEW ZEALAND FRUITGROWERS AND HORTICULTURISTS

The 1901 Conference (Anonymous 1901) was a milestone in the development of horticulture in New Zealand because it brought together horticulturists of varied persuasion and the carefully prepared *Proceedings* include the discussions that followed the formal papers; the latter innovation provides some of the most interesting facets of the meeting. Incidentally credit must go to the Department of Agriculture because "The cost of obtaining a shorthand report and printing the proceedings was also borne by this Department" (Kirk 1902, p. 380). It is likely that the conference engendered a community of interest by horticulturists from many parts of New Zealand and this must have been an important factor in the later development of an Institute of Horticulture.

The Conference was held in June 1901 in Dunedin under the auspices of the Dunedin Horticultural Society, and "The special help given by the Government, in the shape of assisted steamboat and railway fares, enabled nearly all the fruit-growers'associations and horticultural societies in the colony to be represented" (Kirk 1902, p. 380). Cockayne represented the Canterbury Horticultural Society and is noted in the *Proceedings* as "Hon. Botanist, Canterbury Horticultural Society". As well as presenting a paper entitled "The plants of the Chatham Islands considered from the horticultural point of view" (Cockayne 1901), the meeting provided Cockayne with a forum to emphasise many of his views which have been referred to above. Thus the earliest comment I have seen regarding Cockayne's view on plant breeding was recorded at the Conference: he emphasised the value of a plant from the plant breeder's viewpoint, "Generally speaking, we should apply the term (horticultural value) to a plant which, from the point of view of beauty or of economic value, especially as a food, is worthy of garden culture. But in addition to the above must be included the value of the plant from the plant-breeder's point of view; whether, for instance, it can be made more valuable for some specific purpose by artificial selection, by hybridisation, or by a combination of both methods. In addition to this, a plant of a certain species may not be capable of direct improvement, but its pollen may be used with the greatest advantage for the hybridising of some well-known garden plant, and the producing thereby of a new garden race" (Cockayne 1901, p. 107). Cockayne returned briefly in 1906 to the theme of plant breeding especially for indigenous plants (Cockayne 1906) in a newspaper article which was part of a series of articles forming the basis for his book "New Zealand Plants and Their Story" (*see* Thomson 1975b). Later, in interviews published in the *Dominion* (Cockayne 1908a, b), he expanded his views on the importance of plant breeding.

With regard to experimental stations, elsewhere in the *Proceedings* (loc. cit., p. 170) it is reported that "Mr Cockayne said that if New Zealand intended to compete with other countries it was necessary to have experimental stations established in different parts of the two Islands, where experiments could be made with manures, fruits, and other products, and where work partly of a scientific character and partly of a practical nature, distinctly for the benefit of production, could be carried on".

Cockayne's very independent and at times fiery, but perceptive, views are a feature of the discussion sections in the *Proceedings*. For example, he observed (loc. cit., p. 112) that the conference was largely composed of fruitgrowers and not horticulturists, "His society (Canterbury Horticultural Society), which was entirely a horticultural society, had sent its delegates down to discuss matters horticultural, and not matters purely commerical". He emphasised that "The most valuable asset in our colony was the scenery, and if we destroyed our forests the scenery would be no longer an asset" and "... it was of as much importance to look after their native plants as the fruit industry". In commenting on the importance of seeing that no more noxious animals were introduced, Cockayne commented that "When he was in the North Island there were enough wild animals for him; and if people wanted sport let them go and shoot wild bulls".

PRESIDENT OF NEW ZEALAND INSTITUTE OF HORTICULTURE

Cockayne's work for horticulture in New Zealand culminated in his election as Dominion President of the New Zealand Institute of Horticulture in 1924 (O'Sullivan 1955) and he presided over the third annual conference on 13 August 1925. He was also a member of the Examining Board from 1928 to 1934 and on the Loder Cup Committee in 1928 (loc. cit., p. 210, p. 206).

In his 1925 Presidential Address (Cockayne 1925) he made a plea for the planting of indigenous trees and shrubs in public places such as railway stations, and in schools; his booklet "The Cultivation of New Zealand Plants" (Cockayne (1923)) provided information on suitable species and was described as "... an invaluable guide to all gardeners, and a revelation of the riches of the New Zealand flora for horticulural purposes" (Allan 1934). He repeated a view expressed earlier (loc. cit., p. 115), "For what can be better for boys and girls than learning something about the plants of their native land and making them their friends? The love of trees, the value of forests, the reverence for Nature; and, not the least, the love of country, can sink deep into the minds of children from their school gardens of native plants, their very own". Despite Cockayne's eloquent plea, the effective use of a range of appropriate indigenous trees and shrubs still seems to be the exception rather than the rule in schools. Cockayne also read the report of the special committee on horticultural education comprising Cockayne, P. Black, and H.B. Kirk (Cockayne 1925, pp. 679-81, and a slightly abbreviated account is given in Cockayne *et al.* 1926).

Cockayne's firm views on matters relating to horticulture were again in evidence at the 1925 meeting, e.g., with regard to plant introductions, "Dr Cockayne was emphatic in his protest against some of the plant introductions made. He instanced gorse, and said: 'The less we have to do with the Acclimatisation Society the better' ... it was a dangerous thing to allow any sort of muck to be brought in" (Anonymous 1925b, p. 682).

Cockayne contributed significantly to the development of horticulture in New Zealand and to the establishment of the New Zealand Institute of Horticulture. In summarising its aims and aspirations in 1924, he was able to report (Cockayne 1924a) that "The New Zealand Institute of Horticulture is now firmly established".

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REFERENCES

Allan, H.H. 1934: Leonard Cockayne 1855-1934. *Journal of the New Zealand Institute of Horticulture 4(3):* 10-5.

Anonymous 1897: Philosophical Institute of Canterbury. *Transactions and Proceedings of the New Zealand Institute 29:* 622-5.

_______ 1898: Philosophical Institute of

Canterbury. Ibid. *30:* 568-73.
_______ 1901: "Conference of New Zealand Fruitgrowers and Horticulturists". Government Printer, Wellington. 199 pp.
_______ 1905: "Cyclopedia of New Zealand 4- Otago and Southland Provincial Districts". The Cyclopedia Company, Christchurch. 1 115 pp.
_______ 1907: *The Press* (Christchurch), 28 May 1907.
_______ 1917: Proposed Department of Scientific Affairs. *Transactions and Proceedings of the New Zealand Institute 49:* 542.
_______ 1919: Biographical notice. Leonard Cockayne, Ph.D., F.R.S., President of the New Zealand Institute. *N.Z. Journal of Science and Technology 2:* 231-4.
_______ 1925a: Dr Leonard Cockayne, F.R.S. A distinguished record. *New Zealand Fruitgrower and Apiarist 7:* 208-9.
_______ 1925b: Plant improvement. Ibid. *7:* 682.
_______ 1926: Cherry blossom time. *City Beautiful 3(1):* 2-5.
_______ 1934: Dr Leonard Cockayne, F.R.S. His life work. *Orchardist of New Zealand 7:* 11-3.
_______ 1938: Leonard Cockayne: horticulturist. *Journal of the New Zealand Institute of Horticulture 8(1):* 1-8.
Arthur, Nola V. 1971: Auckland Institute and Museum Library manuscript collection. Reference No. MS74. Dr Leonard Cockayne, C.M.G., F.R.S. (1855-1934). Typescript retained at Auckland Institute and Museum Library. 21 pp.
Atkinson, J.D. 1976: DSIR's first fifty years. *N.Z. Department of Scientific and Industrial Research Information Series 115:* 1-220.
Chilton, Chas. 1924: History of the Christchurch Beautifying Association 1. Introduction. *City Beautiful 1(2):* 11-2.
_______ 1925a: History of the Christchurch Beautifying Association IV. The river banks. Ibid. *1(5):* 4-5.
_______ 1925b: History of the Christchurch Beautifying Association V. Beginning of the campaign against public advertisements. Ibid. *1(6):* 5-7.
_______ 1925c: History of the Christchurch Beautifying Association VII. The Riccarton Bush and the Provincial Government Buildings. Ibid. *1(8):* 5-9.
Cockayne, L. 1891: Humble-bees. *New Zealand Journal of Science 1 (new series) (2):* 74-5.
_______ 1897: "The daffodil. Special popular lecture delivered before Canty Phil. Institute". Manuscript (MS74). Auckland Institute and Museum Library. 33 pp.
_______ 1898: On the freezing of New Zealand alpine plants: notes of an experiment conducted in the freezing chamber, Lyttelton. *Transactions and Proceedings of the New Zealand Institute 30:* 435-442.
_______ 1900: A sketch of the plant geography of the Waimakariri River basin, considered chiefly from an oecological point of view. Ibid. *32:* 95-136.
_______ 1901: The plants of the Chatham Islands considered from the horticultural point of view. *In* "Conference of New Zealand Fruit-Growers and Horticulturists". Government Printer, Wellington. Pp. 107-15.
_______ 1905: Copy of holograph letter dated 2 January 1905 from Cockayne to Sir Joseph Hooker, F.R.S. 4 pp. Copy at Botany Division, DSIR.
_______ 1906: New Zealand plants. Their story VI. The meadows. *Lyttelton Times* (Christchurch), 16 May 1906.
_______ 1907: The cabbage-tree, flax, and manuka: three common New Zealand plants. *Young Man's Magazine 8:* 373-5.
_______ 1908a: Scientific plant breeding. An important appointment. Increasing the value of flax. *Dominion* (Wellington), 7 May 1908 (interview).
_______ 1908b: Scientific plant breeding. What could be done in New Zealand. Dr Cockayne's ideas. Ibid. 8 May 1908 (interview).
_______ 1918: Holograph letter dated 9 August 1918 from Cockayne to C.E. Foweraker. 6 pp. Held by Mrs C.E. Foweraker, Christchurch.
_______ (1923): "The Cultivation of New Zealand Plants". Whitcombe and Tombs, Christchurch. 139 pp.
_______ 1924a: The New Zealand Institute of Horticulture. Some of its aims and aspirations. *New Zealand Fruitgrower and Apiarist 6:* 674-5. 9-10.
_______ 1924b: New Zealand plants for the British Isles. *The Garden 88:* 660-2.

_______ 1925: Presidential address. *New Zealand Fruitgrower and Apiarist 7:* 678-81.

_______ 1933: George M. Thomson as a biologist. *Evening Post* (Wellington), 28 August 1933.

Cockayne, L.; Black, P.; Kirk, H.B. 1926: Horticultural education for New Zealand Institute of Horticulture report. *New Zealand Journal of Agriculture 32:* 36-9.

F.E.L. 1907: News notes and wants. *The Plant World 10:* 266-7.

Gardner, W.J.; Beardsley, E.T.; Carter, T.E. 1973: "A History of the University of Canterbury 1873-1973". University of Canterbury, Christchurch. 530 pp.

Godley, E.J. 1967: A century of botany in Canterbury. *Transactions of the Royal Society of New Zealand (General) 1:* 243-66.

Hoare, Michael E. 1977a: "Beyond the 'Filial Piety'. Science History in New Zealand - A Critical Review of the Art". Second Cook Lecture 1976. Hawthorn Press, Melbourne. 33 pp.

_______ 1977b: "Reform in New Zealand Science 1880-1926". Third Cook Lecture 1976. Hawthorn Press, Melbourne. 31 pp.

Kirk, T.W. 1901: Appendix IX - Division of Biology and Horticulture. In *Ninth Report of the Department of Agriculture:* 308-77.

_______ 1902: Appendix X - Division of Biology and Horticulture. In *Tenth Report of the Department of Agriculture:* 359-470.

Lamb, R.C. 1972: Beautifying Association was formed 75 years ago. *The Press* (Christchurch), 26 August 1972.

Moore, Lucy B. 1967: The Cockayne Memorial Lecture, 1965. Leonard Cockayne, botanist. *Transactions of the Royal Society of New Zealand (General) 2:* 1-18.

O'Sullivan, M.J. (1955): "History of the Royal New Zealand Institute of Horticulture". Royal New Zealand Institute of Horticulture. Mimeographed. 228 pp.

_______ 1977: The origin of the Institute. *Annual Journal of the Royal New Zealand Institute of Horticulture No. 5:* 100-3 (extract from Chapter I of O'Sullivan (1955)).

Percival, E. 1958: The establishment and early history of the Canterbury College Mountain Biological Station, Cass. *In* Philipson, W.R.; Brownlie, G. (Compilers) "The Flora of Cass". University of Canterbury, Christchurch. (93) pp.

Scholefield, G.H. 1924: "Who's Who in New Zealand and the Western Pacific 1925". 2nd edition. Venables, Napier. 240 pp.

_______ (1932): "Who's Who in New Zealand and the Western Pacific". Rangatira Press, Wellington. 356 pp.

Scholefield, Guy H.; Schwabe, E. 1908: "Who's Who in New Zealand and the Western Pacific". Gordon and Gotch, Wellington. 202 pp.

Thomson, A.D. 1975a: Aspects of the early history of Government-sponsored plant breeding in New Zealand. *Crop Research News No. 17:* 12-4.

_______ 1975b: The original publication of Leonard Cockayne's "New Zealand Plants and Their Story". *N.Z. Journal of Botany 13:* 807-9.

_______ 1976a: A history of the publication of scientific and agricultural research in New Zealand. *Crop Research News No. 18:* 17-25.

_______ 1976b: Hybridisation and evolution. *New Zealand Genetical Society Newsletter No. 1:* 9-10.

_______ 1979: Annotated summaries of letters to colleagues by the New Zealand botanist Leonard Cockayne -1. *N.Z. Journal of Botany 17:* 389-416.

Table 1 Home addresses of Cockayne after he left "Tarata", New Brighton, Christchurch.

Year	Month	Address on letter from Cockayne to colleague
1903	November	Box 338A P.O. Christchurch
1904	May	Sumner, Christchurch
	October, November	Island Bay, Wellington
1905	January	Sumner, Christchurch
	June	80 Armagh Street, Christchurch
	December	Ollivier's Road, Christchurch *
1908		Ollivier's Road, Christchurch ‡
1909	June	Canal Reserve Road, Christchurch
	November	127 Linwood Avenue, Christchurch
1910	February, June	127 Linwood Avenue, Christchurch
1911	February	181 Linwood Avenue, Christchurch
	June, September	127 Linwood Avenue, Christchurch
1912	January, February, May, December	181 Linwood Avenue, Christchurch
1913	February, June	181 Linwood Avenue, Christchurch
1914	5 January	181 Linwood Avenue, Christchurch
	6 January	20 Colombo Street, Wellington
	February, April, July, October	20 Colombo Street, Wellington
1915	January, March	20 Colombo Street, Wellington
	June	13 Colombo Street, Wellington
	August	20 Colombo Street, Wellington
1916	January, March, May, July, August, September	13 Colombo Street, Wellington
1917	February	Ngaio
1918 to 1934		Ngaio

* Godley (1967) noted that on 5 July 1905 Cockayne purchased a property which is now 51 Ollivier's Road, Christchurch.

‡ Scholefield & Schwabe (1908).

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(N.B. N.D.H. theses are deposited in the Lincoln College Library and are available through the N.Z. Libraries Interloan Service - no additional theses, to those listed in the 1979 Annual Journal, have been presented and examined.)