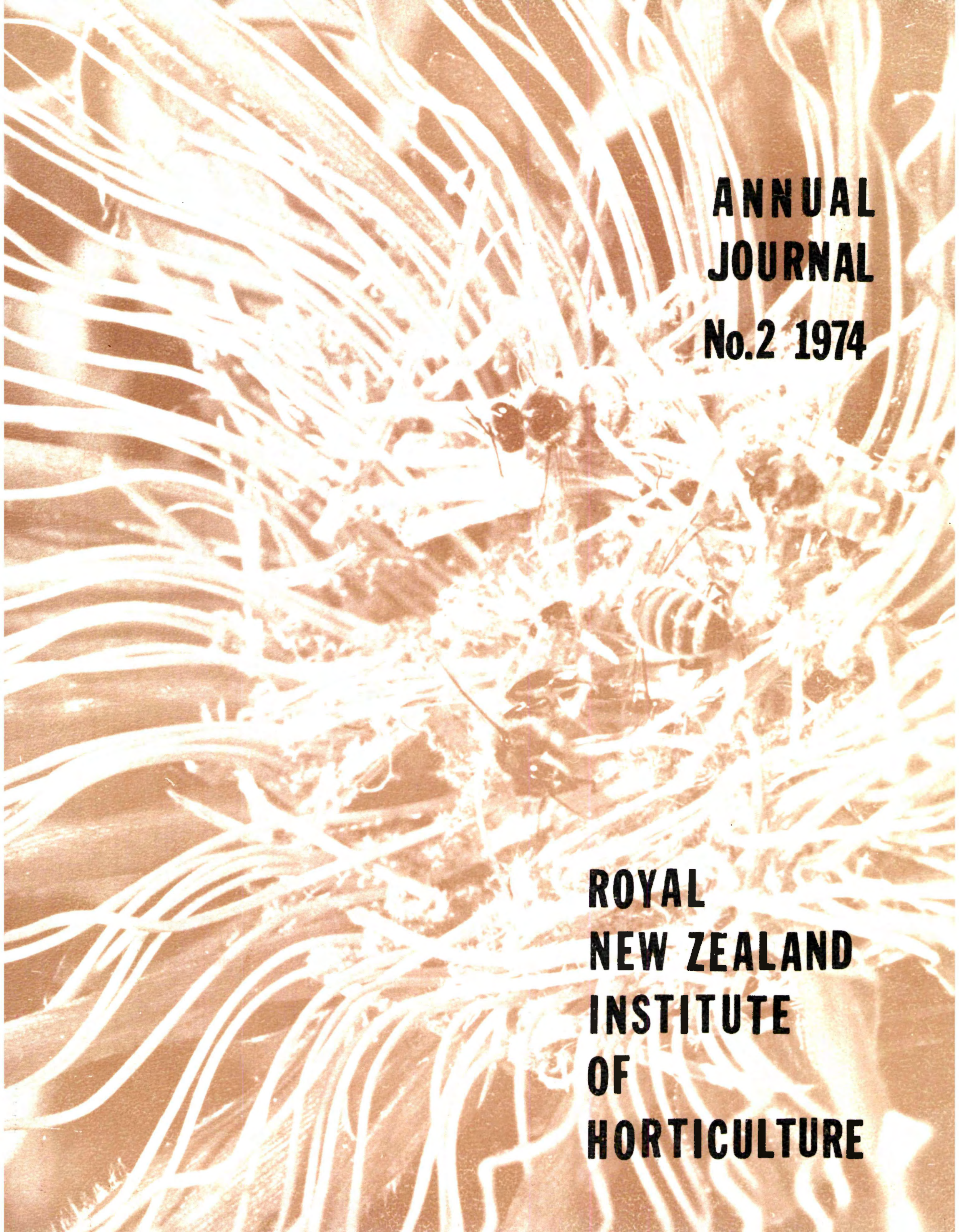

ANNUAL JOURNAL

No.2 1974

ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE

ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE (INC.)

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Cover Picture *by M. B. Thomas*

Honey bees trapped in a flower head of *Protea longiflora.* Honey bees, German wasps and even bumble-bees are often captured and die where they are trapped. *Protea longiflora* is the only recorded Protea species to trap insects—which are ensnared around their necks by loop strands from the stamen filaments.

As the flower ages the stamen filaments, which are crinkled and quite strong, tend to collapse into the flower to form a tangled mass. Bees and other large hymenoptrens which pollinate proteas, tend to tunnel into the flower in search of food where they become physically trapped.

Zondag (1971) examined a large *P. longiflora* bush with over 1000 flower heads. He estimated that about 6,000 bees may have been trapped in the one bush.

Ref: Zondag, R. 1971. Honey bees trapped in *Protea longiflora.* N.Z. Entom. 5(1) 85-87.

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Contents

Changes in the Canterbury Landscape

by S. CHALLENGER

ALTHOUGH the early history of horticulture in New Zealand is not exhaustively documented, some phases have been examined with a degree of care. Three of the R.N.Z.I.H. Banks Lectures, for example, have dealt with the subject - Dr R. C. Cooper's account of "Auckland Gardens" in 1971, M. J. Barnett's "History and Development of Tree Planting in Canterbury" in 1946, and the pioneer, by Robert Nairn in 1932, on "The Early History of Horticulture in New Zealand". Allan Hale, although deeply immersed in New Zealand history, unfortunately only produced one major horticultural contribution – "Pioneer Nurserymen in New Zealand" (1955). Miss E. M. Herriott's account in the Transactions, N.Z. Institute (1919), "A History of Hagley Park, Christchurch" was very largely the source of M. J. Barnett's contribution dealing with the history of the Christchurch Botanic Gardens, in Chapter 2 of "A Garden Century" (1963).

This talk today is not particularly deep but aims to deal superficially with landscape change, largely in Canterbury and in which garden history is part of the total landscape change. I would like to link this change, where I can, with source causes, but time has not allowed me to dig very deeply. Perhaps my most useful original evidence is some reminiscences by John Joyce in the Christchurch Star, 1919, regarding early Christchurch and the gardens with which he was involved. Joyce appears to have been neglected by the garden historians, but he certainly has a part to play in my story.

If we look at reconstruction maps of the Canterbury vegetation during early European times the significance of the four patches of bush on the plains, between the extensive areas on Banks Peninsula and the foothills of the Alps, become immediately apparent. It was at the edge of one of these patches, at Riccarton, that the Deans Brothers settled in 1842. Fortunately it is still present and protected, for the other sites, at Papanui, Kaiapoi, and Rangiora have disappeared long ago.

The description of the Deans Brothers first journey inland, to this bush, is interesting in the comparisons it offers to today. The journey was by whaleboat to the site of the present Barbadoes Street Bridge. Then it was by Maori canoe to the bend in the river close to the present Riccarton Road; and on the whole of this journey the canoe was forced through a dense growth of vegetation, largely flax and niggerheads. When the travellers left the river, the path was forced through a dense entanglement of fern, tu-tu, tussock, spaniard, and other growth, breast high. This was the virgin landscape of Canterbury.

The scene at Lyttelton, the port of arrival for the first four ships in 1851 was portrayed pictorially by Sir William Fox. Reproductions of his paintings are given in John Oakley's "Paintings of Canterbury 1840–1890" (1969) on pp. 26 and 27. The character of the backdrop of the Port Hills, portrayed by Fox, was described verbally by Samuel Butler after his own arrival on 27 January 1860:

> *"Oh the heat and the dust! How shall I describe everything – the little townlet nestling beneath the bare hills, the scattered wooden boxes of houses, with ragged roads of scrubby ground between them – the tussocks of brown grasses, the huge wide-leaved flax with its now seedy stem, sometimes 15 or 16 ft high. We dined at the Mitre. Much grieved to find beer was sixpence a glass. This was indeed serious. After dinner I commenced the ascent of the hill between Port and Christchurch. I thought it very beautiful. It is volcanic, brown and dry; large intervals of crumbling soil and then a stiff wiry uncompromising-looking tussock of the very hardest grass. Then perhaps a flax bush. Then more crumbly dry brown soil mixed with fine but dried grass and then more tussock. Volcanic rock everywhere cropping out. Sometimes red and tolerably soft, sometimes black and abominably hard. There was a great deal, too, of an uncomfortable prickly shrub which they call Irishman that I do not like the look of at all. At last we near the top and look down upon the plain. But the view was of the 'long stare' description. There was a great deal of country, but very few objects to attract the eye and make it rest awhile in any given direction. The mountains wanted outlines. They were rather a long blue lofty, even line . . . The plains were lovely in colouring, but would have been wonderfully improved with an object or two a little nearer the mountains. I must confess that the view, although fine, rather disappointed me."*

This general character is much as one would see it today, although currently perhaps less spartan. I find a considerable sympathy for Butler's comments on the plains, for it strikes me in similar fashion, and demonstrates that the physical bones of any landscape scene are vitally important in its continuity.

The early "gardenscape" that changes this virgin scene in fragmental fashion was well described by Charlotte Godley in her letters, later published as "Letters from Early New Zealand 1850–1853" (1951). Initially, of course, the Godleys stayed in Wellington and descriptions from here are equally interesting.

Describing their own garden in Wellington, Charlotte gives an almost-old-world atmosphere:

> *"The garden is really very pretty . . . with sweet briar, honeysuckle, clove pinks, white moss roses and other real English plants . . . and overrun with fuchsia which makes hedges almost. There is some kitchen-garden too . . . with our own cabbages, horse-radish and lettuce . . . and there are lots of watercress in a stream close by. What is a great matter here is that the whole place is well fenced in." (Winds were there in 1850, too!)*

The Victorian context to gardening is readily shown in her description of Mr Daniel Wakefield's property at Hutt:

> *"Conservatories you see, to almost all the good houses. But he has a lawn too, with plenty of geraniums in bushes!"*

Charlotte's wonder at the geranium *bushes* is due to her English experience, of course. The troubles of clearing the bush are observed and commented upon at Mr Petre's, at Hutt:

> *"They have an excellent fruit garden that was begun by Mr Molesworth 10 years ago. Their clearings have been very artistically done, and a good deal of bush left, in patches, so that it does not look so bare as most places about. Their great pride is a lawn which is already nearly free of stumps – at present the great disfigurement of the Hutt. The bush has been cleared with fire, so that when the trees are cut down, about three feet from the ground – which is as much trouble as they can take here – a black and very unsightly root is left."*

In the same vein she makes observations at Otaki:

> *"The bush has very fine trees, comes close up to the cultivation, and has so far been left in patches of wood that ornament the country very much. But as anyone can go and cut for firewood . . . they will gradually melt away. Besides, the trees that are so left generally die of their own accord when they lose the protection of the bush around."*

and here she gives a succinct statement which categorises a major problem in the decorative use of many New Zealand trees to this very day. Finally, with regard to Wellington, she comments upon the origin of the garden flora:

> *"It is I suppose rather characteristic of an English colony that the gardens here are full of English plants and roses."*

but interestingly enough she mentions Acacia in the next paragraph, demonstrating the early introduction of Australian plants too.

One of the major impacts on New Zealand's landscape, however, has been the sub-divisional pattern imposed by the surveyor, although initially these "lines on paper" would be far less significant than the impact of clearing bush and other aspects of winning a livelihood. The surveyor's task was gigantic. He had to survey all the land, establish a land registry and legal records, fix the sites for towns and the intermediate roading pattern, all before he could hand over legal title. The original Surveyor General, Felton Matthew, had only a few assistants to help him in this gigantic task. So since the pressure in land was enormous, the grid iron system was used as the only practical method. But it did mean that the effect on the landscape was that all possibility of a "natural pattern", founded on the landscape's patterns, was lost for ever.

Nevertheless, considerations for 'reserve' land, retained for amenity and recreational purposes, began early, with the settlement of New Zealand. The New Zealand Act of 1840, for example, authorised land to be placed "in trust for the public uses of our subjects there resident", and Governor Hobson was specifically required to report on land suited for health and enjoyment, and forbidden to dispose of it to a private individual.

The first New Zealand legislation in 1841 stated that Crown Grants were not to be issued for land which in the opinions of the Land Claims Commissioners was required for any purpose of public utility. Similar legislation concerning Crown land has been continued through to today.

This far-sighted legislation was enacted, it should be remembered, when the blight of industrial towns covered the mother-nation of Britain, and even before the 1848 U.K. Health Act set the legislative framework for "public walks" which eventually blossomed into the public parks system. In Christchurch, the open spaces of the Avon and the Heathcote, and of Hagley Park are owed, fundamentally, to this source, as are the core open spaces of many early established New Zealand cities.

There was a less happy change which parallelled the urban scene – the development of agricultural land. The settler came to New Zealand as an agriculturist, and his immediate concern was the transformation of his environment to suit the land for cultivation, for sheep, and for cattle, especially dairy. Canterbury was originally intended as an intensive agricultural production area, and, with its limited tree cover quickly became pastoralist. But elsewhere in the country there were vast changes in the landscape appearance, over a period of 40-50 years, in the initiation of these occupations. The change is best illustrated by statistics:

New Zealand – Total area		26.87 million hectare
Forest on settlement		17.80 "
Today – Total Forest		6.27 "
Exotic	.57	
Indigenous	5.70	

In other words, between 1840 and the present day 12.1 million hectares of forest cover have been removed, fundamentally to initiate agriculture, and as a result of which, has largely resulted the erosion problem so familiar today.

In Canterbury, where clear land was available, and the intended pattern was intensive production, the establishment of cultivation was rapid. 1858 saw 3,000 hectares under cereals, but by 1883 the total had risen to 153,000 hectares. But the original fertility was rapidly depleted and weed invasion occurred, coupled also by severe wind erosion, to which the lack of shelter gave emphasis. The illustration in Oakley's 'Paintings of Canterbury', p.59, of 'Cricklewood', dated 1875, shows the typical Canterbury scene emerging – hard-edged boundaries, with shelterbelts superimposed upon the surveyor's grid iron pattern.

Canterbury made early attempts to provide shelter, as witness the 1858 Ordinance of the Canterbury Provincial Assembly, Planting of Forest Trees. In 1871 there was a Forest Tree Planting Encouragement Act, and in 1874 the first N.Z. Forests Act, which attempted to conserve indigenous forest. But these moves were largely ineffectual, and much was wasted by burning off. Even in Canterbury, which was naturally deficient of timber, the original 22,500 hectares had fallen to 2,850 by 1885, chiefly by the clearance in Banks Peninsula.

Settlement was initially controlled by the presence of standing bush, and where bush was absent, by soil type and by the need for drainage. Several blocks of land near Lincoln College, for example, were by-passed in the initial take-up of land due to drainage problems, whilst the stony lands of the upper terraces astride the Selwyn, between the Waimakariri and the Rakaia, were not taken up until post-1875, relatively late in development.

Christchurch, of course, was taken up early, as was Lyttelton. Perhaps we can return here to Charlotte Godley, describing all the new scenes to her relatives in England, and reflecting the dominance of climate, soil and topography. In residence in Lyttelton, she says:

> *"Here we have no brook, only, as we call it, a gully, dry or very nearly so, and the rivers on the plains are quite a different kind – like deep running canals, as clear as crystal, running very fast too and with rather deep banks."*

This last comment I find of interest for I had long regarded the steep banks, rather than graded ones, as a New Zealand idiosyncrasy, and was interested to find it was merely reflecting nature. On 18 November, summer coming on, Charlotte comments:

> *"I think I told you that our little patch is drained far too well and unless pains are taken with watering the things gradually die down."*

Staying with the Godleys at this time was a Captain Parsons, who heroically watered the garden, carrying 70 buckets of water into the garden one morning, getting up at 4 a.m. to do so!

Oakley, p.36, gives an 1861 painting of the scene at Ferrymead described by Charlotte in 1850, and little changed in the interval:

> *"If there were ready made trees it would be a beautiful valley, but for the present there is that great want. Things grow so fast under a fence or any protection against the wind that garden work is very satisfactory."*

The view from the Bridle Path, leading to Ferrymead (Oakley, p.35) is contemporary with Charlotte's comment about Christchurch:

> *"It was very curious to me to see the plains actually dotted over with small houses, all round the site of the town. When I was there 2½ months ago there was just one built about a month before."*

Certainly a vast difference to the 10,600 hectares covered today! Later, after another visit, she says:

> *"There are houses and gardens and cultivation all the way along; the patches in some places quite touching each other. The whole place so cheerful and busy that it has quite lost the dreary look I thought it to have had last year."*

This gardening did not progress without a source, and we start to see the rapid introduction of the cosmopolitan range of plants we grow today when, stimulated by her stay at the Deans Brothers in December 1850, Charlotte says:

"Those settlers who came out in ships touching at the Cape generally brought supplies of flowers and shrubs from there and they all do uncommonly well – and even bear the wind pretty well – which the roses do not!"

Thoughts turn also to the reverse traffic in plants when Charlotte discusses problems and methods with New Zealand native plants:

"The ferns especially will not bear great light upon their crowns and fade down directly. There is an understanding man near here who collects plants and fills cases to send home. The cases have to be made with the boards grooved into each other, painted and glazed and carefully filled with putty to exclude the air entirely."

This concise and accurate description of a Wardian Case shows that the technique was widely spread, within eight years from the publication of Nathaniel B. Ward's book on the subject.

Of course, collecting from the wild can be dangerous when uncontrolled, and John Joyce, in his articles in the "Christchurch Star" in 1919 comments about this:

"Another thing of the past is the beautiful tree fern, which was ever to be seen growing in the nooks and shady corners of the cottagers' gardens. Now this fern is scarcely ever to be seen. Very many people used to take a trip to Dry Bush or Kennedy's Bush in those days and bring loads of ferns home with them, so that it was a usual sight to see young people coming back after their long walk on Sundays with as many ferns as they were capable of carrying. I often took a jaunt there myself and brought many a heavy load home with me. This went on for many years until the bush got completely denuded of its beautiful ferns – more especially after Joubert and Twopeny held their exhibition in the park, along the Lincoln Road, very many years ago. I forget the year, but I remember well the fernery which the late Andrew Duncan, the nurseryman and seedsman of Cashel Street, built in this exhibition at that time. His gardener who built it was named Mudd and that fernery gave a great stimulus to the building of ferneries. Everyone who could afford to do so built a fernery after that exhibition, so that by the time the ferneries were built the tree ferns had disappeared from their native habitats close at hand, until Oxford bush and the West Coast had to supply the demand. Of late years most of those ferneries have disappeared."

Although these comments are written almost seventy years after those of Charlotte Godley, they do in fact, refer to a much earlier period of time, for Andrew Duncan to whom Joyce refers, died in 1880. But they demonstrate the danger of repeated removals, despite their apparent insignificance when considered one by one. John Joyce was a gardener of "the old school", literally born and bred to the profession, as his own account from the "Star" (1.3.1919) shows:

"I was born in 1850 on the Kilbree Estate, County Cork, owned by a gentleman named Wallace Adams. Here my father had served as gardener for more than forty years, and brought up a family of six sons and one daughter. I spent five years learning the gardening profession under my father, and then left to study under another gardener on the Kilboy Estate, where I spent two very happy years of my life. I rose to a good position, and then came the opportunity of going to New Zealand."

Joyce arrived in New Zealand on 4 September 1870, and after a number of posts, including employ by Christchurch's first Mayor, "Cabbage" Wilson, in his nursery in the Bedford Row area, appears to have settled in Papanui, where he had gardening posts of major responsibility and also undertook garden layout over a relatively wide field. Joyce is undoubted one of many examples of men who were trained in aristocratic estates in Britain, and then attempted to translate these ideals in gardens being created in the newly emerging colony of New Zealand. There were, in the early days of New Zealand, many examples of fine gardens maintained on a scale unheard of today, and employing several full time gardeners. In fact, the story of these gardens, their basic patterns of development and eventual breakdown into modern city suburbs would be an excellent historical study that could keep an investigator happy for a lifetime.

An even better example of such an influence in New Zealand is the Taylor's, father and son. Ambrose Taylor had been employed at Chatsworth, Derbyshire, the famous estate belonging to the Duke of Devonshire, who had that most famous of all famous gardeners, Sir Joseph Paxton, as its head gardener from 1826 to 1858. Ambrose Taylor was undoubtedly influenced by Paxton when he in turn became Head Gardener, and he must have carried these ideas with him when he came to New Zealand in 1889. Here, at the age of 54 he took charge of the Botanic Gardens and Hagley Park. His term as Curator is recorded as being one of "unending frustration", and the contrast between the monied estates of Chatsworth with its eighty-two gardeners, and the financial problems of Christchurch cannot have been greater.

Ambrose's son, Edgar Taylor, who is still alive at the ripe old age of 83 years was employed by the well known firm of A. W. Buxton as the firm's landscape architect. Buxton operated a landscape contracting business and had very wide connections in both North and South Island. The link between Paxton, and Edgar Taylor carrying out landscape work in Hawkes Bay, may be tenuous, but the influence, to greater or lesser extent, must have existed, in just the same way that it must have existed when Edgar Taylor, in 1946, later became landscape architect for Christchurch City Council. To prove this, of course, a close study of the style and character of the various designs carried out would need to be undertaken, but his insemination process is undoubtedly the way in which philosophies of design, consciously or unconsciously, are spread.

Joyce does not appear to have had such aristocratic connections, but nevertheless he played his part. One particular association of interest was with the Rhodes family, for Joyce was head gardener to Mrs R. H. Rhodes at "Elmwood" in Papanui Road, Christchurch, for about 12 years. "Elmwood" lay opposite Innes Road, but today the only remnant visible as open space is Elmwood Park. In 1898 "Elmwood" was used as the official residence of Lord Ranfurly, the Governor General, and it was used intermittently for the current Governor General's residence subsequently. In 1896 Joyce was "loaned" to Heaton Rhodes, later Sir Heaton Rhodes (the son of Mr and Mrs R. H. Rhodes) to undertake the layout at "Otahuna", Tai Tapu, and later he was involved in the layout of Meadowbank, Ellesmere, for Mr George Rhodes.

Joyce entered business on his own account around this time, and was involved in a range of work, throughout Canterbury at least, and possibly wider afield. Joyce himself lists work at Ashburton, Mt Somers, "Woodbridge" (Clarence Bridge, Kaikoura) as well in Christchurch itself.

The period when these pioneer garden designers came to New Zealand was significant, for England had been exposed to a sequence of design styles in the previous 100 years. The climax of the "Landscape Garden" – a misnomer if there ever was one, for these 'gardens' were frequently vast estates, able to absorb 100,000 forest trees within their bounds – had been succeeded by the "Picturesque", which in turn had been developed into John Claudius London's "Gardenesque". And the Victorian bedding plant styles succeeded this. So the Taylors and the Joyces, and the other initiators of garden fashion brought with them at least the "Gardenesque" and "Bedding plant" attitudes. These styles appear to have stuck in New Zealand for longer than in any other country where they made their debut. We still see many plantings of single "specimens", rather than coherent groupings; many of our reserves reflect not only the surveyor's "hard edge" but also the linear placement of gardenesque selections. Our approaches to "design" frequently have an old world naivety about them, and stick firmly in the past.

The large-scale gardens which New Zealand saw from its settlement until the 1890's have largely disappeared under the triple impact of increased land values, taxes, and labour costs, and today the garden that can afford a single full-time gardener is rare. "Otahuna", designed by John Joyce for Heaton Rhodes, employed six full-time gardeners in its heyday.

In Christchurch, Papanui Road was the abode of the rich upper class – for the class system was evident in deeds if not in words. It is rather sad to reflect on the way that gardens surrounding these fine houses have vanished with hardly a trace. The occasional tree begrudgingly retained in a quarter acre section, in one of the many houses carved from the 10 – 20 acre private park, is often all that remains. Merivale Lane and surrounds have absorbed the 20 acre estate of J. Studholme and the adjacent property of C. W. Turner, which now has Rugby Street right through it. The 25 acres of paddock belonging to J. T. Matson, with its complement of emus, ostriches and alpaca is now gone under Murray Place, and reference has already been made to Elmwood Park, the sole remnant of Mr and Mrs R. H. Rhodes at "Elmwood". Towards the top of Papanui Road, the Triggs Estate has St James Street right through it. The retention of "Mona Vale" by the City Council is an item of signal importance in Christchurch, so busily engaged, through the years, in destroying its past.

All these gardens, of course, required ample supplies of nursery stock. Christchurch has always had its share of nurseries, from its very beginnings with the Scot, William Wilson, arriving in September 1850. His nursery is now covered by part of the business area, for it was sited in the area bounded by Manchester, Lichfield, Madras and Cashel Streets. Allan Hale has given a very comprehensive account of these pioneers, however, to which I have nothing to add, except by way of discussion on what they grew.

The patterns of fashion in gardens and garden design can be traced through plans, where – and if – they exist; through the gardens themselves – often buried under roads and small homes; and also through nursery lists. None of these sources are in plentiful supply in

New Zealand. As a last resort one can turn to the "garden guides" and hope that their weight of emphasis in pagination and reference to varieties does reflect changing taste too. There appears to be some correlation, although too much emphasis cannot be placed on such an analysis.

The most comprehensive Christchurch nursery catalogue I know is Nairn's 150 page issue of 1906-7, quite an event in its way, and certainly containing a magnificently wide selection of stock. Nairn's Nursery finally closed about six years ago but it will at least retain its identity as a 'landscape node' on the Southern Motorway.

The range of stock was tremendously wide, covering the whole gamut of nursery stock from stove plants and florists' flowers (in the old fashioned sense of the word) through to ornamental trees and shrubs. The range of varieties was vast by today's standards, and the fruit section, for example, contained 85 varieties of apples, 35 cherries, 55 peaches, 66 pears and even 43 different named varieties of gooseberry. Each list of the many was a specialist nurseryman's list in its own right, whether dealing with flowers, shrubs, stove plants, bulbs or the many other items. This gives us an idea of what the well stocked gentleman's garden should contain, for no nursery grows such a range of stock without an established demand.

The garden guides used in an attempt to elucidate the changes of public taste were Murphy's Garden Guide, 2nd Edn, 1889; David Tannock's, of 1920; and Bretts of 1947. Added to Nairn's 1906 catalogue they do illustrate a pattern of sorts when their emphasis is analysed. The following table is an analysis of the percentage number of pages devoted to each major form of gardening. Obviously many minor interests exist, but it is not possible to correlate them all with significance.

	1889	1906	1920	1947
Ornamental Trees and Shrubs	0	40	5	16
Ferns	2	0.5	0	0
Greenhouse	5	10	10	6
Vegetables	12.5	0	18	14
Fruit	17	8	11	10
Florists' Flowers	25	10	0	0
Flower garden overall	6	25	28	28

Any statistician would be most suspicious of the validity of a table such as this, but nevertheless several trends appear to be present:

1. An increased interest in ornamental trees and shrubs.
2. A considerably increased interest in the flower garden, as opposed to "florists' flowers" (i.e. the "show" flower, generally with somewhat mathematically specified virtues).
3. A reduced interest in fruit.
4. Reduced interest in ferns.

Most of these matters are, however, of private concern. The public concern with its total landscape has been pressed by many societies, and notably amongst many in Christchurch have been the Canterbury Horticultural Society, founded in 1864; the Christchurch Beautifying Association (1897), and the Papanui Beautifying Society (c. 1920), which had John Joyce as one of its early advisers.

The 75th anniversary of the Christchurch Beautifying Association was marked, amongst other things, by the production of a little booklet emphasising highlights in its history. Extracts from that publication can readily signpost their attitudes.

The inaugural meeting was held:

> *"in the Oddfellows Hall, Lichfield Street, on 8 September 1897 for the purpose of forming 'a society to undertake the Beautifying of the City Reserves'."*

and they were soon at work:

> *"with its declared policy 'to plant and otherwise beautify the uncultivated public places in the city', the Society turned to the island by the Hereford Street bridge, which after the recent demolition of the mill which had stood there for many years, had become overgrown and unattractive. Here was an excellent opportunity for the newly formed association to co-operate with the City Council in a planting venture which attracted great public attention. On 6 June 1898, after a short ceremony, trees including magnolias, maples, a matipo and a camellia tree were set in position by several leading citizens assisted by their wives. Round the whole would go a mass of roses interspersed with Japanese maples, with daffodils and lilies to provide spring and autumn effects."*

Whatever we may think of the appropriateness of such a random mixture today, it obviously was well received by the citizens of the day. But new objectives were soon developed.

> *"Meanwhile, moving further afield, the association encouraged the planting of suburban streets with well-chosen trees, the provision of garden plots at*

city street intersections, the removal of unsightly poles and hoardings, at the same time persuading residents to dispose of high front fences which all too often hid attractive gardens.

In February 1906, Mr H. G. Ell, who until his death in 1934 was a constant battler for scenic improvement and left as his chief memorial the Summit Road, pointed out that Deans Bush might be acquired by the city. It would be a great pity if this area, with a great variety of trees and shrubs should be lost through inaction. Two years later the association received a gift of £500 from the estate of the Honorable J. T. Peacock, this sum to be used to beautify the reserves and gardens on the banks of the Avon."

The successful retention of Deans Bush was referred to early in this survey, and the Avon is still a pleasure to the city.

The involvement of the garden owner in the street's appearance was later given formal approval when:

"In 1933 Mr R. B. Owen pressed for "a competition for the best gardens as seen from the street", urging at the same time the removal of unsightly fences."

It is a pity that the interest developed became largely identified when "bedding-plant" gardens, obscuring the work of greater significance undertaken by the Association:

"In October 1952 the hope was expressed that with the removal of the tram tracks from Cathedral Square a new lay-out might be planned with no traffic in front of the Cathedral. Mr G. A. J. Hart had produced plans to this end, maintaining that the work of the Association should not be too much concerned with the judging of garden competitions. The suggestions made by the Association should bear more fruit."

Well, the fruit was bourne, eventually, in 1973, with the total facelift that the Square has eventually received. Whether the action would have eventuated without the push of the Commonwealth Games is a mute point, but the "new layout" is here.

The detailed pattern we have seen cannot help but be distorted, but the general truth of the story is correct. New Zealand has passed through tremendous landscape changes in only 130 years, more than other nations have in 13 centuries. Today it is poised on the brink of even greater landscape change.

1972 saw a change of Government, largely over the landscape issue of Lake Manapouri. Public opinion now accepts attention to environmental matters in the face of undoubted costs, which would be quite unthinkable 20 years ago. The age of "man in sympathy with his environment" is slowly being heralded in, and we owe it, not only to ourselves, but also to the many pioneers who played their parts in setting the scene.

Book Review

PLANT PROPAGATION by K. R. W. HAMMETT
A. H. & S. Reed, Wellington
$2.50

BOOKS on specific horticultural subjects, written by New Zealand authors have been relatively few in number, and Dr Hammett is to be commended for his efforts in preparing this book. Within self imposed limits of size he has attempted to cover those aspects of plant propagation which he considers most important; seed and cuttings. In this selection the author will, of course, meet with critics who might argue the merits of other techniques which he has passed over, and some might argue that certain chapters of the book could have been deleted in favour of descriptions of budding and grafting techniques.

Similarly the author has also found some difficulty in deciding which level of horticulturist to cater for; the home gardener, the serious student, or the commercial nurseryman. Thus while the body of the book is more likely to be useful to the keen amateur, the recipes for media or composts are in quantities more suited to a commercial nurseryman. It might also have been an advantage to include a warning on the dangers of storing seed and potting composts once the fertilisers have been incorporated. However, these sorts of difficulties were no doubt compounded by the limitations in size.

Within these limitations Dr Hammett has produced a book which will be of considerable assistance to the keen amateur, intent on building up a stock of plants for his garden, and, hopefully, it may also instil some enthusiasm for this subject into others.

reviewed by M. Richards.

The Influence of Snagging Methods on the Growth of Roses in a Nursery Trial

(Extracts from a thesis for the National Diploma of Horticulture (N.Z.) submitted by D E Estcourt in 1971)

ABSTRACT

Following normal budding in January on *Rose multiflora* rootstocks several snagging methods were compared in a nursery trial in Hawke's Bay. There were no significant differences in plant size between treatments. The traditional method of removing stock growth, four months after budding, produced the most satisfactory results Treatments had less effect on plant size than scion varieties. Economic aspects of rose bush production are discussed and normal treatment was most profitable The incidence of virus disease interfered with the interpretation of this experiment. The use of virus free budwood and rootstocks is recommended and is an important factor affecting the profitability of rose plant production in New Zealand nurseries.

INTRODUCTION

The aim of this trial was to determine the most effective way of snagging rose rootstocks after budding. Special attention was paid to the timing of these operations.

The intention was to produce saleable trees under conditions normally encountered. The trial was conducted in a commercial nursery and involved 400 *Rosa multiflora* stocks planted in four rows.

Cuttings were taken from a stock bed grown specially for cutting material. The clone had been used for a number of years. It had not been indexed for viruses.

Commercial rose nurseries in New Zealand bud onto *R. multiflora* in early summer, while in European countries, grafting onto dormant *R. canina* stocks and summer budding onto *R. canina,* are employed (Garner 1958).

The standard treatment for budded roses here is the complete removal of stock tops, down to the bud, 4 months after budding. This method is obviously the result of work by pioneer nurserymen who have modified traditional European methods to suit mild New Zealand conditions

A detailed study of snagging methods was thought a worthwhile project as no published references to New Zealand experiments could be found

GENERAL MANAGEMENT PRIOR TO BUDDING

The stocks were propagated from ten inch cuttings made late in June 1969. To prevent growth of suckers, all buds except the two terminals were removed, they were heeled in moist sand to callus.

On 8 September, the stocks were planted out in rows 1m apart, 18 to 20cm between cuttings. They were pushed to a depth of 12cm into a slit in the ground, made with a spade, and firmed. Soil was mounded up around them to prevent excessive moisture loss from dry winds which prevail in Hawke's Bay in spring.

Weeds were controlled by regular use of a rotary hoe, with hand hoeing around the stocks. No chemical weed control was employed in the trial area.

In mid-January 5cm of water was applied by sprinkler irrigation. This ensured a good sap flow in the stocks for budding, and should promote a good bud take.

Soil was drawn back, using chop hoes to expose the shanks. Buds could then be inserted 7-10cm above the roots which is considered the most satisfactory budding height for most Hawke's Bay conditions.

Budwood was cut from bushes grown for this purpose. The selection of budwood was made in accordance with a recommendation by Kordes (1964). "When cutting buds . . . make sure they are taken from a stem which has carried a high quality bloom, typical of the variety . The best buds are usually found half way down the shoots. The thorns are removed by hand and if they snap off easily, leaving a damp green patch underneath, this is proof that the buds were ready to be taken".

All buds were inserted, by one operator, on 28 January 1970, using conventional T-budding techniques, (Garner, 1958). All buds were tied by one operator, using rubber ties.

Each row was budded with one of the following:

'Super Star' 'Josephine Bruce'
'Fragrant Cloud' 'Western Sun'

These varieties provided a range of growth habits and disease resistance.

LAYOUT

The trial block was laid out in randomised ten-plant plots to try to minimise any variation caused by soil conditions or disease. There were two guard plants between each plot, so only 80 of the 100 stocks in each row were actually employed in the trial. Each treatment was replicated four times.

TREATMENTS

TREATMENT A. Stocks were broken over just above the bud, a month after budding. The stocks were snapped half way through, by hand, on the side in which the bud was inserted.

TREATMENT B. The stock tops were reduced in length, a month after budding. Lateral growths from the top of the stock were severely shortened to leave only 15 to 20cm of growth. Leaves were left on these laterals, and new growth commenced quickly.

TREATMENT C. A month after budding, sharp secateurs were used to sever the stocks at the top of the budding cut. The cut was angled back slightly to drain off sap exuding from the cut.

TREATMENT D. The stocks were left intact.

TREATMENT E. Identical to Treatment A but carried out 4 months after budding.

TREATMENT F. Identical to Treatment B but carried out 4 months after budding.

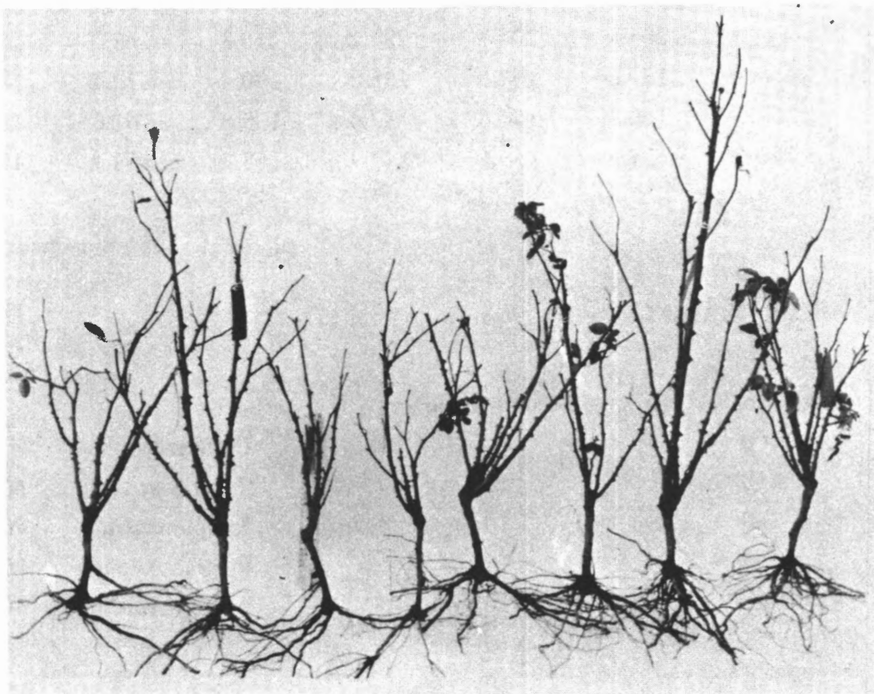
TREATMENT G. Identical to Treatment C but carried out 4 months after budding.

TREATMENT H. The stocks were left intact.

Seven months after budding, all stocks that had not previously been completed snagged, were cut back to the bud.

RECORDS

Five weeks after budding, a count was made of successful bud takes. Subsequent shoot growth was measured in inches at 2-weekly intervals for 9 months, and at monthly intervals subsequently. The incidence of disease was noted as it occurred. When the plants were lifted, soil was washed from the roots and they were weighed individually.



Treatments: A B C D E F G H

Influence of snagging methods on the size of rose plants. Typical plants selected at time of digging

Table I:

INFLUENCE OF SNAGGING METHODS ON GROWTH OF ROSE PLANTS MEAN HEIGHTS (CM), AT TIME OF DIGGING

	EARLY TREATMENTS				LATE TREATMENTS			
VARIETY	A	B	C	D	E	F	G	H
Super Star	60.5	31.5	43.7	64.3	64.8	59.4	63.8	38.1
Josephine Bruce	62.7	67.1	49.5	54.1	58.4	46.2	56.4	45.0
Fragrant Cloud	42.7	43.9	49.0	54.4	53.6	50.3	59.4	46.5
Western Sun	24.9	35.8	38.9	14.2	36.8	49.8	54.6	18.3
Mean All Varieties	47.8	44.5	52.2	46.7	53.3	51.3	58.4	36.8

Table II:

INFLUENCE OF SNAGGING METHODS ON SIZE OF ROSE PLANTS MEAN FRESH WEIGHTS (g), AT TIME OF DIGGING

	EARLY TREATMENTS				LATE TREATMENTS			
VARIETY	A	B	C	D	E	F	G	H
Super Star	132.4	89.30	109.7	137.5	150.5	115.7	152.2	83.1
Josephine Bruce	233.0	206.1	204.7	229.1	218.3	163.0	257.6	178.0
Fragrant Cloud	150.3	137.0	167.3	168.0	170.7	172.4	182	140.9
Western Sun	87.6	160.3	144.6	37.4	135.8	161.6	168.4	65.2
Mean All Varieties	150	134.7	156.5	142.9	168.7	153.1	189.7	116.8

Table III:

SALEABLE PLANTS AFTER GRADING

	% First Grade	% Second Grade
Treatment A	60	10
B	50	10
C	40	10
D	60	10
E	65	10
F	75	10
G	70	10
H	50	10

Cultivar		
Super Star	60	15
Josephine Bruce	70	Nil
Fragrant Cloud	70	10
Western Sun	40	5

GENERAL MANAGEMENT AFTER BUDDING

When scion shoots reached a height of 15cm they were cut back to 7 to 10cm. This is normal nursery practice aimed at producing bushy plants and reducing losses due to wind damage.

Weed control was maintained by the use of hand hoes and a rotary hoe.

To help prevent bacterial dieback during winter 1970, particularly on sprouted buds, the antibiotic streptomycin was applied. During the growing season, sprays for pest and disease control were applied.

Just prior to lifting, a U- bar wrencher was drawn along each row, severing the roots. Fingers on the bar imparted an upward lift to the soil, loosening the bushes and making digging easy.

RESULTS AND DISCUSSION

Although some trends were noted, final analysis showed no significant differences between treatments (Table I – II). The choice of variety produced a much greater influence on plant size, than treatments.

However, prior to harvesting, some differences were observed in plant response to snagging treatments and the following points can be noted.

(a) Early removal of the stock growth (Treatment C) stimulated early scion growth in autumn and this continued in following spring. Later snagging (Treatment G) had a smaller influence on spring growth but compensated with increased growth in the early summer period. Early stock removal would have reduced potential root development, resulting in overall reduction in growth rates. Later stock removal showed a normal response to pruning, governed by the release of growth hormones in the absence of growth-inhabiting substances associated with mature foliage.

(b) The reducing of stock tops produced good growth, although the effects were not as marked as snagging.

(c) Breaking over produced good results as shown in Table II. The bud plumped up before the stock became dormant and then made rapid spring growth.

(d) Removal of stock tops in August had a detrimental effect on scion growth. Bud development prior to removal was poor, and bud movement after removal was late so that early growth remained weak. Auxins released from the stock top would have suppressed bud development. By contrast, no such suppression occurred in breaking over or earlier snagging, leading to more rapid scion development and strong growing plants, following these treatments.

(e) The cost of production is important. The quickest and cheapest method would be traditional snagging to the bud in one simple operation done locally in May, leaving the top in one piece, which would be easy to gather and dispose of. This treatment was also most profitable when the production of first grade plants is considered (Table III).

Breaking over would require two operations. First the stock has to be snapped over and then snagged in August. Two operations would almost double the time involved and, in the absence of improved quality in saleable plants, the increased cost incurred would not be warranted.

Several cuts would be required to reduce the stock top, leaving many small pieces to be gathered. The stock has to be snagged later, making this a very costly treatment, with no increase in profit due to treatment.

(f) The suspected presence of virus diseases in 'Western Sun' could account for high percentage of plant losses prior to harvesting. It was assumed that 'Super Star', 'Josephine Bruce' and 'Fragrant Cloud' were slightly infected or rather symptomless varieties (Fry & Hammett 1971). Only 44% of 'Western Sun' plants were saleable, (Table III), the rest were discarded due to weakness and disease. This percentage is far too low to be economical.

(g) Where bud plumping occurs before cold winter weather commences (e.g. Treatments E and G) there would be distinct advantages for districts subject to severe conditions. These plump buds would be able to survive severe conditions better than unripened buds.

This trial was conducted during a year with a mild winter, so this point could not be investigated.

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Observations on Rose Wilt Virus

by K. H. MARCUSSEN

ALTHOUGH rose wilt virus has been observed in New Zealand for many years it was not acknowledged as such until 1969 when it was accepted that a virus complex was involved after graft transmission was proven by Drs Fry and Hammett.

In their study there were no indications of any transmission other than by grafting but nursery men have since been warned that all stock plants, except those from indexed material or of seedling origin, must be considered suspect of containing the disease.

This in itself has been an excellent move. It was common practice in many nurseries, especially in the North Island, to take cuttings from plants which had been budded the previous summer. Such stocks might contain various systemic diseases, e.g. Verticillium wilt, apart from the range of viruses infecting roses. A considerable improvement in the output of many commercial rose nurseries has been brought about.

One major difficulty, however, still exists. It is possible to have clean rose stock, but no indexed cultivar plants are available for budwood. This means that selection, based on observation right from the time the buds break dormancy in their first spring after budding, must be carried out to obtain the best possible material, even if that is no assurance that rose wilt virus is not present.

Rose wilt virus, as we call it today, is a very complex problem. What happened to those plants which after having shown slight symptoms in the nursery grew away from it and produced reasonable plants? Does rose wilt virus become latent? Can it remain dormant for many years and then suddenly show up, possibly through adverse growing conditions, or is it overcome by the plants?

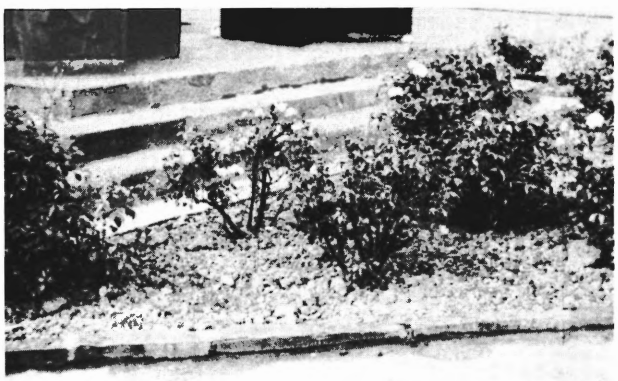
Whatever happens, some strange developments do take place. Observations made in Christchurch over the past five years seem to indicate that spread of rose wilt virus, other than by graft transmission, can occur.

Incidence of Spread

At the time when Drs Fry and Hammett's work became known (1969), one plant in a bed of established bush roses, cultivar 'Iceberg', had been observed to show the typical symptoms of rose wilt virus. The plot was close to the Ministry of Agriculture and Fisheries' office and we used this plant to show what the symptoms were.

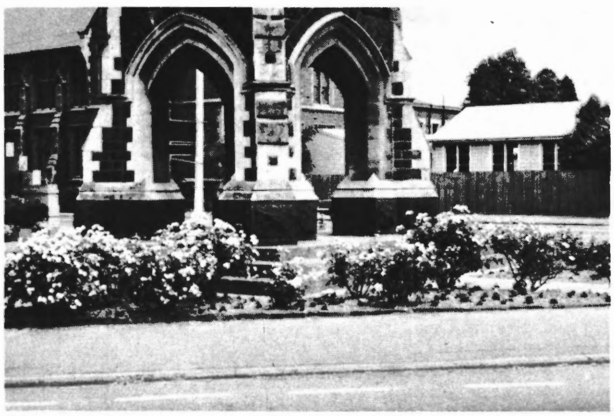
In 1970 two neighbouring plants also showed symptoms and after discussion the case with Dr Fry a photographic record was made (Fig. 1). In June 1971 soil samples were taken from the rooting zone of the three affected plants and sent to the nematologist attached to Plant

Fig 1



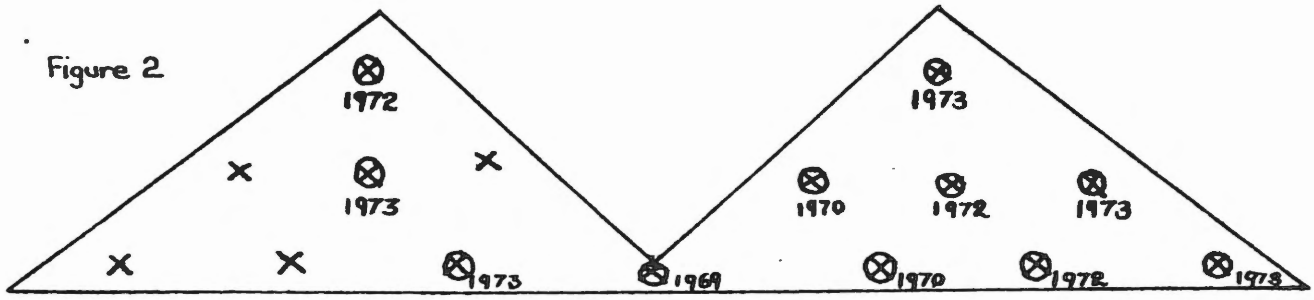
1970. Three plants affected. The original extreme left.

Fig 3



1973. View of plot under observation. Should be compared to Fig. 2.

Figure 2



Pattern of spread. The year quoted is when symptoms were seen first.

Diseases Division, Auckland. They were taken at three levels: 0 to 10 cm, 10 to 20 cm, 20 to 30cm. No vector species were found in any of the samples.

In 1972 another two plants were found to show the symptoms of rose wilt virus. They weakened to such an extent that they were removed during the following winter.

The spread continued and symptoms were observed on an additional six plants in October 1973. On some of these plants odd branches only appeared to be affected, but there was no doubt that rose wilt virus was present.

This is the only case I have been able to follow where a pattern of spread of this problem has shown up, but it certainly indicates that rose wilt virus can be spread by means other than graft transmission.

A plan has been drawn (Fig. 2), which shows the recorded spread and Fig. 3 shows the plot during 1973 when the roses were in flower. The photos are taken from the same side of the plot.

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Book Review

TREES FARMS AND THE NEW ZEALAND LANDSCAPE

GEORGE STOCKLEY

Northern Southland Farm Forestry Association, Dipton, New Zealand. 220 pages.

Not only for the farmer will this book be useful. It is easy to read and easy to understand. It is obviously written by a man of the "earth" whose practical knowledge of trees is extensive. The book contains a lot of practical information about trees and shrubs in the farm environment and the author's manner of writing certainly conveys this. As an example he says that "some nurserymen thrash hell out of radiata pine during the conditioning process".

The selection of trees and shrubs together with comments about those recommended will be of considerable value to the farmer and home owner with extensive space. The Prunus group which is especially important for homestead planting is dealt with too briefly and the flowering and fruiting crab apple group *(Malus spp.)* are not mentioned. The chapters on the production of rooted cuttings and container grown plants are beyond the realm of all except perhaps the ardent hobbyist.

The pages on establishment and maintenance are full of practical advice and are epitomized in the author's words — "it is surprising the number of people who will go to the trouble to produce a tree or will happily pay a high price to purchase a rare specimen, and then plant it with a minimum of preparation in some God-forsaken spot, turn their backs on it and then expect it to establish itself with no further thought to maintenance or protection."

The line illustrations by Clive Anstey suitably convey the underlying message of the book which is to plant now for the future with the added support about what to plant and how to plant it.

It is a pity that the drab jacket of the book does not display the enthusiasm which is evident within.

Reviewed by J. O. Taylor.

Evolution of the Proteaceae and Cultural Implications

by
P. J. HOCKING and M. B. THOMAS
(Department of Horticulture, Lincoln College)

INTRODUCTION

Although the family Proteaceae is relatively small, it embraces many beautiful trees and shrubs, e.g., the Australian Warratah *(Telopea speciosissima)*, the South African Sugar Bush *(Protea repens)*, and the Chilean Fire Bush *(Embothrium coccineum)*. A large number grow well in the warmer parts of New Zealand and are becoming increasingly popular.

Unfortunately, some of the most beautiful species of *Banksia, Protea Dryandra* etc. are either difficult to propagate or die soon after removal from the propagation bench. Consequently, many New Zealand nurserymen routinely suffer considerable set-backs and economic losses with proteaceous lines. A host of reasons has been advanced to explain the sudden demise of these plants, but few explanations are plausible or scientifically based. This is probably due to a lack of basic information on, and understanding of proteaceous distribution, ecology and physiology.

This article deals with the evolution, phytogeography and adaptive mechanisms of some Proteaceae and attempts to seek out factors which might shed light on causes of cultivation problems. Special reference is made to Australian heathland Proteaceae.

DISTRIBUTION AND EVOLUTION

The family Proteaceae consists of about 60 genera and 1300 species (Hutchinson, 1967). Present distribution is disjunct and virtually confined to the southern continents (Ramsay, 1963). Most Proteaceae are in Australia (approximately 35 genera and 800 species) and South Africa (approximately 14 genera and 380 species), with a few in Central and South America, tropical West Pacific, New Zealand and tropical Asia northwards to Japan (Hutchinson, 1967). Two Sub-families are recognized by Hutchinson (1967):–

1. Grevilleoideae – includes *Grevillea, Banksia, Dryandra* etc.
2. Persoonioideae – includes *Protea, Leucadendron* etc.

Persoonioideae (referred to by Rao (1971) as the Proteoideae) predominate in South Africa, while the Grevilleoideae are well represented in Australia (Ramsay, 1963). South Africa and Australia have no genera in common. Australia has several genera in the Persoonioideae, whilst South Africa has only one genus belonging to the Grevilleoideae. Although the Australian flora has a strong affinity with that of South America there is little evidence suggesting a similar relationship with the flora of Southern Africa (Burbidge, 1960). In the genus *Orites* for example, there are two species in South America and eight in Eastern Australia and Tasmania (Rao, 1971. The two New Zealand proteaceous genera *(Knightia* and *Persoonia)* are absent from South Africa and South America, with *Knightia* being confined to New Zealand and New Caledonia.

Proteaceae is an ancient family and its origin remains one of the major phylogenetic mysteries. Johnson and Briggs (1963) consider proto-Proteaceae existed before the Upper Cretaceous under tropical and sub-tropical rain forest conditions. By the end of the Upper Cretaceous, the Proteaceae had evolved and distribution was perhaps almost cosmopolitan, although evidence for this is rather inconclusive (Rao, 1971). Darlington (1965) believes the Proteaceae developed in the tropics and migrated southwards during a long period of widespread warm, moist conditions. Later, during a cold climate they became extinct in Antarctica and survived only in more northerly refugia, from where they spread southwards again with climatic improvement.

Burbidge (1960) discusses the evidence for an Antarctic origin and points out that the paucity of Proteaceae in New Zealand is unusual if they originated in Antarctica. Rao (1971) believes that Australia was the home of the Proteaceae which originated under mountainous rain forest conditions and later spread into the lowlands. Separation of ancestral stocks occured early during angiosperm development with subsequent independent speciation in the different land masses.

Proteaceae in Australia

It appears that many proteaceous genera arose in

Australia during a warm epoch, e.g. *Grevillea, Banksia, Dryandra* and *Persoonia* (Wood, 1959). Crocker (1959) states that by the Early Tertiary, Australia had a broad-leaved vegetation including proteaceous genera allied to *Hakea, Banksia* and *Persoonia* and concludes that these plants had sub-tropical affinities. Specht and Rayson (1957) give evidence that present-day sclerophyllous genera of Proteaceae e.g. *Banksia,* evolved under a warmer and moister climate than at present.

The Australian distribution of Proteaceae is interesting. They are only abundant in the relatively moist S.W., S., and E. coastal belts of Australia and are poorly represented in the arid regions. Seven of the genera in N.E. Queensland are endemic there. The S.W. province of Western Australia has five endemic genera (Gardner, 1959) while there are no species common with N.E. Queensland. Evidence suggests that many proteaceous genera were formerly much more widespread than at present, e.g. fossils of *Dryandra* spp. now confined to S.W. Western Australia have been found in Victoria (Johnson and Briggs, 1963).

Geological history shows that during the Cretaceous period the central part of Australia was flooded by the sea (Crocker and Wood, 1947), which almost reduced the continent to two large islands, one western, the other eastern. Consequently the flora of the central area was destroyed and the floras of the east and west became isolated. When the epicontinental sea receeded, the central part of Australia emerged as a flat, saline desert, uninhabitable to plants and has remained a formidable barrier to migration and inter-mixture of the Floras (Rao, 1971).

In addition, it appears that during the Miocene, earth movements occured in S.E. and S.W. Australia resulting in a great diversity of habitants and local climates (Wood, 1959). Browne (1945) provides evidence that during the Late Pleistocene, Australia's pluvial climate changed to an arid one with marked seasonality which essentially continues today. Australia also experiences periodic droughts which are very intense and may extend for months. These changes provided strong selective pressures and those proteaceous taxa which could adapt, spread from the rain forests, e.g. *Hakea, Banksia* etc., while others remained confined to them or became extinct. The selective pressures also led to speciation and subsequent endemism (Wood, 1959). This is especially so in the S.W. province of Western Australia, one of the world's richest floristic regions. About 75% of the species are endemic, a figure similar to that of the Cape Province flora of South Africa where there is strong endemism, particularly in the Proteaceae.

Burbidge (1960) regards the S.W. Province of Western Australia as the chief centre of proteaceous development in Australia, e.g. the three largest genera *Grevillea* (250 spp.), *Hakea* (140 spp.) and *Banksia* (40 spp.), have their main development there. However, Beadle (1962) points out that centres of greatest species abundance within a genus may not represent the centre of origin, but rather a local expression through edaphic and climatic control of a once plastic genus which migrated into an area capable of stimulating adaptive radiation.

Proteaceae and the heathlands of Australia

Many of the cultivated Proteaceae come from the Australian heathlands. Typical heathland vegetation consists mostly of small stunted trees and shrubs, including *Banksia* spp., *Acacia* spp., *Eucalyptus* spp., *Epacris* spp. (the Australian heaths), *Casuarina* spp. etc. (Gardner, 1959; Specht, 1963). It invariably occurs on extremely impoverished acid to neutral sandy soils of the moist coastal areas of South West, South and Eastern Australia. The soils have very low available P, N, K and Ca, while Mo, S, Cu, Zn and B may also be extremely low (Specht, 1963; Stewart, 1959; Wood, 1959). P levels may be below 150 ppm in some soils of the S.W. Province of Western Australia (Beadle, 1962). Wood (1959) suggests it is the limiting P supply which determines the low N levels of these soils, since C, N, P and S occur in fairly constant proportions in soil organic matter.

Jeffrey (1967) considers that heathland Proteaceae have adapted to a low P and N requirement. Beadle (1954, 1968) also favours physiological adaptation and believes many of these plants have the ability to tolerate a low P turnover. Specht and Groves (1966) found that P is taken up in spring and stored as polyphosphate which is hydrolysed to orthophosphate and used in growth during summer. Wood (1959) showed that some species can pass into a static (but not dormant) condition when P and N levels are reduced, and remain in this state for up to two years. According to Wood (1959), the low fertility of the soils protects the heathland species against invasions by plants with a higher nutrient need.

Growth period

Lamont (1973) points out that the growth period of Australian Proteaceae may vary from five months, as in certain winter rainfall districts, to the whole year in others. It is noticeable that most of the South African Proteaceae inhabit the winter rainfall areas (Werner, 1951). Lamont (1973) mentions that proteaceous plants are unable to store water or tolerate large water deficits and therefore are not well adapted to drought. However,

Levels of nutrient element supplied by fertilisers in peat/perlite mixes (left to right)

g/m³ of potting mix

N	450	45	45
P	30	300	30
K	25	25	250

Grevillea rosmarinifolia
showing N & P toxicity–N response N–deficiency

N	0	450	0	450
P	0	300	0	300
K	0	250	0	250

Left: *Hakea laurina* –showing toxicity at high NPK

Right: *Tomato 'Best of All'* –showing response to high NPK and severe deficiency with no nutrients.

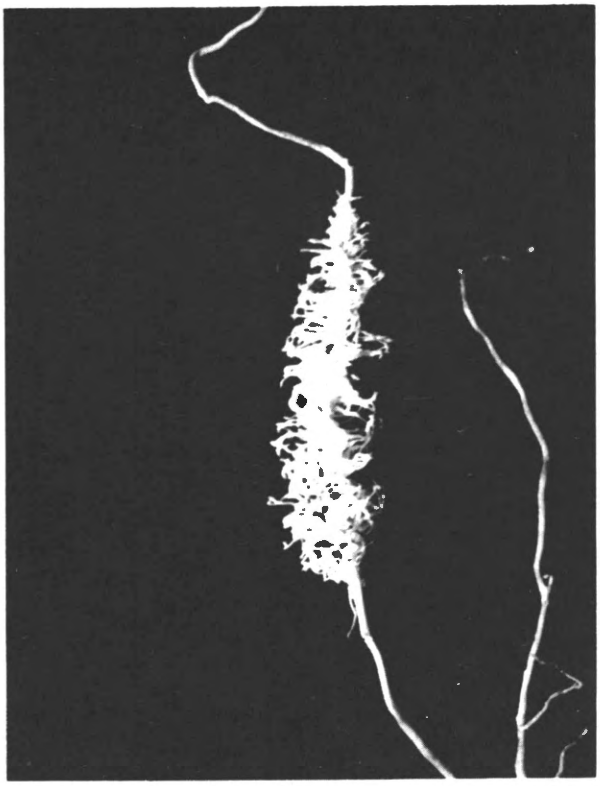
N	450	450	45
P	300	30	300
K	25	250	250

Camellia japonica responds in a different manner to the plants shown above and rather indifferently in the early stages of growth.

they are able to start or stop growth at any time during the year according to whether or not conditions are suitable.

Many proteaceous species are drought avoiders since they possess an extensive root system with deep lateral roots that penetrate into moist sub-soil (Specht and Rayson, 1957b). Wood (1959) points out that southern Australian heathland species, while flowering in spring show maximum growth during summer, the driest time of the year. For example, Specht and Rayson (1957a) found that *Banksia ornata* and B. *marginata* at Coonalpyn Downs, South Australia, only commenced growth when the mean temperature exceeded 18°C (November to April) which is out of phase with the wet season (winter) of this region. The growth of related heathland plants is also vigorous during summer in coastal Queensland where, although the temperature is high, it is accompanied by heavy rainfall. Thus, while heathland species from both these areas have their maximum growth in summer, those in Queensland are growing when rainfall is high and those in the south are exploiting soil water reserves with their deep root systems as rainfall is almost zero. Specht and Rayson (1957) suggest that the occurrence of Proteaceae on low fertility soils and the summer growth pattern of southern taxa are connected with the evolutionary history of heathland vegetation which apparently flourished during the Pleistocene period on widespread, infertile soils.

Proteoid roots on *Hakea laurina.*



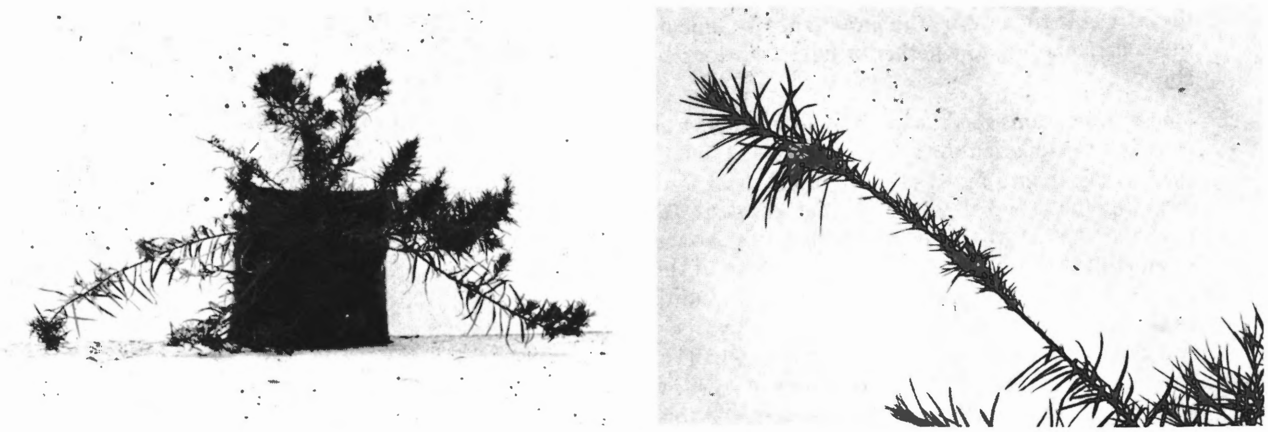
Close up of proteoid roots.

Proteoid roots

Purnell (1960) defines a proteoid root as a dense cluster of rootlets of limited growth along a lateral root, and several others have described their development. They appear to last only one season and by the end of summer are dry and shrivelled (Purnell, 1960) although the parent roots last indefinitely (Lamont, 1972a). Lamont (1972a) found them to be physiologically active for two to three months and they seem to be produced by the youngest roots of the root system. Purnell (1960) and Lamont (1972b) have described their anatomical features.

Proteoid roots have been found on a wide range of Australian Proteaceae, Purnell, 1960; Jeffrey, 1964 and 1967; Rao, 1971; Lamont, 1972 a and b), but they have also been observed on South African genera, e.g. *Protea* spp. in work at Lincoln College.

Several studies have been made to determine the nutritional significance of proteoid roots. Jeffrey (1967) working with *Banksia ornata* heathland, found a discrete zone 2.0-3.5 cm. thick in the soil profile composed of a mass of proteoid roots. The zone was not more than 5 cm deep and proteoid roots penetrated into the litter layer.



Symptoms of phosphate toxicity on *Grevillea rosmarinfolia.* The plant on the right appears to have recovered from an initial period of mild toxicity.

Levels of nutrient element supplied by fertilisers in peat/perlite mixes (left to right)

	g/m^3 of potting mix			
N	45	450	45	45
P	30	30	300	30
K	25	25	25	250

Protea repens

Left	Good growth under vey low nutrient levels
Centre Left	Nitrogen toxicity
Centre Right	Phosphorus toxity
Right	Good growth and no adverse effect from high potassium levels.

Under some conditions the proteoid root carpet may be almost continuous. Jeffrey (1967) considers it may act as a trapping surface for nutrients from a number of sources including cyclic salts and litter decomposition. In glasshouse culture they have been observed to develop on the top of a moist bench.

Beadle (1968) using *Hakea dactyloides,* found consistent development of proteoid roots on plants grown under low P, but not on plants grown under high P. Lamont (1972a) found that proteoid roots responded to lower levels of N and P than non-proteoid roots, and concluded nutrient concentration, especially N and P, largely determines the relative contribution of proteoid roots to the plant. Jeffrey (1967) found that they were very effective at absorbing P and considered this was due to a large surface area.

Rao (1971) states that proteoid roots are directly involved in N and P uptake under natural conditions, and they do not appear to be mycorrhizal. Lamont (1972a) found no evidence of endophytic fungi or bacteria despite extensive investigations. The roots are neither modified N fixing nodules nor a reaction to invasion by pathogens, and Lamont (1972a) concludes that proteoid roots are normal components of the root system of many Proteaceae.

The development of proteoid roots in the Proteaceae appears to be a remarkable adaptation to cope with low fertility soils. They probably evolved on ancestral Proteaceae when Australia and S. Africa were closer together, since it is unlikely that they would have arisen independently in the different genera. It seems that even in the period when early angiosperms flourished, some Proteaceae were adapted to low fertility soils primarily determined by low available P (Beadle 1962).

Proteoid roots are probably of little importance in nursery or home garden situations despite the great ecological significance of this adaptation, because the plants are able to absorb adequate nutrients through their non-proteoid root system. In fact, Lamont (1972a) found that high levels of soil organic matter and nitrogen tend to decrease the ratio of proteoid roots to non-proteoid roots.

Adaptions of the Proteaceae

As pointed out above, many of the S. African and Australian Proteaceae have evolved proteoid roots as a means of enhancing nutrient uptake, and certainly in Australia, most members of associated heathland families have specialised means of increasing their nutrition e.g. the *Epacridaceae (Epacris etc.)* use endophytic mycorrhizae, the *Fabaceae* and *Mimosaceae* have N. fixing nodules and the *Casuarinaceae* (a non-legume family) also have N. fixing nodules. Further, most of the sclerophyllous heathland species are sensitive to changes in their micro-habitats (Woods 1959). For example Pryor (1959) points out that the intricate distribution pattern of heathland *Eucalyptus spp.* accords with microhabitat changes. Gardner (1959) states that several heathland Proteaceae show marked specificity or adaptation to environmental parameters, e.g. climate, soil type and fertility, altitude, proximity to the sea, water and temperature regimes etc. and appear to have a very limited ability to tolerate changes. It is proposed that the high degree of adaptation and intolerance to change shown by the Proteaceae has a profound effect on the nutritional requirements and responses of these plants under cultivation.

Nutrition

Beadle (1962) found no improvement in the growth of *Hakea dactyloides* as soil P increased. Specht (1963) observed that seed germination of *Banksia ornata* was not improved by increased fertility. In addition, seedlings were unable to withstand the shock effects of some fertilisers. Moore (1966), and Moore and Keraitis (1966) using *Grevillea robusta* seedlings found that development of deficiency symptoms for P and N depended both on the level of each nutrient and also the balance of the two. Available soil P was considered to be the most important factor. However, *G.robusta* seedlings responded to increasing levels of N especially at high levels of K, and vice vera i.e. there was a significant interaction between N and K in the growth of *G.robusta.*

Probably the most important work so far is that of Grundon (1972) who studied the nutrition of Queensland heath vegetation. He found that Proteaceae were suppressed by high P levels. Grundon (1972) noted P Toxicity at low N and sometimes K levels and considers that the Proteaceae have a high capacity for using very low levels of available P since the metabolism of these heathland species is adapted to use P more efficiently than other species. He concludes that high P levels are likely to be toxic or to suppress the heathland Proteaceae.

Work at Lincoln College has confirmed the marked sensitivity of several Proteacease e.g. *Protea sp., Hakea laurina* and to a lesser extent *Grevillea rosmarinifolia* to high levels of P. especially when the plants are small. Apparently the sensitivity of *G. rosmarinifolia* declines as the plants become larger. In addition, *G. rosmarinifolia* seems to respond quite well to increased N in the compost.

Jeffrey (1964) has shown that many Proteaceae are calcifuges, and because they are adapted to make maximum growth at low Ca. levels, they are unable to avoid excessive Ca. uptake, when grown in soils with high levels of Ca resulting in toxicity A similar situation is thought to occur with P. Consequently, the Proteaceae are very prone to P toxicity. Ca levels may also be critical, not only through direct toxicity but also indirectly via external and internal pH effects on the plant's nutrition.

In the past, many proteaceous losses have been attributed to pathogenic fungi, particularly *Phytophthora spp.*, causing root rots and a blackening and die-back of shoot tips (Salinger, 1964). Hewett (1972) believes that *Phytophtora cinnamomi* is perhaps the greatest destroyer of Proteaceae However, symptoms of P toxicity in Proteaceae have been observed at Lincoln College as a blackening of shoot tips followed by rapid death. Therefore, it is quite probable that many deaths attributed to *Phytophthora* spp. are in fact due to P toxicity since many nurserymen use composts which are high in nutrients, especially N, P and K.

It is also important to remember that the degree of toxicity would vary with:–

1. Plant size – generally large plants would be more tolerant than small ones.
2. The species – e.g. *Grevillea rosmarinifolia* appears to be more tolerant of P and N fertilizer than *Hakea laurina,* which is in turn slightly more tolerant than *Protea spp.*
3. The type of potting compost – its drainage, aeration structure and texture etc.
4. The aerial environment e.g. temperature regime, relative humidity, air circulation etc.

There are several other adaptive and ecological factors which seem to be important when Proteaceae are cultivated. A free draining acid soil or compost is desirable (Salinger, 1963). This is to be expected since most of the cultivated Proteaceae come from acid, sandy, well-drained soils.

Also a warm coastal or frost-free hilly situation seems to be beneficial as most Proteaceae appear to need good air circulation and are intolerant of frosts, correlating with their predominately coastal or steepland distribution. For example, Eliovsen (1957) states that *Leucadendron argenteum* does best in frost-free coastal areas where there is a sea mist as on the Cape Peninsula.

Watering may be critical since many of the Proteaceae are xerophiles (Willis 1966) and come from areas with a marked seasonal drought.

In addition, some species show little growth in spring and should not be watered in the same way as many other plants which are at their maximum growth. The quality of the irrigation water may be another important factor. Eliovsen (1957) considers that basal watering is better than overhead sprinkling and warns against sprinkling the leaves, especially on dull cloudy days when evaporation is low. Some form of trickle irrigation may be beneficial here. Heavy summer rain and warm humid conditions appear to be injurious to many S. African species (Eliovsen 1957).

Propagation by seed may present problems since the seed in some of the species does not mature until about a year after flowering (Salinger 1964). Seeds may be abortive in some countries because there are no suitable pollinators present and often the percentage of fertile seeds (as in *Protea* spp.) may be very low indeed (Stevens 1965).

Conclusions

The Proteaceae are an extremely old Angiosperm family which probably arose in the distant past in the tropical regions from where they became widespread. They migrated south and some adapted to the different climates encountered. Early in their development an ancestral line became adapted to infertile soils by developing proteoid roots and physiological tolerance of low nutrient levels. During the intervening geological periods up to the present, other adaptive mechanisms evolved. Concurrently, selection pressures and continental drift led to the extinction of many groups and resulted in the present day disjunct distribution of some genera in the southern continents. In particular the Proteaceae are intimately associated with the heathland areas of S. Africa and Australia where conditions stimulating intense adaptive radiation once occurred. Both these areas are extremely low in P and N and survival of the vegetation is primarily determined by the ability of the plants to withstand long periods of mineral starvation combined with drought. Proteoid roots enhance their ability to absorb nutrients and are an ecological advantage to this essentially successional group of plants.

It is not surprising that the complex adaptation of many Proteaceae to their habitats makes them intolerant of changes in environmental parameters, e.g. soil fertility, pH etc. This is most important when these species are grown in nurseries and gardens, often in environments to which they are unadapted and which, in many cases, they cannot tolerate. Often nurserymen have failed to realise this and explain the demise of these species in vague terms of disease or failure to form proteoid roots. However, it is more likely to be the high nutrient levels, especially P, of their potting mixes that is causing the plants to die since many of the Proteaceae are intolerant of such abundant nutrients. The growers are killing these plants with kindness!

In addition, other adaptational features of the Proteaceae e.g. specific pollinaters, intolerance of alkalinity, the need for good air circulation (possibly an adaptation to windy sites) etc. may be the cause of problems under cultivation.

Finally, the following pointers for nursery culture, based on research at Lincoln College and in conjunction with the factors already discussed are listed:—

1. **Phosphate Fertilisers**
   Only very low levels are required. Medium levels 300 P/cu.m (3lb superphosphate/cu.yd) will rapidly kill Proteas and cause foliar burn on Grevilleas in light weight mixes. High P levels have probably been the greatest single problem in the nursery culture of proteaceous plants. Young plants are particularly sensitive.
2. **Nitrogen Fertilisers**
   Low to medium levels of nitrogen are required. Grevilleas show a marked response to nitrogen fertilisers although Proteas can be severely burnt back by medium to high levels.
3. **Potassium Fertilisers**
   No potassium toxicity has been observed; however only low levels appear necessary.
4. **Other Aspects of Nutrition**
   An acid to neutral medium is best. Normal liming rates (6kg/cu.m) appear quite satisfactory for many Proteaceae using a soil-less container mix such as 50% peat and 50% perlite. No foliar chlorosis has yet been observed in trials at Lincoln College, because adequate levels of chelated iron have been included in the mixes. Young plants are particularly sensitive to fertilisers and may be killed by even very low levels of P and possibly N in the mix. A container mix consisting of 25% soil and 75% perlite and no fertilisers or lime has proved very satisfactory. Soil does not appear

to be essential in potting mixes and it is unnecessary to supply micro-organisms to form mycorrhiza. Current research (Baylis 1972, Lamont 1972, a) does not support the view held by some nurserymen and workers that Proteoid roots are the result of a mycorrhizal association.

5. **General Culture**

Proteaceous plants should be grown in an open, well-drained mix. As already discussed they are fairly drought resistant. However, young plants under glasshouse conditions will need regular watering. Older plants must also not be allowed to get too dry. Caution must be used with watering since some species, particularly Protea spp., can be killed if water lies on the leaves especially if this is coupled with stagnant or warm, humid air conditions. Fans for internal air circulation in glasshouses can be very useful.

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The Banks Lecture, 1973
Horticulture and the Environment

Delivered to the Jubilee Conference of the Royal New Zealand Institute of Horticulture at Palmerston North, 24th February, 1973 by Hon. Duncan MacIntyre.

I have been asked to speak on "Horticulture and the Environment" and I am going to do so under the subtitles "A Matter of Balance" and "Where are you Heading?"

Horticulture and Agriculture were introduced into New Zealand by the early settlers – first the Maoris and later the Pakehas. The kanaka, scots pine, oaks and other trees are evidence in the city today of the early pioneers. They also introduced the radiata and macrocarpa which are common features of our landscape. The New Zealand bush was not outstanding to them. It was merely something to be cleared and only in recent years has there developed a general interest in protection. Some introduced plants such as the sweet briar, gorse, broom and blackberry ran amok. The pioneers had no knowledge of soil erosion since this is not a great problem in many parts of Europe. As crops were attacked by insects birds were imported and some, such as the sparrow and the blackbird, were of questionable value due to their effect on our flora. Animals such as the rabbit, deer, opposum, weasel and cat were imported – some to become serious pests.

However, things have changed over the years. Today developed countries – those which can afford to have other interests than search for food – have gradually become aware of the importance of environment, ecology and conservation. Reservations of land are put aside, legislations are passed, funds – never adequate – are set up, and all of these things, although much too late and too small, are none the less of great significance.

Some countries are even becoming conscious that past and present interference with the environment could threaten their very existence. The quality and quantity of water is an important factor and even in New Zealand we are beginning to realize we do not have an unlimited supply. We also suffer polluted air, noise pollution, chemical pollution etc. Our cities, with the spreading blight of ten-acre subdivisions, sprawl onto good land. The bulldozer moves in to clear the land – sometimes even to clear the topsoil and leaves behind the treeless subdivision where the tallest plant may be only a sick daphne. City councils have an insatiable urge to seal every grass verge and to remove every tree least it block a drain, drop leaves, or be in the way of a car. At last you and others like you have been activated by such actions. Many of you have visited England and Scotland and seen trees protected by legislation. You have seen avenues and houses built amid and amongst trees in the United States. Cities such as old Auckland, Christchurch, Cambridge, Wellington and Dunedin are remarkable for their belts of trees which were established by the pioneers and which have defied the land clearers. In Sweden trees growing in large underground pots have been incorporated in engineers' reconstructions of the main cities. These examples have not all been easily achieved. Conflicts develop between the people and the government or city departments involved. Results depend too much on politics and costs. H. R. H. Prince Semhart's message to you all, "Keep an eye on Governments" – central and local.

Horticulture and environment have much in common. "The environment is everything that isn't me". When an average person considers the environment he thinks in terms of trees and plants, but the most important consideration is balance. Your horticultural interests range from those of the home gardener to the experienced professional and you all understand the importance of this basic need. The right balance of elements in the soil, air and water, and the correct amounts of sun and shade are all-important. The right amount of care and sometimes of judicious neglect also adds to give the correct working balance necessary for success. When the various factors get out of balance there is trouble. The whole chain of gardening is a limited ecology, with each link depending on the next, and an understanding of this can be translated to an understanding of daily life. But unfortunately we human beings tend to think in narrow tracks. In our gardens the responsibility is ours. If we don't look after things nobody will. But outside our fences it is someone else's job – the council – the government – or nature herself. But the local council is made up of people like ourselves – and even members of the government have some resemblance to us. And nature these days has more than she can cope with.

What we all forget at times is that there is no such thing as an organism that is independent of its environment, and man, for all he likes to think that he is supreme, is no exception to this rule. Ecology has been defined as the science of the mutual relationship between organisms and their environment. We are only one of the organisms in this relationship, and the main difference between ourselves and the others is that they create while we destroy. It should be a sobering thought to realize that if nature ever had to make the choice between our survival and that of earthworms there would only be one logical choice because the worm improves the environment for ALL life. Again, it is a matter of balance. If you say that we deserve more consideration because we have better brains than worms, that can be challenged in two grounds: First that nature is only interested in results not theories, and second that our brains have so far rarely been an asset to our environment.

Over the last few years we have talked a lot about conservation, with one main result for most people. The world itself has become hackneyed. Conservation is rapidly becoming a catch word for the unthinking who want to jump on the latest bandwagon while it is creditable to do so. Most people have almost forgotten it is derived from "conserve" which means some thing more than planting a few trees once a year on Labour Day. For conservation is not merely a matter of leaving as much as possible of a country untouched by developers, or refusing to allow houses and factories to be built where trees and plants are growing. We have to use the earth – it is the only one we have – and people need food, jobs and houses, which means using the natural resources from which all these things come. But if you draw too much from a savings band account you go broke, Nature may allow you an overdraft, but you won't get any extensions and so you are back to living within your income. In other words, "A matter of balance".

Those giant human brains we are so proud of have another deficiency. They don't enable us to face facts unless they are touching us, and this inability could well be the death of us.

The first to practice conservation in New Zealand was the Maori. He lived a life very close to the earth and with the animals, trees, and plants that he introduced he also brought with him a need to conserve. Then came the Europeans and today with increasing population making an impact on our natural resources we are forced to find some formula to protect these resources and use them at the same time. Unfortunately this often results in conflict and many battles are waged between conservationists.

In the past we used our resources as if there were no limit and even today the demand for desirable areas is increasing. Beaches and lake shores, creeks and hill sites are becoming more and more sought after. Prices increase and authorities fall behind as they baulk at the cost and haggle over needs and priorities.

Why am I stressing this? Because you have in you the spark to light the tinder to produce the heat needed to mould governments and authorities. You have worked for legislation to protect plant 'inventions'. You need to continue the drive for legislations to protect each special tree. Today there is a cry from smaller urban areas – "We must have new and more industry" – for many good reasons. It will ease the rate burden, give us employment for our children, increase the values of our properties etc. "Light industry" are the magic words that will solve every community's difficulty. But it brings its own problems. More people, traffic congestion, pollution, increased buildings, and perhaps in time, heavy industry. The peaceful residential and rural characteristics are swept away and what has been gained? More people, more costs, more rates and more pressure.

Development and the environment often come into conflict. Most of our slums are clustered around industrial areas, and yet with planning, planting and perseverance the slums, industry, and development can be handled so that the environment is improved rather than desolated. Most houses in isolation on a bare plane are unattractive – unless perhaps in an igloo in a blizzard as night is coming on. One tree can transform the scene, but one petunia or butterfly does little for the quiet of man's soul as he views the house, far less lives in it. To you members of this Society I do not need to stress the point – that planned plantings make an area worth living in. They do something to our innerselves and perhaps this is one of the last remnants of our earlier instincts from the time we lived in the forests and trees. But what I do want to stress is that to achieve such plantings and planning it is necessary for enthusiasts to goad, persuade and at times bully the authorities. This is a challenge to you all, not just as a short term project, but as part of your reason for being banded together as horticulturists.

To achieve much it must be a long term aim. In 1852 in the U.S.A. there was talk of the need to preserve the redwood and the resolution was introduced into the Californian Assembly. It did not pass but the idea carried on. In 1918 a group of citizens founded the "Save the Redwoods" campaign. Today they are still working. They have done a wonderful job but the pressures are mounting and each year their work becomes more and more difficult and costly. These people had set their aims long before the words 'Environment' and 'Conservation' were in common use. Today we would call them conservationists. So let me review this category of people. What is the nature of the beast?

He is concerned, energetic, sensitive and generous. But within his own ranks are his worst enemies. For the very things that make conservationists alert to the conditions of their environment and willing to fight for its betterment sometimes become exaggerated and self defeating. Over-emotion can turn many away and earn the soothing comment that you are a "bird and bee" crank. Extremeism is shown in many ways – mostly damaging. When conservationists seriously say that they will block any attempt to erect another power installation in their area they can be eroding their influence. It has been said that ecology is the most important thing in the world – until the lights go off. Most power plants and installations are ugly but we have to have them. Conservationists can do much to see that they are less obstrusive and that they are in the best sites. It is on the moderators, who are repelled by extremeism, that the success of conservation depends, for the number of people prepared to do something is very small. More are needed but they can be very quickly eroded by the extreme. To quote Alexander B. Adams, "I am not in the least advocating a surrender to anti-conservation interests, but the Charge of the Light Brigade did not win the war." Throwing oneself in front of a bulldozer, calling a developer names, or being highly emotional at a legislative hearing may be useful – sometimes. There are occasions when only the loudest voice will be listened to, although it can be fun to lose one's temper and carry on in an extreme manner, the principal question is, will doing so help the cause?

Another group of people who can damage the cause are the self-important who find in conservation the excitement they do not find in their ordinary lives. There people exist in all activities – business, charities, welfare, politics – but conservation can attract more than its share, for to be heard in conservation you do not need to be a professional or to have studied long years and hold a position of responsibility. Again to quote Adams, "There are few causes left today in which a person can become a martyr quite so quickly. Completely absorbed in what he is doing he can persuade himself that the angels are on his side".

More and more the success or failure of conservation depends, not on the man out in the bush, on the mountains, or at the seashore, but on the man at the office and in the lobbies. Raising money, keeping in touch with legislation, activating members and keeping up with what is happening or is to happen.

I have used the illustrations before that the captain of a large tanker must start taking action to turn or stop his ship as much as ten miles before it turns, and if he leaves it too late no amount of frantic action will prevent a crash. Horticulturists know this principle well, because there are certain reaction times with growing plants, and only a limited amount of speeding up can be done. If a plant that must be watered every day gets none for a week you won't help much by giving it seven times the quantity on the seventh day and not even telling it you are sorry, will save the plant. One of our difficulties is our inability to appreciate dangers that don't yet touch us directly and the fact that any time needed for correction starts from when we start correcting. It cannot be shortened to make up for our procrastination.

Nature as you well know, is unimpressed by excuses. "Too little too late" is only an epitaph. Hence my assertion that it is in the offices and corridors that you must be active.

The environment and conservation today are becoming more and more complicated. A knowledge of law, science, finance, fund raising and public relations are called for. The people who can co-ordinate these skills and who can gain the confidence of those in authority can see where the trends lead and can initiate research, talks and investigations before the crisis – before the head-on crash. These are the people who achieve more for the environment than all the protests, news releases and bloody-mindedness we have become accustomed to. Too often the conservation movement has been branded as over-emotional, often parochial and mostly impracticable. This drives away many of the people most needed, but the challenge remains – and remains strong to you members of the institute because so many of you have the skills I have listed and have the strong discipline of dealing with nature and her laws.

The greatest needs of conservation today include the need to enlist the help of management minded people – with this talent it becomes a great challenge – and the work done will last for many generations.

There are many years of neglect to be repaired. The environment includes the people. And so much can and must be done to heal the scars, soften the blemishes and remove the sharp and ugly edges. When the day comes that an informed majority demands that our immediate environment needs to take priority, we will need a nucleus of caring people ready to link with others across our small and embattered planet to act together as one people sharing one limited world. Members of this Institute are unusually well qualified to enlarge your interests to help educate others into understanding and meeting the needs of our environment, not by belabouring them with the unreasoning fanaticism that sees no path but its own, but by sharing what can be done in widening ways reaching out from your own particular sphere of gardens or parks.

Last year in addressing a group in Auckland I took as my theme, "That a small open space in a built up area was more valuable to the people than our vast National Parks". If you can work on this your work will remain as a monument to you, and if perhaps somewhere along the way you can persuade the average man to turn off occasionally that brain that gets him into so much trouble – if now and then he can go back to using those primitive senses that remind him of the joy to be had of the delicate scent of flowers, the rustle of leaves, the crisp sound of walking over frosted grass, the deep green peace of trees, then maybe he will begin to use his intelligence to appreciate and care for the true value and quality of life. For with people, as with the environment that we are a small part of, the solution is a matter of balance.

To quote Adams once more, "Conservation is not, as some would lead us to believe, the complete denial of one activity against another. Instead it is a search for balance, a means of keeping things in their orderly places. It is a concept of a civilised mind".

Citation for the Award of Associate of Honour John Osborne Taylor

Mr J. O. Taylor commenced his horticultural training in Christchurch at the age of fifteen. He served an apprenticeship with the Christchurch Domains Board and Reserves Department of the Christchurch City Council. In 1944, after service with the Royal New Zealand Navy, he was accepted as a student at the Royal Botanic Gardens, Kew. He was awarded the C. P. Raffill prize for the best lecture given by a student during the year.

On his return to New Zealand, Mr Taylor passed his N.D.H. examination in 1948 and was awarded the Cockayne Gold Medal. The following year he travelled to the United States of America to further his studies at the Arnold Arboretum and New York Botanic Gardens. While in America, he was instrumental in sending to New Zealand many new plants of considerable note, among which were *Forsythia* 'Arnold Giant'; *Forsythia* 'Beatrix Farrand', *Prunus* 'Halle Jollivette' and *Acer columnare*.

In June 1950, Mr Taylor was appointed Nursery Foreman at the Christchurch City Council's Nursery at Linwood, and later became Assistant Curator of the Christchurch Botanic Gardens, until he went into business as a nurseryman onhis own account in 1954.

For eight years, Mr Taylor was the tutor in charge of the horticulture classes at the W. E. A. in Christchurch, and for several years was a lecturer at the Technical night school. On three separate occasions for periods of two years at a time, Mr Taylor was appointed visiting lecturer in Ornamental Horticulture and Nursery Management at Lincoln College.

His first assignment as a written examiner for N.D.H. examinations was in 1950, and he has been involved with this work almost continuously up to the present time.

As Chairman of the Canterbury District Council, he has fostered the work of the Institute of Horticulture and successfully steered the Horticultural Producers' Council through its initial stages.

As a member of the Executive of the Canterbury District Council since 1948 he has been Chairman of and sat on many sub-committees concerned with horticulture. Horticultural education has always been one of Mr Taylor's major interests and as a lecturer for the Canterbury District Council of the Royal New Zealand Institute of Horticulture at the Technical College evening classes, he contributed a great deal.

He has for some years been a Vice-President of the Institute, a member of the Examining Board, the Finance Committee and the Publications Committee, and has shown his ability not only as a horticulturist but also as a sound administrator. As such Mr Taylor has interested himself in commercial horticulture matters and has acted as Representative of Lincoln College on the Nursery Stock Research Extension and Advisory Committee.

As a member of the Management Committee of the Canterbury Horticultural Society and Chairman of several sub-committees for the past twenty-two years, Mr Taylor has contributed much as a lecturer, judge and noteworthy exhibitor for this Society. He was a foundation member of the Canterbury Native Flora Society, (now the Canterbury Botanical Society). After selling his nursery business Mr Taylor accepted an appointment as Senior Lecturer in Horticulture (Park and Recreation Administration) at Lincoln College in 1972.

Ornamental Plant Introductions in New Zealand

BY B. K. POWELL

New plants introduced to the New Zealand market fall into two categories – those raised locally (or sports of varieties already established in the country), and varieties which are imported from overseas. Of the many introductions imported each year, only a few ever reach the Nurserymens' catalogues; some are not suited to our humid conditions and fail to survive the twelve months quarantine period. Of the rest, initially some may appear to have adapted well to the change of climate, under the sheltered conditions which they usually enjoy during the period of quarantine. However, the acid test is how well they will perform as garden plants, and if they can exhibit under N.Z. conditions, the special merit which led to their introduction.

Some failures soon become evident, such as susceptibility to mildew or leaf burn in summer. Other plants may grow well for several years before it has to be admitted that they are not suited to N.Z. climatic conditions, or that the originators' claims have been exaggerated. Because of our relatively mild growing conditions, a percentage of new introductions make quantities of lush foliage at the expense of flowers and fruit, which were the main feature in their native country.

A study of shrub catalogues will show that a number of "Recent Introductions" hailed at first as something outstanding, have within a few years, disappeared from the pages, leaving only the old well-tried varieties. It should be emphasised that before a new plant is released to the public, it must be garden worthy or superior to those currently available.

However, there are always some really good new plants and shrubs, both home raised and imported from overseas, which show improved habit, better colour, larger fruit or a stronger constitution than the earlier types.

It is hoped that the following plants will come into this category, but doubtless a few will fall by the wayside, for reasons which are not yet apparent.

Arctostaphylos uva-ursi 'Radiant' is a mat-like ground cover shrub with glossy leaves and pinkish-white flowers. It grows well in sun or shade, and is useful for clay banks, where the trailing branches take root. It has not yet flowered with us, but is still a worthwhile plant, even if it does not produce the crop of large bright red berries that are a feature in its native California. *Arctostaphylos* 'Point Reyes' is another good ground cover form, with leathery leaves growing tightly together along shiny red stems. This is said to have pink flowers, but it also has not yet flowered. Other taller growing cultivars imported at the same time, such as *A. bakeri* 'Louis Edmunds' and *A. stanfordiana* 'Fred Oehler' were found to make open straggling plants under Taranaki conditions and were dropped.

Acer palmatum 'Shin Deshojo' was imported from Japan as an improved form of *A. palmatum* 'Chishio', and that is just what it has proved to be, with its more vigorous habit and brighter spring and autumn colour.

Berberis thunbergii 'Aurea', recently introduced from America, has bright golden-yellow foliage which fades very little as it matures, so the effect throughout the summer is eye-catching. The low shrub is very hardy and should be planted in full sun to obtain the brightest colour, though in light shade it is still a striking picture.

Among the many recently introduced golden foliage callunas, the only cultivator which showed no sign of sun damage during the hot dry summer months was 'Beoley Gold'. At a time when our other golden varieties were all suffering from varying degrees of foliage burn, 'Beoley Gold' remained un-marked. It has a neat compact habit, and holds its yellow colour all the year, making an attractive contrast to the cultivars which turn orange or red with the coming of winter, such as 'Robert Chapman' and 'Orange Queen'. The latter is another new variety which is bright gold in spring, changing during the late summer and autumn to a reddish orange. Some sun burn was apparent during the summer, but we feel this cultivar should not be condemned without further trial. Taranaki this season has experienced an exceptionally hot and dry summer. The winter colour is very good, being an intermediate shade between the yellow of 'Beoley Gold' and the red of 'Robert Chapman'. Another new calluna with bright winter colour is 'Sunset'. This has a slightly more open habit than 'Orange Queen' and turns a deeper shade in winter.

Corynocarpus laevigatus 'Picturata' is a sport of *Cilaevigatis* 'Purea' variegata, in which the golden variegation appears in the centre of the leaf. The leaves are streaked and blotched with light green, and surrounded by a border of dark green. It is compact and fairly slow growing, and promises to be a good container plant for semi-shaded conditions. In *C. laevigatus* 'Moonlight' the leaves are narrower and the centre variegation is pale yellow, streaked with light green, which merges with the dark green band round the edge of each leaf. It is very bushy and strong growing, and should make a good container or specimen plant for mild districts.

Gleditsia triacanthos f. *inermis* 'Sunburst' is a graceful, rapid growing, small deciduous shade tree. The fern-like foliage, which at the tip of each branch is bright yellow, creates an effect as if the tree were in bloom. The cultivar 'Ruby Lace' has bright red foliage in spring, which darkens to bronze-green as the leaves mature. This contrast persists throughout the growing season as the branches lengthen.

Liquidambar styraciflua 'Golden Treasure' is a variegated form introduced from Australia. The light and dark green leaves are edged with an irregular band of creamy yellow. In autumn the yellow edge fades to white, the dark green becomes burgundy and the light green portions of the leaf turn orange to pink. This is a spectacular small tree, and will be outstanding in districts noted for good autumn colour.

Metrosideros kermadecensis 'Red 'n Gold' is a sport which appeared on a seedling in the Nursery. One branch was noticed to have a very red stem and a broad creamy yellow band round each leaf. The young cutting grown plants are very bushy and make good tub subjects for a few years until they out-grow the container. 'Red 'n Gold' has in turn produced a sport – as yet un-named – which seems likely to outshine its parent. This has the same red stems and shiny foliage, but the variegation is reversed, the centre of each leaf being creamy white, surrounded by an irregular band of deep green. At least half the leaf surface is cream, but this has not in any way affected the vigour of the plant, which appears to be fast growing and bushy. At this stage it is impossible to do more than guess at its size at maturity, or what its appearance will be as an adult tree. In the meantime, it is a most attractive container shrub, with the variegation persisting into the adult foliage.

Pieris japonica 'Flamingo' introduced a few years ago from America, is the nearest to a pink andromeda. The pendulous racemes are almost red in bud, and when fully out the individual bells range from light to deep pink, many streaked with red. This variety seems to be relatively slow growing, probably the result of flowering so heavily from an early age. Another worthwhile pieris from America is 'Pink Delight', raised by the Oregon State University. The flower stems and sepals are pinkish and the flowers are tinged with pink, the whole giving the impression of soft pink racemes. This variety also flowers freely from an early age.

Protea 'Ethel Taylor', a new seedling found by Mr C. Taylor of Hawera, is probably a cross between *P. laurifolia* and *P. neriifolia.* It shows characteristics of both species, having the sturdy upright habit and long flowering season of *P. laurifolia* and the hardiness of *P. neriifolia.* The large flowers, on strong stems, are a deep silvery pink tipped with black, and late in the season the colour is deep pink with light chestnut brown tips.

Robinia pseudoacacia 'Frisia', the golden locust, is a fast growing small deciduous tree, often used for street planting in Europe, where it appears to tolerate poor soil and a certain amount of atmospheric pollution. The bright yellow foliage holds its colour all through the summer, turning a coppery buff before falling in the autumn. It is said to be rather brittle, so exposed sites should be avoided. Our first plants, while in quarantine, were grown in a shade area, but even under these conditions, the foliage colour was brilliant, appearing from a distance more like a mass of golden-yellow flowers, completely covering a small tree.

Pseudopanax lessonii 'Gold Splash' is a sport which appeared in Mr T. C. Davies' garden a few years ago. The foliage is heavily streaked with golden yellow, the leaves often being as much yellow as green. As with many sports, there was an early tendency to revert. For several season new stock plants have been raised from the best coloured tips, and this will continue until the chances of reversion have been almost eliminated. This shrub has the promise of being an outstanding patio tub plant. It is at its brightest in full sun however, even in semi-shade it is most attractive.

In the last few years we have imported a number of rhododendrons from Holland, England and U.S.A., some of which will be new to New Zealand. As a commercial Nursery we have to concentrate on types for which there is a known demand, for the home market or for export, rather than import those of interest only to the specialist. The average home gardener these days prefers a small to medium sized shrub, free flowering, with a neat compact truss. It should begin blooming at an early age, and have attractive foliage throughout the year. To meet the increased interest in yellow flowered rhododendrons, we have included such cultivars as 'Evening Glow', 'Honeymoon', and 'Harvest Moon'. Others which came to us highly recommended, but have not yet flowered in the Nursery, include 'America', 'Anna Rose Whitney', 'Bessie Howells', 'Cotton Candy', 'Nova Zembla', 'Ruby Hart' and 'Scintillation'. In response to the demand for dwarf rhododendrons, both for the home market and export requirements, we imported a number of low growing cultivars. Almost without exception it was found that those with *R. forrestii 'Repens'* in their parentage are useless in our climatic conditions, and consequently have had to be discarded. It is unfortunate as this group includes many desirable dwarf cultivators with dark shiny foliage and neat bright red flower trusses.

Other plants introduced or promoted by this nursery during the past few years, include the bright red azalea 'Elsa Karga' and the salmon-pink variety 'Comptesse de Kerchove', both from Australia. The latest azalea from Australia is the pale lilac-pink 'Silver Anniversary' in which the semi-double flowers almost completely cover the foliage.

Azara integrifolia 'Variegata' is an attractive addition to the golden foliaged shrubs. Each leaf has a wide border of creamy yellow, which in winter, is heavily streaked with bright pink.

Camellia 'Brigadoon', a semi-double pink from America. This is a good example of the present trend in garden camellias. Nowadays more open bushes with the flowers displayed to full advantage are preferred to those smothered in quantities of foliage – a particularly bad habit with many of the older varieties. Another recent introduction from California is *Camellia japonica* 'Tiffany', a very large soft pink in a loose peony to anemone form.

Cytisus x praecox 'Gold Spear' is a dwarf broom from England. It displays an abundance of bright yellow flowers and has a more sturdy habit than *C. x praecox* Forming a neat bush, like the other brooms, it does well in poor soil, preferring plenty of sun and good drainage.

Cornus mas 'Aurea'. A bright yellow foliaged shrub, which glows like a patch of sunshine, but requires a sheltered position, as the leaves are liable to be damaged by wind.

Feijoa sellowiana 'Variegata' was imported from England. It is a variegated form of the normal fruiting plant, having a distinctive creamy white border to the leaves. Although our plants flower quite freely, they have not set any fruit so far. With its attractive variegated foliage and neat compact growth, this will be a worthwhile garden shrub.

Hamamelis mollis 'Pallida'. A very free flowering "Chinese witch hazel" imported from England. Reported to be one of the best cultivars of recent years, the sulphur yellow flowers are a softer shade than *Hamamelis mollis.*

Pyracantha 'Shawnee', was developed by the U.S. National Arboretum. A most attractive shrub in spring, when its branches are wreathed with small white flowers. It is spectacular again in the autumn when the branches glow with masses of clear yellow to light orange berries, persisting for several months.

Rhododendron 'President Rossevelt', imported from Australia, is a handsome shrub worthy of garden space for its foliage alone. The centre of each leaf is creamy yellow blending with an irregular band of light green, shading to dark green round the edge of the leaf. When our first plants flowered, we were pleasantly surprised to find that the blooms were also most attractive. It displays compact conical heads with the individual flowers almost white in the centre, shading to cardinal red round the edges of the petals.

Podocarpus lawrencii was imported from Australia under the name *Podocarpus alpinus* 'Glaucus' and was labelled as such until an Australian visitor identified it as a form growing on the hills round Canberra. It is a low growing, spreading shrub with arching branches and small crowded blue-grey leaves and red berries.

Pittosporun tenuifolium 'Tom Thumb' is a seedling raised by Stuart Bros. of Clinton. It forms a neat compact bush about 18 inches in height, the mature leaves having the dark purplish colour of the parent cultivar *P. tenuifolium* 'Purpurea'. Another outstanding new *P. tenuifolium* is 'Irene Paterson' which originated in Christchurch. The pale green leaves are heavily mottled with white, forming a striking contrast with the black stems. The foliage seems to be at its best in semi-shade conditions, too much sun tending to produce a yellowish appearance.

Pseudopanax 'Sabre' and 'Trident' are *P. lessonii* seedlings, selected in the Nursery for their distinctive foliage. 'Sabre' forms a slender small tree, with long narrow, purplish-green leaves, while 'Trident', with its bold three lobed leaves and more branching habit, makes a good tub speciment. Both are extremely hardy, wind resistant and will withstand dry conditions.

Wistaria sinensis 'Caroline'. Imported from America, is a free flowering cultivar with light mauve racemes. From the nurseryman's point of view, its greatest merit is that it can readily be grown from softwood cuttings, thus preventing the possibility of suckering, which can occur with grafted plants.

Magnolia grandiflora 'Samuel Sommer' was raised by the Saratoga Horticultural Foundation in California. It produces huge creamy white flowers, ten to fourteen inches across, and the glossy dark green leaves make it an excellent tub or patio tree.

More than a dozen new Leptospermum cultivars raised in Australia, have been a welcome addition to the standard cultivars grown here for some years. All except 'Ashburton Wax' have large double flowers, and several produce blooms in three distinct shades on the same twig. 'Blossom' is a clear apple-blossom pink, with a very long flowering season. The name 'Pink Pearl' may seem a bit of a misnomer as the large flowers are almost white, but the unopened buds do resemble tiny pink pearls, hence the name. There are several good deep reds, including 'Burgundy Queen', 'Crimson Glory' and 'Winter Cheer'. The quantity and size of flowers on some cultivars, has to be seen to be believed, some of the best being 'Sunraysia', 'Fascination' and 'Gaiety Girl', all with light and deeper pink flowers.

The Fiftieth Jubilee Conference January 23rd, 24th, 25th, 1973

A Brief Account—J. O. Taylor

IN January 25th, 1922 at the first annual conference of the N.Z. Bud Selection Committee there was a strong move to change the name of this Committee to the N.Z. Pomological Board. In the debate which insued the late Mr A. H. Shrubshall persisted that the proposed new body should have wider objectives in order to embrace the needs of all sections of horticulture in New Zealand. He won the day with a motion which changed the name to the N.Z. Institute of Horticulture with the first objective to "Encourage, foster and improve every branch of horticulture, ornamental and useful". The first elected secretary-organiser was the untiring Mr George Green of Auckland.

The first meeting took place in the austere concert hall of the Y.M.C.A. in Christchurch. By contrast, the 50th Jubilee conference was held in the Conference Room of Christchurch's magnificant new Town Hall.

Following a conducted tour of the Town Hall an address of welcome was given by his Worship the Mayor of Christchurch, Mr N. G. Pickering, who then opened the Conference. The programme was balanced between business sessions and addresses on horticultural topics. Three coloured movies under the title of "Horticultural Panorama" were shown following the opening address. In the evening Mr S. Challenger, Reader in Landscape Design, Lincoln College, gave a stimulating illustrated address entitled "Landscape Change and Development over the years in New Zealand".

Saturday's full programme dealt with business of the Institute with the Annual Report, the Annual Accounts, the Examining Board Report and Accounts taking most of the time.

The retiring Dominion President, Mr J. F. Living, A.H.R.I.H. (N.Z.) presided over a conference of 80 delegates representing a total of 1629 members. He reviewed the years' activities and referred to the changes that have occurred during the first fifty years of the Institute's history. In his concluding remarks, Mr Living said that the Institute must face the next era of its history with keen inquiry into what is to be the role that the Institute can best play to serve horticulture in the future. Having found that role it must be pursued with the same determination and purpose that characterised the founders fifty years ago.

Mr Living was presented with an illuminated address by the incoming President, Mr A. M. W. Greig, A.H.R.I.H. (N.Z.).

Specially invited guests to the Conference were Mr Edgar Taylor, the sole surviving member of the inaugural committee which met in 1922 and Mr John Hipwell, the first student to gain the National Diploma in Horticulture of the Institute.

In the evening an outstanding Banks Memorial Lecture was given by the Hon Duncan McIntyre, Minister for the Environment. (This is reported elsewhere in this Journal).

On Sunday, delegates had options for outings which were arranged in conjunction with the N.Z. Institute of Parks and Recreation Administration. These were to the Arthurs Pass National Park, Banks Peninsula via the Summit Road to Akaroa or a tour to Diamond Harbour via Lyttelton and Governors Bay, and they concluded a busy, enjoyable and memorable conference.

The Single-Queen and Two-Queen Systems of Colony Management Under Commercial Beekeeping Conditions

(Extracts from a thesis for the National Diploma of Apiculture (N.Z.) submitted by G. M. Walton in 1972)

ABSTRACT

The two-queen method of colony management was initiated by partitioning standard single-queen colonies 8 weeks before the predicted start of the nectarflow. Over a two year testing period involving the equivalent of 269 colony years, the two-queen system consistently produced more honey than the single-queen system ($p < 0.01$). Greater differences occurred between seasons using the same method of management than between the two different methods of management in either season.

INTRODUCTION

The honeybee colony has been utilized for the production of honey and beeswax since ancient times. In recent years and in many parts of the world it has been substantiated that the gains obtained by beekeepers for honey and beeswax have been far outweighed by the benefits to agriculture as a whole in the provision of a pollination service for crops.

The New Zealand Ministry of Agriculture & Fisheries has recognised the importance of the honeybee in the economy of the country and has protected it by legislation in the form of the Apiaries Act, 1969.

Although the industry has become increasingly mechanised with fewer commercial apiarists owning a larger number of hives, no real change in honey yields per colony has been evident. Over the last 10 years hive numbers in New Zealand have remained relatively static at 190,000, and the total net surplus crop averages 5,300 tons per annum.

One of the major factors hindering increased honey production has been recognised as the lack of sufficient queen bees to provide for a regular requeening programme. Regular requeening is an economic asset. It has been shown that under New Zealand conditions colonies with first-year spring-reared queens made no attempt to swarm and that they produced significantly greater yields of honey than colonies with second-year queens (Forster, 1969). In a further experiment using first-year spring-reared queens, Walton (1974) compared the performance of different types of colony build-up methods of management. It was shown that under these statistically randomized conditions the two-queen method of colony management resulted in significantly greater honey yields than spring-requeened single-queen colonies, which in turn, produced more honey than single-queen colonies divided in the springtime.

The present investigation was undertaken to further assess the two-queen system, as compared to the single-queen system, but with emphasis on commercial and economic considerations. The study was carried out in the Waipukurau area of the Hawkes Bay province under poor nectar-secreting conditions during the 1970/1971 season and repeated under excellent nectar secreting conditions during the 1971/1972 season. Prior to the major nectar flow forage sources included willow *(Salix spp)*, dandelion *(Taraxacum officinale)*, manuka *(Leptospermum spp.)* and kanuka *(Leptospermum ericoides)*. The main nectarflow consisted of white clover *(Trifolium repens)* which normally commenced yielding in early December, extending through to late January.

All colonies, apiary sites, supporting facilities, and most of the labour were provided by Mr D. L. Ward and Sons, Commercial Apiarists of Dannevirke. Their assistance in this study is gratefully acknowledged.

LITERATURE REVIEW

A colony of honeybees, *Apis mellifera L.*, is normally headed by a single queen whose functions, in addition to egg-laying, includes exerting some degree of control over the behaviour of the worker bees within that colony. With a queen present the colony survives and functions as a social unit. A honeybee colony is perennial (cf bumble-bee colonies), but members within the colony are being replaced continually. Unlike the worker bee with a life expectancy of 2-3 months, the queen of a colony has been known to live up to 9 years; however she is usually replaced within 4-5 years.

Supersedure and swarming are occasions where a colony may naturally tolerate more than one queen. Colonies which rear queens under such conditions usually restore themselves to a single-queen status very rapidly. The manner in which colonies do this has been the subject of many published accounts, including those of Huber (1792), Taranov (1955), Jean-Prost (1958), and Simpson (1958), for swarming; and Butler (1957), Gary (1959), and Allen (1965), for supersedure.

But there are conditions in which a colony will tolerate more than one queen. On occasions a supersedure queen may mate and begin to lay in the presence of her mother, even side by side, without showing any trace of animosity towards her (Taranov, 1951; Butler, 1954). Two queens may be present in the same hive for extended periods of time (Doolittle, 1908; Kelsall, 1940; Mathis, 1952).

In their endeavour to utilize the honeybee to suit their own requirements, many beekeepers try to prevent swarming and supersedure by using suitable colony management techniques. Both types of behaviour are discouraged by beekeepers because a loss of bees and an interruption in the brood-rearing cycle is involved. Beekeepers regularly replace ageing queens by young ones of proven strain. Young queens are vigorous, have a high egg-laying rate and are less likely to swarm (Forster, 1969).

By substituting a new queen for an old queen a new situation arises that does not occur in "undomesticated" colonies of bees. This new situation involves the acceptance by a colony of an introduced queen foreign to that colony. Beekeepers over the years have practised dozens of methods of introducing queens into colonies. Various forms of direct and indirect release, the use of odours and differences in the time interval between dequeening and requeening, have all been used by beekeepers striving for a satisfactory and sure way for queen introduction.

Replacement of an old queen generally requires that she is found and removed. However various techniques of requeening without the need to remove the original queen have also been developed. One conventional method of requeening without dequeening involves partitioning a portion of the brood nest, using a division board or screen, and then introducing either a queen cell or a mated queen to the queenless portion. After the acceptance of the second queen the partition is removed and the two units reunited. Generally the young vigorous queen survives.

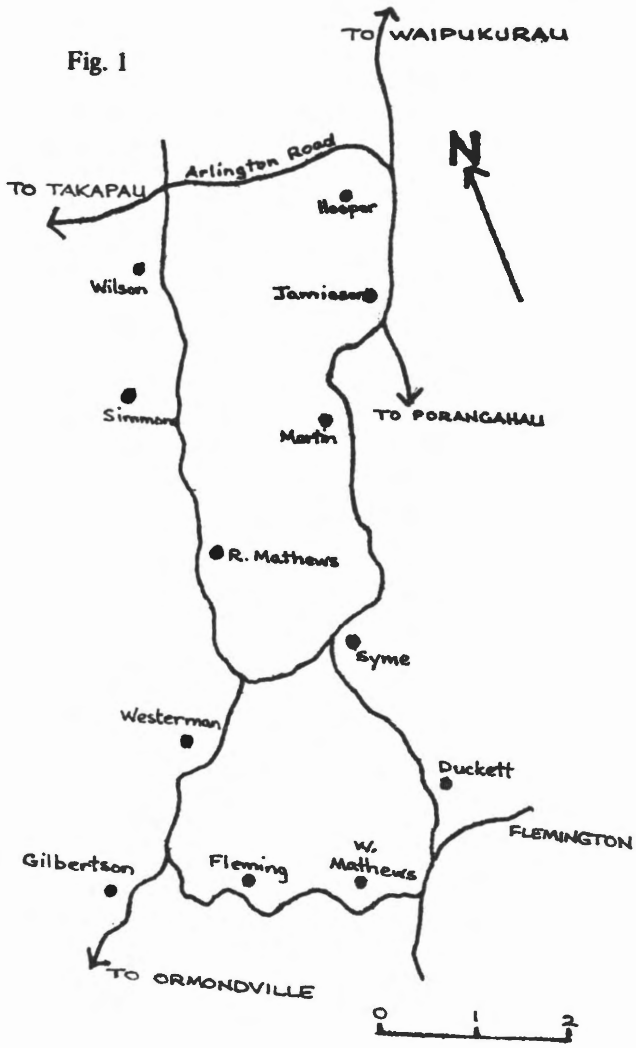
From the techniques of requeening without dequeening has developed an intensive method of colony management called the two-queen system. The harmonious existence of two queens in a colony unit is the basis of the two-queen system. Darchen and Lensky (1962, 1963) showed that the maintenance of induced polygynous colonies on a commercial scale required (a) that the individuals of the colonies acquire a common odour, (b) that the queens be in a similar physiological state, and (c) that the colonies be united slowly.

The acceptance of more than one queen in a colony depends upon the behavioural tolerance of both the queens and the workers. Skirkyavichyus (1965), using both cage and field experiments, concluded that queens of the same age always behave aggressively towards one another on contact, but those of different ages did not exhibit this pattern of behaviour. Not all observers agree with this. Huber (1792) and Davis (1908) witnessed queens of different ages in combat. Rivalry was much greater between virgin queens than between mated queens (Darchen and Lensky, 1963).

Using the principles that the mutual coexistence of queens and larger adult populations result in larger honey yields, Farrar (1936) developed and advocated the two-queen system as an intensive method of colony management. Since then many research workers (Dunham, 1951; Farrar, 1953, 1958; Holzberlein, 1955; Lysne, 1957; Moeller and Harp, 1965; Banker, 1968; Kornely 1969; Chaudhry and Johansen, 1971) have tested this system of management. Farrar (1937) established that during any 2-week nectarflow the honey production per unit number of bees increases with the colony population. Not only did bees gather more honey, but they gathered it more effectively. Under two-queen management, strong colonies that are divided 5 to 7 weeks before the honeyflow will yield much more surplus than undivided colonies (Farrar, 1958). In the experience of Moeller and Harp (1965) any system that insures egg production of 2 queens in a single colony for about 2 months prior to the nectarflow will boost honey production more than any other type of management practice. They found that populations in two-queen colonies commonly approach twice the population of single-queen colonies. After 6 weeks of development a two-queen colony may contain in excess of 100,000 adult worker bees.

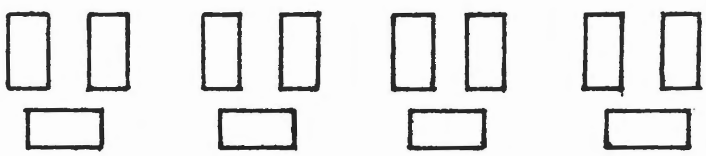
Walton (1971, 1974), in tests carried out in the Taranaki, Manawatu, and Hawke's Bay provinces in New Zealand found that two-queen colonies produced 47.5 percent

Fig. 1



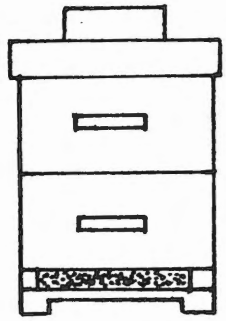
Location map of the 12 apiary sites (South-West of Waipukarau).

Fig. 2



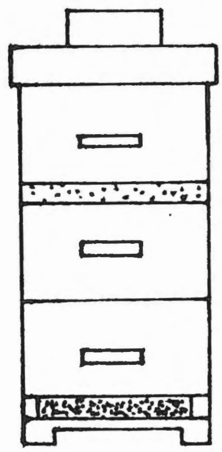
Configeration of the hives within the apiary.

Fig. 3



A single-queen colony contained within two brood chambers.

Fig. 4



A two queen colony with half the adult brood population together with the old queen, contained in two brood chambers below the division. The remaining population together with a newly-mated queen is held above the double-gauze division and with its own entrance.

more extracted honey than standard single-queen colonies, and 116.6 percent more honey than spring-divided colonies. Most overseas researchers have found that the two-queen system resulted in populous colonies and improved yields. Dunham (1953) established over a 12 year period that two-queen colonies produced 75 percent more honey than single-queen colonies. Working in dry conditions in Israel Lensky and Golan (1966) found that the two-queen colony method showed no advantage in honey yields over single-queen colonies. However their method of establishing the two-queen colony differed from most other researchers in that they united two complete single-queen colonies.

Many research workers (Farrar, 1953; Lysne, 1957; Moeller and Harp, 1965 ; Banker, 1968) have reported that there is less swarming in two-queen colonies. Swarming is discouraged in commercial beekeeping because it divides the foraging force and influences the efficiency of nectar gathering. Chaudhry and Johansen (1971) recommended that two-queen colonies should be united at the beginning of the main nectarflow rather than prior to it as the best means of swarm control. As the two-queen system is a method of requeening a colony without dequeening, it prevents any interruption in brood rearing (Haydak and Dietz, 1967). At the end of the summer two-queen colonies have accumulated larger pollen reserves than single-queen colonies and as a result of this they emerge in springtime with a larger population of young bees (Farrar, 1958).

Among the disadvantages of the two-queen system is that more skill is required on the part of the operator (Morse, 1970). The increased height of two-queen colonies make them subject to greater stock and wind damage than the single-queen colonies (Banker, 1968; Walton, 1970).

The two-queen system has been advocated in New Zealand for a number of years (Walsh, 1948; Rodie, 1953; Walton, 1970). Although a number of producers who raise their own spring queens employ the two queen method of management, the system has not had wide acceptance in New Zealand principally because of the difficulty in obtaining early season mated queens (Walton, 1970).

Few researchers have attempted to make an economic evaluation of the system. Farrar (1958) reported that less equipment was required in producing a given crop of honey than is customary under single-queen management. However he found that there were some limitations to the use of standard hive equipment for two-queen colonies. Less travel by the apiarist is needed under the two-queen plan in order to produce a given quantity of honey (Morse, 1970). Peer (1969) established two-queen colonies from package bees and found that there was significantly less cost and required less time and equipment per pound of honey produced than did single-queen colonies.

MATERIALS AND METHODS

Twelve permanent apiary sites were selected in the Waipukurau-Flemington area of Southern Hawke's Bay and formed part of a "beekeeper's round". The apiaries were approximately 1.5 miles apart and contained 12 colonies within each. An apiary location map is shown in Fig. 1. Colonies were positioned in a row containing 4 groups of 3 hives (Fig. 2). This configuration was found to be the most practical arrangement in the opinion of the beekeeper-owner; for it aided the use of the air-blower to remove honey supers, and also the hives were less prone to stock damage. Research has shown that linear repetitive apiary layouts tend to increase the amount of worker drift between colonies (Jay, 1966). However with only a small number of colonies per apiary this effect was considered to be of slight significance.

Eight weeks before the predicted early December start of the major nectarflow, all 12 apiaries contained over-wintered single-queen colonies housed in standard Langstroth hive equipment. Six apiaries were randomly selected to continue as single-queen colonies; the remainder were assigned to the two-queen method of colony management. All apiary treatments were re-randomised upon repeating the experiment the following year.

Although it was recognised that the incorporation of both single-queen and two-queen methods of management within each apiary would be the most desirable form of experimental design, this did not lend itself to an economic evaluation of the commercial beekeeping methods of operation – the major aim of the experiment. The comparison of colony management methods in the 1969/1970 season (Walton, 1971, 1972) under vigorous experimental conditions, had established clearly the superiority of two-queen colonies over single-queen colonies.

The owner and his employees carried out the yearly management requirements. Daily work sheets were provided. These recorded: the date, number of labour units, type of vehicle, mileage travelled, reason for the visit, general district conditions, apiary working time, the number of effective colonies, hive height, and the type and quantity of equipment used. A two-man team undertook all field work, aided by a AA 160 diesel International

Harvester truck with a 7/12 tons seasonal Certificate of Loading. During the honey extraction period a third man was employed to extract the crop.

All queen bees required for the experiment were raised by the owner in the Dannevirke-Waipukurau district. Although most queen rearing took place in the early autumn months, a number of queens were raised in the September-October period. The latter catered for the replacement of winter losses, spring increases, and the establishment of the two-queen system. Single-queen colonies were requeened in autumn at an average rate of once every two years. Colonies destined for two-queen colonies received their second queen in October of each year.

The single-queen colonies were managed in a manner somewhat similar to that employed by most New Zealand beekeepers. These colonies were over-wintered in two brood chambers (Figure 3) and manipulations included reversing in September, a check on stores in October and November, followed by supering, honey removal, and wintering down.

The two-queen method of management was initiated in mid-October following the randomized allocation of 6 over-wintered single-queen apiaries. The steps involved in this system are summarised as follows (variations would occur in other New Zealand localities):

(1) One week before the arrival of the caged mated queens for the establishment of the two-queen colonies, an excluder is inserted between the first and second brood chambers. The excluder allows the quick positioning of the queen without the need to find her.

(2) With the arrival of the second queen a week later, the brood chamber containing the over-wintered queen, with approximately half the brood and adult bee population, is placed upon the entrance board. A second brood chamber, empty save for sufficient food stores, is then positioned next and a double-gauze division placed on top. The queenless brood chamber is next placed upon the double-gauze division and is also provisioned with sufficient food stores. The young spring-mated queen is introduced into the centre of this brood nest using standard cage introduction techniques. The self-contained upper unit has its own entrance built into the rim of the double-gauze (Figure 4).

(3) The upper unit of the two-queen colony requires a second brood chamber after 4-6 weeks of development. The introduction of the second queen was seldom unsuccessful. If a queen had not been accepted, the upper and lower units were united and operated as a single-queen colony. All colonies were regularly checked for adequate supplies of honey.

(4) The double-gauze division was removed and replaced by a queen excluder upon indications that an early season nectarflow might restrict brood rearing in the lower unit. In the Waipukurau area surplus quantities of manuka in later November sometimes forces a restriction in brood next areas. However the removal of the double-gauze permits the upward movement of honey and gives laying room to the queen in the lower unit.

(5) As the commencement of the clover nectarflow the upper and lower units are united by removing the double-gauze or excluder. An attempt is made at this stage to reduce the brood area to two or three brood chambers. It is quite common for the brood to occupy 4 brood chambers at the beginning of the major nectarflow. However it is not desirable to continue brood rearing at such a high rate through the flow because this population would not reach worker foraging age until the end of the clover flow.

(6) From the time of uniting, and through the autumn, winter and spring months, these colonies that commenced in October as two-queen colonies are maintained and operated as single-queen colonies.

Colony performance was determined by assessing the quantity of extracted honey produced. All honey supers were weighed before and after honey extraction; the difference was taken as the measurement of extracted honey per colony.

Colony yields were statistically tested for significance by the Biometrics Section of the Ministry of Agriculture and Fisheries.

RESULTS

(a) Honey Yields

Colony build-up during the spring and early summer months was good in both years of testing. However, climatic conditions, and particularly the prevailing easterly winds, curtailed clover nectar secretion during the 1970/1971 season and low yields resulted. Favourable conditions during the 1971/1972 season resulted in large colony yields.

At the beginning of the second year of testing difficulty was experienced in obtaining sufficient queen bees to establish the two-queen system. Poor September seasonal conditions resulted in a low queen-mating success. As a result, only 48 instead of 72 two-queen colonies were established.

The quantity of extracted honey produced from the test colonies in the 1970/1971 and the 1971/1972 seasons are shown in Tables 1 and 2. The term "effective colonies" refers to those colonies that were observed to be unaffected by queen failure, supersedure, or swarming. No colonies were infected by American Foul Brood disease *(Bacillus larvae)* during the two years of testing. The protozoan intestinal parasite *Nosema apis* was detected in a number of colonies during both years of testing and may have had some effect upon colony build-up rates and honey yields.

The two-queen system of colony management clearly resulted in larger yields of honey in both favourable and unfavourable nectar-secreting seasons. Between 60-75% more surplus honey was obtained using this system of management compared to the standard single-queen system. However greater differences were evident between seasons using the same method of management than between methods of management in the same season.

(b) Equipment Used

All colonies were over-wintered in two brood chambers. Additional storeys were added throughout the spring build-up and nectar-flow to accommodate brood production and honey storage, depending upon

TABLE 1 – Quantity of Extracted Honey (lbs) per Colony during the 1970/1971 Season.

	Apiary Location	All Colonies: No. of Colonies	All Colonies: Average Yield	Effective Colonies: No. of Colonies	Effective Colonies: Average Yield
SINGLE-QUEEN COLONIES					
	R. Mathews	12	84.3	11[a]	74.6
	Gilbertson	12	33.8	9	44.6
	Fleming	12	43.0	10	51.6
	Syme	12	25.0	11	28.0
	Jamieson	12	47.9	11	52.3
	Hooper	12	42.8	10	50.5
Total/average		(72)	46.1	(62)	50.3
TWO-QUEEN COLONIES					
	Wilson	12	95.7	11	101.8
	Simmons	12	73.6	11	78.8
	Westerman	12	63.5	10	71.7
	W. Mathews	12	55.1	11	58.7
	Duckett	12	70.2	10	82.7
	Martin	12	87.8	10	101.8
Total/average		(72)	74.3	(63)	81.9
Standard error/colony			41.0		34.0
% increase 2Q/1Q			61		64
Significance			S.		H.S.

S. = Significant at 5% level.
H.S. = Significant at 1% level.
a = One colony which yielded 192 lbs of extracted honey was eliminated because it was a naturally induced two-queen colony.

method of management and seasonal conditions. The number of standard Langstroth storeys required per colony is shown in Table 3. Table 4 indicates the number of storeys and colonies required per ton of honey produced in both the 1970/1971 and 1971/1972 seasons of testing. The two-queen system required more equipment per colony unit than the single-queen system. However, in terms of unit quantity of honey produced, the two-queen system required less hives and fewer standard Langstroth storeys.

(c) Apiary Working Time

Throughout the season a record was kept of the working time spent within each apiary – from the time of alighting from the truck in the apiary until re-boarding. The average time involved, to the nearest 5 minutes for the various apiary visits during the course of the two seasons of testing and for the two methods of colony management, is indicated in Table 5.

Apiary working time is of course dependent upon the number of labour units, teamwork, working skills, mechanisation, number of colonies per apiary, and the type of manipulation required; and thus will vary from beekeeping enterprise to enterprise. Under the conditions of this test, each 12-colony apiary was maintained by two reasonably proficient beekeepers. They were aided in their work by a ramp from the rear of the truck and a mechanical air-blower to remove bees from full supers of honey. It would be expected that a single man maintaining an apiary would take more than twice the time to complete the necessary tasks. Two men working together should show an economy of effort.

TABLE 2 – Quantity of Extracted Honey (lbs) per colony during the 1971/1972 season.

		All Colonies		Effective Colonies	
	Apiary Location	No. of Colonies	Average Yield	No. of Colonies	Average Yield
SINGLE-QUEEN COLONIES					
	Wilson	12	202.5	11	213.7
	R. Mathews	12	193.5	11	211.1
	Westerman	12	166.3	10	198.9
	W. Mathews	12	114.2	11	120.9
	Syme	11	74.1	9	89.4
	Jamieson	10	153.5	9	170.6
	Total/average	(69)	151.7	(61)	169.0
TWO-QUEEN COLONIES					
	Simmons	12	282.7	10	296.6
	Fleming	9	266.0	8	280.1
	Duckett	7	176.7	3	278.0
	Martin	8	275.5	7	296.3
	Hooper	12	273.5	10	304.4
	Total/average	(48)	260.6	(38)	293.7
	Standard error/colony		148.0		123.0
	% increase 2Q/1Q		71		74
	Significance		H.S.		H.S.

H.S. = Significant at 1% level.

TABLE 3 – Number of Standard Langstroth Storeys Required per Colony.

	Single-queen	Two-queen
1970/1971 Season		
Start of Season	2.00	2.00
Additions	1.69	2.68
Seasonal Total	3.69	4.68
1971/1972 Season		
Start of Season	2.00	2.00
Additions	4.07	7.33
Seasonal Total	6.07.	9.33

TABLE 4 – Equipment Required per Ton of Honey Produced in Unfavourable (1970/1971) and Favourable (1971/1972) Seasons.

	Single-queen	Two-queen
Storeys required		
1970/1971 Season	178.9	141.1
1971/1972 Season	89.7	80.2
Colonies required		
1970/1971 Season	48.4	30.1
1971/1972 Season	14.8	8.6

TABLE 5 – Apiary Working Time (in minutes). Apiary visits in common, 1970/1971, 1971/1972 seasons.

Month	Reason for visit	Single-queen	Two-queen
September	Feeding/reversing	20	20
October	Inserting excluder for 2-Q	–	15
October	Introduction of 2nd queen/feed	10	40
November	Feed and acceptance checks	20	30
November	Brood box addition, 2-Q check	–	15
December	Supering/uniting	10	25
December	Supering	10	15
March	Wintering/requeening S-Q	45	15
	Sub-Total	115	175
1970/1971 Season			
January	Honey removal/supering	15	20
February	Honey removal	15	20
	Total	145	215
1971/1972 Season			
January	Honey removal/supering	30	45
February	Honey removal/supering	30	45
February	Honey removal	25	35
	Total	200	300

TABLE 6 – Apiary Working Time (hours and minutes) per Ton of Honey Produced in Unfavourable (1970/1971) and Favourable (1971/1972) Seasons.

	Single-queen	Two-queen
1970/1971 Season	9.45	9.00
1971/1972 Season	4.06	3.35

The two-queen system required 2 extra apiary visits and involved longer apiary working times. The time taken to requeen half of the single-queen colonies in March/April was the only occasion where the single-queen apiary working time exceeded two-queen times. However in terms of unit quantity of honey produced, the two-queen system required less time spent in the apiary (Table 6).

DISCUSSION

In both favourable and unfavourable nectar-secreting conditions the two-queen system of colony management clearly resulted in larger yields of honey. The superiority of the two-queen system over the standard single-queen method of management in this field trial is in agreement with the findings of many others (including Farrar, 1936; Dunham, 1951; Moeller and Harp, 1965; Chaudhry and Johansen 1971). The increased yields can be explained in terms of colony population. The introduction of a second queen to a partitioned single-queen colony for a 7-8 week period before the predicted start of the clover nectar-flow boosts the production of foraging worker bees.

The 10-year district average for the Hawke's Bay area is approximately 70 lbs per colony. This is one of the higher honey producing areas of New Zealand. The 46 pounds per colony obtained from the single-queen colonies in what was regarded as a poor season can be termed a reasonable crop in some other areas of New Zealand.

The comparison and evaluation of the single-queen and two-queen systems of colony management, as used under the commercial beekeeping conditions of this test, has shown that the two-queen system requires more equipment and maintenance time per unit colony than the single-queen system. However, in terms of the beekeeper's final product – honey, the two-queen system requires less colonies, less equipment, and less apiary working time than the single-queen system, per unit quantity of honey produced.

ACKNOWLEDGEMENTS

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The Beautiful Kermadec Pohutukawa

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Metrosideros kermadecensis W. R. B. Oliver, the Kermadec pohutukawa, is endemic to the northern Kermadec Islands, i.e. to Raoul and the adjacent Herald and Milne Islets. Prior to its description as a distinct species (Oliver 1928) it was considered to be conspecific with the tropical Pacific *M. collina* (J. R. & G. Forst) Gray which according to Dawson (1970) occurs naturally from Fiji to the Society Islands. Previously many people had included Hawaiian and Marquesan populations under this species but these are now considered to belong to *M. polymorpha* (Forst.) Chessem. *M. kermadecensis* is not only distinct from these two but is actually more closely related to the New Zealand pohutukawa, *M. excelsa* Sol. ex Gaertn. *(M. tomentosa* A. Rich.)

In recent years *M. kermadecensis* has become increasingly widely planted in coastal North Island districts. Although it can reach 25 metres high on Raoul it has not yet attained anything like that stature in New Zealand, in fact in cultivation it is usually seen as a small tree rarely exceeding 6 or 7 metres. Metcalf (1972) is probably correct in stating it is less hardy than *M. excelsa* (Raoul is about five degrees north of North Cape but I should not be surprised to learn that Kermadec pohutukawas would grow successfully on the Otago Peninsula or even around Oban on Stewart Island. Certainly it can be cultivated on Banks Peninsula and the Port Hills in Canterbury

Occurrence in the Northern Kermadecs

The photographs accompanying this article do not give an accurate idea of the abundance of the Kermadec pohutukawa on Raoul although they were all taken there. In fact, it is the dominant tree over much of the Island, and extends from near sea level to the top of Moumoukai, the highest point in the Kermadecs, just about 518 metres (1,700 feet). As one approaches Raoul the grey green of

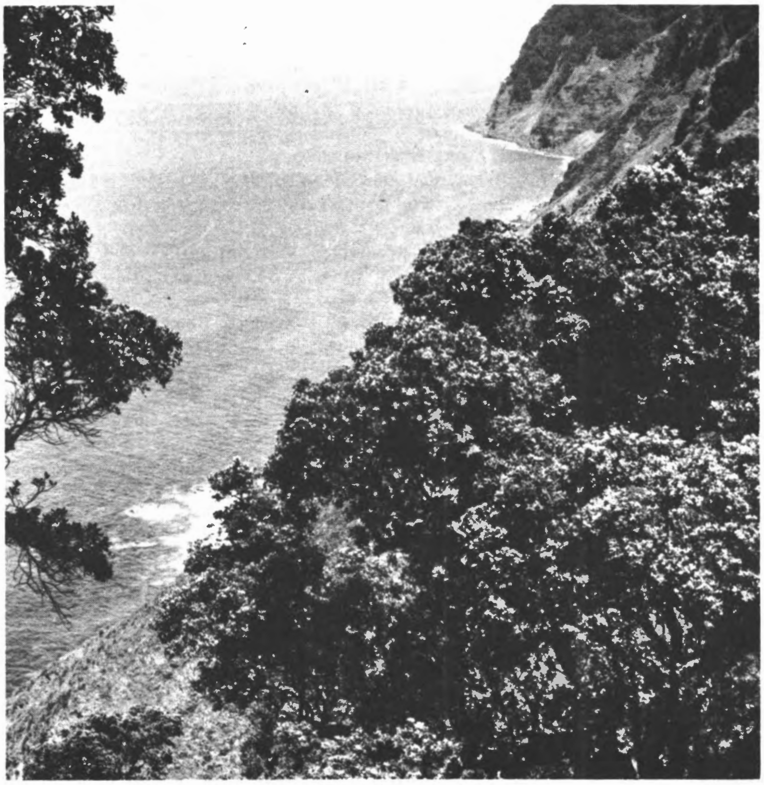
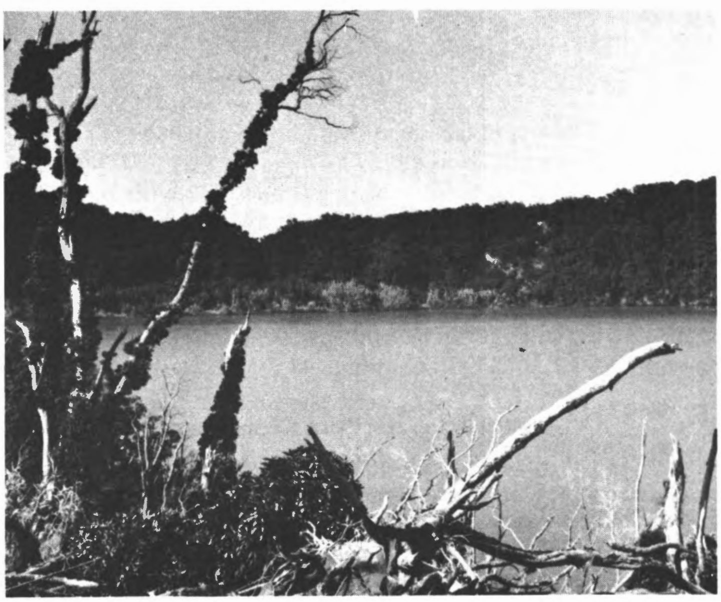


Fig 1

Metrosideros kermadecensis on the steep southern coast of Raoul.

Fig 2



Trunks of *Metrosideros kermadecensis* regenerating in the Raoul crater two years after an eruption.

Fig 3

Leaves and flowers of *Metrosideros kermadecensis* on Raoul.

this species seems to form an almost uninterrupted canopy over much of the steep volcanic slopes. *Fig. 1.* Regeneration however is very restricted because of the depredations of feral goats and thus the abundance of Kermadec pohutukawa at present is partly a tribute to its longevity because goats have been on the Island for nearly a century and a half. Hopefully, these destructive animals will be eliminated before very long. The group of small islands off the north and north east of Raoul are collectively called the Herald Islets. They mostly have a lava base upon which is a cap of soft pumiceous tuff. Kermadec pohutukawa covers at least some of this tuff cap, and owing to extreme exposure, on the smaller ones there may be only a small grove of stunted trees at the summit.

Occasionally it is reduced to a shrubby stature and is thus a far cry from the huge gnarled and twisted giants which one sees in some of the higher and wetter parts of Raoul. Often this aspect is enhanced because of the effect of past hurricanes having partially blown the trees over, after which rooting occurs from the trunks and branches touching the ground, whilst fresh trunks grow upwards. In addition, the prominence of pendulous tufts of reddish aerial roots from the lower side of many branches results in the appearance of a great tangled network of stems and roots, the closest parallel to which I have seen being the banyan type of *Ficus* or fig. The capacity of species of *Metrosideros* belonging to this group of the genus to exhibit this banyan-like effect is well-known and can often be seen in *M. excelsa* along northern New Zealand coasts, as well as in *M. collina* and *M. polymorpha* further north. Another feature that is common to Metrosideros species and banyans is that they often begin life as epiphytes and finally strangle the host.
The association of *Metrosideros* species of the *M. collina* group, (i.e. including the New Zealand and Kermadec pohutukawas) with volcanic islands is very common. From Hawaii to New Zealand they thrive on tuffs and lavas, although they are not normally restricted to such habitats, and of course can be cultivated in a wide range of garden soils. They are pioneer plants after eruptions and hence form the chief vegetation around some of the recent Hawaiian lava flows, on White and Rangitoto Islands in New Zealand, as well as on Raoul. Another aspect of their ability to colonise areas after eruptions is illustrated in *Fig. 2.* There the trunks of Kermadec pohutukawas are seen bearing tufts of leaves and flowers, the branches being ripped off by an explosive blast two years earlier. The force of this eruption caused some trees in the crater to be completely torn out of the ground as if they had lain directly in the path of a hurricane. No other trees survived as close to the centre of the volcano or were able to regenerate in this manner with all their branches absent. In parts of the Raoul crater unaffected by this 1964 eruption there are dense stands of erect Kermadec pohutukawa saplings 10 metres or more high dating from the eruption of about a century earlier. At present the same thing is happening as a result of the 1964 eruption, particularly now the goats are being drastically reduced by shooting. Already the young saplings are beyond their reach.

Characteristics if M. kermadecensis and its comparisons with M. excelsa

The main differences between Kermadec and New Zealand pohutukawas are in leaf size and shape and flower colour. The leaves are smaller and generally more rounded in *M. kermadecensis,* being mostly below 5cm long in this species and longer than that in *M. excelsa.* Also the apices are usually rounded in the Kermadec plant and obtuse in the New Zealand species. *Fig. 3.* However, both have glabrous and glossy leaves in the juvenile state. The stamens are about 2cm long in *M. kermadecensis* and usually around 3cm in *M. excelsa.* Although Allan (1961) gives stamen lengths of 1 to 2cm for the Kermadec plant as against 3 to 4 for the New Zealand pohutukawa, the differences are not always so well-defined. In cultivation it is widely recognised that the two species are distinguishable because *M. excelsa* only flowers in the middle of summer, hence its popular name of New Zealand Christmas tree, whereas *M. kermadecensis* flowers nearly all the year round. Strangely, although the Kermadecs are in a lower latitude, this does not seem to be the case there. In the winter of 1969 very few trees were flowering on Raoul, and in the summer of 1966-67 flowering was abundant from mid November for about two months, after which it rapidly tapered off. Of course, like most species, individual plants showed some variation from the average.

Within the Kermadec populations of *M. kermadecensis* there does not seem to be much significant variation. I have mentioned the difference in size being largely correlated with the degree of exposure. In Denham Bay in the south west of Raoul some trees tend to have smaller leaves than usual, a feature not related to the degree of exposure. Apart from a little difference in the flowering times of individual trees, the only difference noted concerning flowers was in one tree on the north side of Raoul which had orange red instead of the usual crimson stamens. As yet no yellow flowered form comparable to the tree of *M. excelsa* 'Aurea' from Motiti Island in the Bay of Plenty has appeared. In

Hawaii the related *M. polymorpha* has thrown pink, yellow and even a white form

In cultivation a variegated sport. *M. kermadecensis* 'Variegata' is quite common and as stated by Metcalf (1972) has often been erroneously known as a cultivar of *M. excelsa*. My suspicion as to the correctness of attributing this cultivar with irregular creamy margined leaves to the New Zealand pohutukawa was first aroused by a cultivated specimen from Adelaide. Metcalf also lists *M. kermadecensis* 'Sunninghill' where the leaves have a central creamy-yellow blotch instead of a marginal variegation. I was informed that 'Sunninghill' arose as a sport from cultivar 'Variegata' but I am unable to verify this. *M. excelsa* has produced a true variegated sport, but this plant cv 'Varietaga' is uncommon.

Suspected and reported hybridisation of M. kermadecensis

Because of the close relationship of species in this group of *Metrosideros*, and the fact that in New Zealand, at least, *M. excelsa* and *M. kermadecensis* often grow in close proximity. the question of possible hybrids needs consideration. As far as I am aware, there are no authenticated records of hybrids although such are mentioned (Metcalf 1972). A wild plant from Parua Bay near Whangarei was collected and grown by Mrs Katie Reynolds. The resulting plant in her garden resembles *M. kermadecensis*, except for the obtuse leaf apices. more than it does *M. excelsa*. A specimen in the Botany Division Herbarium collected by Mrs Reynolds at Tametarau near Whangarei has leaves like *M. excelsa* but has the shorter stamens of *M. kermadecensis*. In addition, the label bears her comment "tree never without flowers". However, Mrs Reynolds discounts *M. kermadecensis* as being involved because the tree from which it came was very large and the Kermadec species was "too recently introduced in this area Around the Treaty House at Waitangi I was shown several small pohutukawas in flower which were supposed to be *M. kermadecensis*. Although it was September the large obtuse leaves and long orange-red stamens did not suggest the Kermadec plant at all. I suspect that they might be hybrids with *M. excelsa* as one parent and with one of the large flowered New Zealand ratas as the other.

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Book Review

Plant Training, Pruning & Tree Surgery

By K. R. W. Hammett; A. H. & A. W. Reed, Wellington

For the keen amateur and to some extent the professional, here is a book about the training and shaping of plants which is well assembled and well illustrated.

The short chapters at the beginning on plant structure and function serve as an adequate introduction to the principles of training and pruning. Missing from the chapter on woody perennial plants are the pruning requirements of some important ornamentals such as *Hydrangeas, Rhododendrous, Forsythia, Citisus* and *Ceanothus*. The emphasis on the art of *Fuchsia* training might encourage the keen gardener to pursue this interesting work which is mostly undertaken. however, with the culture of Fuchaias in pots in glasshouses

Tree surgery principles are well covered but as the author explains in a book of this size. 68 pages, it is impossible to cover every detail. For those wishing to seek further information a useful book list for further reading is appended.

Plant Training, Pruning and Tree Surgery is a handy little book professionally assembled in a way which can be readily followed by the amateur

Reviewed by J O. Taylor.

A Study of Bird Damage in a Commercial Orchard in the Auckland District

(Extracts from a thesis for the National Diploma in Fruit Culture (N.Z.) submitted by G. V. Jensen)

SUMMARY

A study of bird damage in the apple variety Golden Delicious was carried out in a commercial orchard in the Auckland district. The study was carried out during the 1971 and 1972 seasons.

Six replicates of four trees were selected. Fruit samples were taken from two of the trees in each replicate at regular intervals to determine the pH and percentage soluble solids of the apples. The remaining two trees in each replicate were inspected at regular intervals and the number of damaged apples was recorded.

Bird damage commenced during the last week in February in 1971, and the first week in March in 1972. Those trees with the highest percentage soluble solids did not necessarily suffer the greatest damage. It was decided the percentage soluble solids was not the main factor in the amount of damage birds caused.

Those trees at the ends of the rows suffered a consistently greater degree of damage than those centrally located.

Regular observations were made to determine bird species and activity in the area. The bird species most consistently observed were blackbirds, song thrushes and house sparrows. Blackbirds and sparrows were observed eating apples and were considered to be the most important depredators.

When frightened, blackbirds and thrushes concealed themselves in the dense hedgerows, while starlings and mynas favoured the taller more open type of hedgerow.

OBSERVATIONS made in commercial apple orchards in the Auckland area indicate that bird damage to fruit is a problem in most years. The extent of the problem has not been investigated, but casual observations the author made, while employed in the fruit-growing industry, indicated that birds may cause sufficient damage for the problem to be economically important.

The later maturing apple varieties e.g. Golden Delicious and Giant Jeniton seem particularly prone to attack. The principal damage is caused by pecking of the fruit, but a proportion of the crop may be rejected for sale because of spoiling by bird droppings.

Damage commences at an early stage of maturation and continues until the fruit is harvested. During the maturation period, apple fruits go through several changes both internally and externally. The sugar level and flavour components increase while the acid level declines. Colour changes also occur. The background colour gradually changes from green to yellow as the fruit matures. Fruit enlargement continues with a resultant softening of the tissue. A rise in the respiration rate also occurs until it reaches its climacteric at fruit maturity. The incidence of bird damage may be linked to one or several of these changes.

It has been suggested the presence of shelter belts in an orchard area may influence the degree of damage caused by birds. Damage to other crops, such as peas, grain, sunflowers is usually more severe near shelter belts or fence lines. Observations suggest the birds use these belts as a source of cover from which to carry out their attack.

The problem of bird attack is probably of greater importance in those orchards where fruit is marketed through gate sales. This fruit is left on the tree to reach a later stage of maturity, than is fruit submitted to the New Zealand Apple and Pear Marketing Board. Since more orchardists in the Auckland area are marketing their apple crop through gate sales, bird damage is, therefore, likely to become increasingly significant. It was decided the problem of bird damage to apple crops bore investigation.

It had been suggested that the rise in the percentage of soluble solids, and the decrease of acidity in the maturing apple, might influence the amount of damage birds cause. It was decided to investigate the effect these changes have on bird depredation. As stated earlier, the presence of shelter belts in an orchard area is thought to influence the amount of damage birds cause. It was felt this aspect bore investigation also. It has been suggested (Dawson and Bull, 1970) that the most troublesome bird species in fruit crops are blackbirds *(Turdus merula)*, song thrushes *(Turdus ericetorum)*, mynas *(Acridotheres tristis)*, Starlings *(Sturnus vulgaris)*, white-eyes *(Zosterops lateralis)* and house sparrows *(Passer domesticus)*. It was decided to carry out observations to determine the bird species present in an orchard area, and which of those species were causing damage.

The study was carried out during the 1971 and 1972 seasons on a commercial orchard in the Albany district. An interesting feature of the property was that all fruit produced was marketing through gate sales.

RESULTS AND DISCUSSIONS

Damage commenced during the last week in February in 1971 and the first week in March in 1972. Although one apple was recorded as being damaged on the 10th of January in 1971, this was not considered to be the start of bird depredation in the variety Golden Delicious.

The percentage soluble solids of fruit from all trees tested at the time damage commenced, ranged from 11.2% to 12.9% in 1971, and from 12.5% to 13.0%, 13.0% in 1972. Those trees suffering the greatest atest damage did not necessarily have the highest percentage soluble solids. The percentage soluble solids tended to be lower, overall, throughout the period in which tests were made in 1971 than in 1972. The amount of damage birds caused in 1971 however was greater than in 1972.

Fruit Sampling

The level of acidity showed a slight but gradual decrease each week, and was considered not to influence the amount of damage birds caused.

The trees on the ends of the rows showed a consistently greater degree of damage in both years. This is consistent with work done by Mitterling (1965) who found that trees located at the periphery of the orchard suffered greater damage than those centrally located.

Bird Observations

The bird species most frequently and consistently observed were blackbirds *(Turdus merula)*, song thrushes *(Turdus ericetorum)* and house sparrows *(Passer domesticus)*. Bird numbers present varied, depending on the time of day observations were made. Bird activity was greatest during the early morning, from dawn until approximately 10.00 a.m. when activity lessened and remained at the same reduced level until dusk, when all activity ceased with the onset of darkness. Bird activity and numbers were about the same in both years. The number of blackbirds present was estimated to be 20, and the number of thrushes to be 5. Estimating the numbers presentwas difficult and conservative estimates were made. The actual number of birds present, therefore would probably have been greater than those recorded. Estimates of the numbers of house sparrows and other smaller birds present were not made.

Other identifiable bird species were also present, but because of their low numbers or the infrequent intervals at which they were observed, they were not considered important as depredators. These species were starlings *(Sturnus vulgaris)*, mynas *(Acridotheres tristis)*, chaffinches *(Fringilla coelebs)*, white-eyes *(Zosterops lateralis)* and goldfinches *(Carduelis carduelis)*.

Starlings were observed in the area during February in 1971. A flock estimated at 100 to 500 birds was observed feeding on the army caterpillar *(Pseudaletia seperata)*. The starlings remained in the area for approximately two weeks and were not observed again the area. A close inspection of the ground at the time the starlings left was made. No army caterpillars could be found. It appeared the caterpillars were a food source for the starlings and when the source was exhausted, the starlings left the area. No starlings or army caterpillars were seen in the area during 1972.

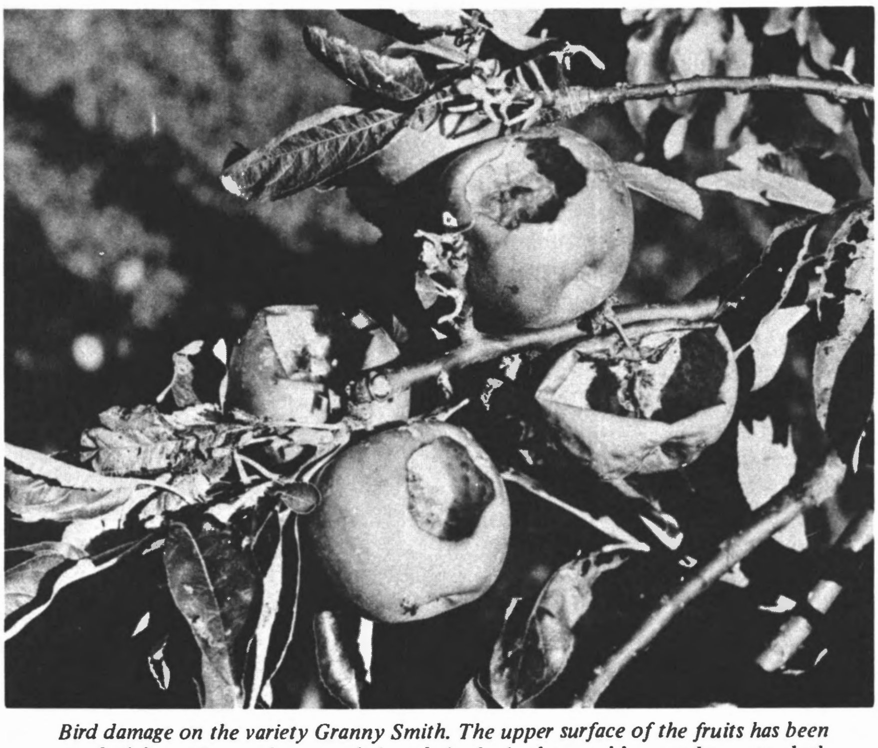
A flock of three mynas was seen in the area on one occasion in April, 1971. In 1972 six mynas were seen on two occasions, once in February and once in April. Although it is suggested by Dawson and Bull (1970) that starlings and mynas cause damage to fruit crops, they were never seen to damage apples.

The only species observed damaging apples were sparrows *(P. domesticus)* and blackbirds *(T. merula)*. Over the two years in which observations were made, blackbirds were observed eating apples on four occasions. Initial damage was caused on three of these occasions. Sparrows were seen to eat apples on six occasions. They were never seen to cause initial damage but were observed to eat only from those apples already damaged. They were usually seen moving over a tree eating from one damaged apple then another. Sparrows were not easily disturbed and could be observed from a distance of approximately 40 feet. Blackbirds however were easily frightened, which made them difficult to observe at close quarters. It is most probable that they cause much more damage than the results of observations indicate.

The different bird species observed had different behavioural patterns as far as the shelter belts were concerned. Starlings and mynas were the birds most frequently seen in the hedgerow at the southern end of the study area. When frightened, they seldom flew out of the area, but flew into the top of the hedgerow or nearest tall trees. They made no attempt to conceal themselves and appeared to use the taller trees as vantage points.

Blackbirds and thrushes however appeared to expose themselves as little as possible. When disturbed they would fly out of the area or into the dense hedgerows on the

Bird damage on the variety Red Dougherty. The top of the fruits has been attacked first. All apples are within reach of the perch.



Bird damage on the variety Granny Smith. The upper surface of the fruits has been attacked first. The partly concealed apple in the background has not been attacked.

eastern and northern boundaries. They were seldom seen in taller more exposed trees. When flying through the study area, they were usually seen to fly low down amongst the fruit trees.

Sparrows and other small birds seemed not to have any preference. The smaller birds were not easily frightened, but when they were, would usually fly only a short distance before continuing their activities as before.

Observations made suggest that the degree of damage a bird species may cause in an orchard area, may be influenced by the type of shelter present. If blackbirds were the most important depredators in an orchard area, the removal of dense shelter belts may discourage the birds from feeding in the area. It seems unlikely however that the elimination of all shelter belts would solve the problem of bird depredation.

Some Suggestions for Helping to Reduce Bird Damage

Some thoughts on ways of reducing bird damage emerged from the study.

The study showed that trees situated on the edge of an orchard area suffered considerably more damage than those in the centre. Where possible the planting of susceptible varieties in the centre of an orchard block should help reduce the amount of damage birds may cause.

Some orchardists employ bird scaring devices to help protect their crop. The most common one used is probably the acetylene scare gun. These "guns" are effective for only a relatively short period of time, so to achieve maximum crop protection they must be used to the best advantage. Maximum bird activity was recorded between dawn and mid-morning, and it is probable most damage occurs at this time. The gun would therefore need to be operated from dawn and continued until at least midday.

Another way of reducing damage would be to commence harvesting fruit at an earlier stage of maturity, thus exposing it to damage for a shorter period of time. There are some disadvantages in doing this however. If the apples are harvested too soon the keeping and eating qualities can be affected. Fruit size may also be affected. If picked too early the apples may not have reached their optimum size and a proportion of the crop may be downgraded. This would be of particular importance on orchards where fruit is submitted to the New Zealand Apple and Pear Marketing Authority. The losses incurred through fruit being downgraded may be greater than any gains made by reducing the amount of damage birds cause.

Economic Loss

The economic loss incurred during the 1972 season was calculated and projected onto a 1,000 bushel crop at harvest. The loss to the grower was approximately $62.00 based on a gross return per bushel of $3.60 for large apples and $3.00 for small. No value was placed on reject fruit.

A loss of this order would be considered of little significance. However it should be remembered that damage can vary considerably between years, and it is quite probable that damage may, in some years, cause significant losses.

Casual observations the author had made over several years would indicate that varieties other than Golden Delicious can at times suffer quite severe bird damage. These varieties are Giant Jeniton, Red Delicious, Gala and Splendour.

If all or several of these varieties are grown in the one orchard area, the combined losses suffered through bird damage could become economically important.

CONCLUSIONS

Although many questions remain unanswered some positive facts emerged. Trees situated on the ends of rows consistently suffered more damage than those centrally located. The degree of bird damage varied considerably between years. Blackbirds and sparrows were the species considered to be the main depredators although other bird species were present.

Bird activity was greatest in the early morning from dawn until approximately 10.00 a.m.

It is doubtful whether the percentage soluble solids of fruit is a major factor in the amount of damage birds cause to an apple variety.

Citation for Loder Cup Award, 1973

- Mrs Kate Reynolds A.H.R.I.H. (N.Z.)

Mrs Kate Reynolds was brought up in a very large home having a wonderful garden full of rare plants, both native and exotic. The four acre property had an area of native bush running down to the mangrove-bounded Hatea River. Because of geographical and climatic features—heavy rainfall, warmth—and in those days, remoteness from progress and development—the area was an almost unique ecological unit, and as such, much sought by visiting botanists.

Her parents, her brother and two sisters all made wild-life and horticulture their special interests, with special emphasis on the botany of Northland.

Mrs Reynolds did not have formal scientific training but she is self-taught. However her approach is scientific insofar as she has regard for truth and accuracy and she has no regard for guesswork. Because of these attributes, and because she is a born observer of nature, her know-ledge is invaluable to those engaged in the field of research. She has collected pollens and fern spores for Dr Lucy Cranwell Smith of Arizona (formerly of Auckland) and specimens for herbaria, including that of the Royal Botanic Gardens, Kew.

She is asked regularly to speak to Garden Clubs, Women's groups Specialist societies, etc., and over the years has given many talks to schools, in classrooms and on Arbor Days. She has helped Training College and University students to collect—and to learn—their native specimens.

Some years ago she conducted a Children's Club—a Native Wildflower Circle—based mainly on field trips, the object being for the children—boys and girls from 7 years to 13 years—to learn and to love their native plants and to enjoy the out-of-doors. For six years she was Guide and Ranger Captain, District Captain, and in this capacity gave girls from several Guide Companies instruction on these lines.

From about 1935 she helped annually with the Cheeseman Memorial Spring Show of native plants in the Auckland War Memorial Museum, taking with her a range of plants from her district and pot-grown specimens. She helped to set up displays, label specimens and acted as Guide and Instructor to school children and students during the ten days of the show. In 1938, during Miss Cranwell's absence overseas, she and Miss Betty Molesworth were in charge of Auckland Museum's Botany Department, for three months. Together they organised the Cheeseman Show that year. For almost two years she was Acting Botanist at the Dominion Museum, Wellington, under the late Dr W. R. B. Oliver.

She is now Honarary Botanist at the Whangarei Museum, and an active committee member of the Whangarei Junior Naturalists' Club.

Thirteen years ago she and her husband purchased a property of two acres thirty-two perches, much of it in gorse and pine trees. Since then they have eradicted these "weeds" and areas of "bush" are becoming established and many rare plants are growing well. Mrs Reynolds' interest in horticulture is very wide, but her deep and abiding love lies with our own very beautiful native plants. In this garden she is striving to demonstrate the beauty and horticultural merits of these. What began as a hobby for her own pleasure, and for the carrying on of a family tradition has extended far beyond her own home circle.

For three years she conducted the Gardening Session from N.Z.B.C.'s local station 1ZN. Last year and this she has tutored an evening class in Horticulture at an Adult Education Centre. In both of these activities she has given emphasis to the merit of native plants, their cultivation and preservation. She has had many articles illustrated by her own line drawings, published by the N.Z. Herald and N.Z. Gardener. During the years 1960-1966, when Whangarei District Council published a monthly journal, she contributed a regular article on native plants.

She did much research on the depredations of oppossums, particularly in regard to damage to Pohutukawas. She found that they were indeed the culprits, proved it beyond a shadow of doubt, and wrote an article, on her findings for N.Z. Herald. When mangroves were wrongly accused of causing pollution and of being "unsightly" she again did research and wrote an article on this interesting plant and its important association. For many years she has diligently and fearlessly fought battles for conversation-individual trees, for historic sites, for forests, islands and lakes. Notable examples are Waipoua Kauri Forest (on two occasions), Kiripaka Reserve, Skull Creek, Whangarei Harbour. She was one of the leading conservationists in the fight to save the Hen and Chickens Islands (Coppermine Island).

Mrs Reynolds has guided overseas botanists throughout Northland and happily has been able to extend hospitality to distinguished scientists such as Dr Ronald Melville, Royal Botanic Gardens, Kew, and Dr and Mrs Harold St. John of Bishop Museum, Honolulu.

Under Lands and Survey Department she is an Honorary Ranger for Scenic Reserves, and is frequently called upon to speak on conservation.

Over a lifetime her interests have involved time, study knowledge and plant materials generously shared. As one scientist remarked, the personality and work of Mrs Reynolds are precisely typical of what the late Gerald Loder had in mind when he presented the cup to New Zealand.

The Commercial Export of Trees and Shrubs

(Extracts from a thesis for the National Diploma of Horticulture (N.Z.) submitted by J. M. Cowan in 1970)

PREPARATION OF PLANTS

PLANTS for export come under the close scrutiny of the Department of Agriculture and for this reason must measure up to a certain standard. They must be completely disease free, preferably of an even grade – sometimes determined by size and age limits of the importing country – and meet the soil-free requirements of the country to which they are destined.

ROOTING MEDIA

With the soil-free requirements of most importing countries it is advantageous for the exporter to turn to a soil-less rotting medium. In some cases this is simply an extension of the propagation of plants for the domestic market, as many nurseries are already using such media for propagation purposes. Modifications may be necessary however to fit in with the requirements of some countries. For example, I have found that a propagating medium of 3 parts sawdust, 1 part sand and 1 part peat is ideal as a rooting media for a wide range of plants but would have to be changed for export lines as most countries prohibit the importing of sawdust.

The use of a suitable media will eliminate such time-consuming operations as soaking and washing to remove soil.

Whatever the rooting media used it must have the following basic properties:–

1. Be easily obtainable in a uniform grade
2. Relatively cheap
3. Sufficiently moisture retentive to suit the requirements of the cutting
4. Porous enough to allow excess water to drain away
5. Sterile, free from weed seeds and decay-producing fungi and bacteria
6. It must be firm enough to hold the cutting in place during rooting, and the volume remain fairly constant i.e. not shrink excessively after drying

With these factors in mind let us now consider the soil substitutes which may be used.

SAND

Clean sharp sand of a fairly coarse grade produces the best results. Coarse sand has good aeration and a good supply of capillary water though it tends to dry out easily. I have found that a silica type sand as found in the Waikato gives excellent results.

PEAT

New Zealand (Hauraki) peat has proved to be almost identical with Cumberland and Irish peat moss. It has a high water-holding capacity which can cause problems in mist propagation.

VERMICULITE (heat expanded mica)

This is a lightweight material the success of which depends on the type of plant and the particle size of the vermiculite used. Complete sterilization is achieved during exposure to extremely high temperatures (2,000°F) in manufacture. Expanded vermiculite is available in four grades: "No. 1 has* particles from 5 to 8 mm in diameter; No. 2 from 2 to 3 mm; No. 3 from 1 to 2 mm; and No. 4 from 0.75 to 1 mm in diameter. Expanded vermiculite should not be pressed or compacted in any way when wet, because its desirable porous structure will be destroyed".

PERLITE (heat expanded volcanic lava)

The success of this grey-white material as a rooting media can be related to three factors: It has good water-holding capacity, drains well and is free from organisms that lead to the rotting of roots, i.e. it is a sterile product.

PUMICE

A valuable material obtained locally from the Waikato area, this is available in various grades based on particle size. It is heat treated thus making a sterile product.

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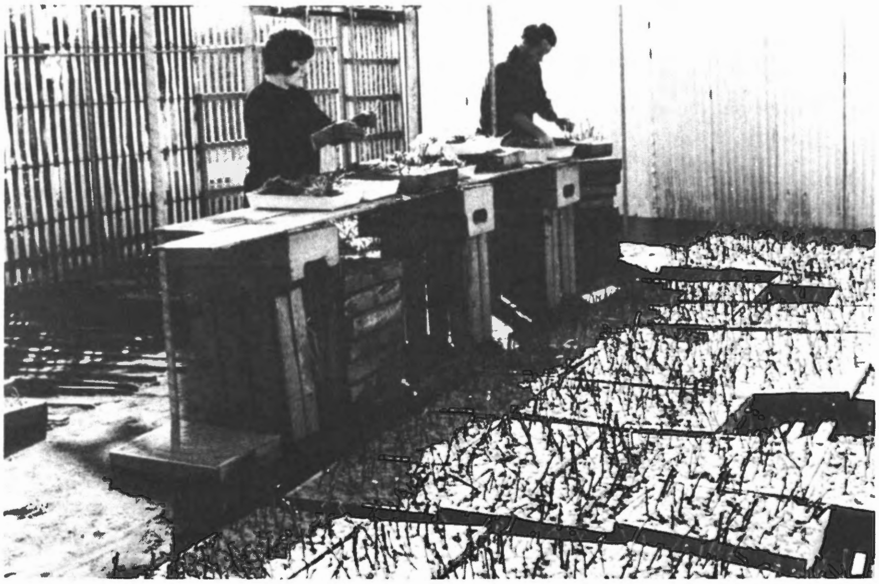
*Hartmann H. T. and Kester D. E., *"Plant Propagation Principles and Practices"*



Lifting and grading is the first stage in the preparation of an order of *Actinidia chinensis* for U.S.A.

Plants rooted in pumice need only a brief dip in water to remove any particles adhering to the roots.
(Photo Taranaki Newspapers).

A Ministry of Agriculture officer inspects chinese gooseberry cuttings for signs of disease or malformation.
(Photo Taranaki Newspapers).

PREPARATION OF PLANTS

1. Lifting
Plants of an even grade should be selected and as much soil as possible shaken off without damaging the roots.

2. Soil Removed by Washing
For plants rooted or grown on in pumice, vermiculite or similar soil-less media, this is simply a matter of dipping the roots in water to remove surplus mix.

Plants grown in soil are usually more difficult to prepare as the root-ball contains considerable amounts of soil which must be carefully removed.

It has been found that soaking of the roots, even for only a few hours, greatly facilitates soil removal. Nevertheless, most exporters still find this operation the most tedious and time-consuming. As far as is known at present practically all washing out is done by hand with a pressure hose. Care should be taken however to prevent root damage and for this reason small fibrous-rooted plants are best dipped individually in a trough or similar container.

Trials with mechanised washing out techniques have met with partial success but this is limited to hardy and preferably deciduous plants which can withstand the rigorous treatment.

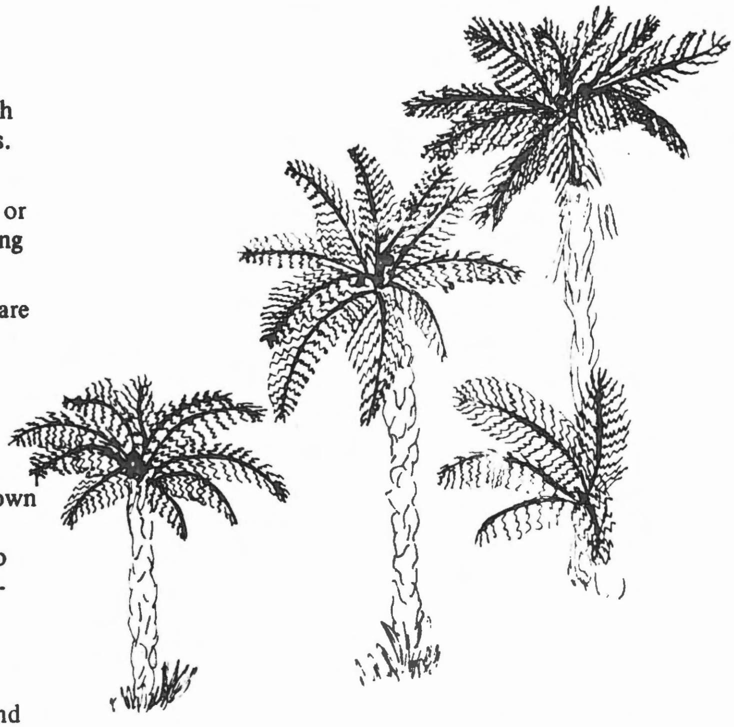
Other labour-saving techniques should be sought and no doubt as this highly competitive trade increases in volume, considerable mechanisation will occur.

The degree to which washing out is carried depends on the soil-free requirements of the importing country. For example, plants destined to Hong Kong may be left with peat attached to the roots, whereas the same plants sent to the U.S.A. would have to be completely free of all such material.

3. Storage
Once soil removal is completed the bare-rooted plants must be stored in such a way as to prevent drying out, at the same time being readily available for inspection.

Personal experience has proven that the ideal way to achieve this is to lay the plant material on strips of clean polythene, or on a clean bench, covering the roots with moist sphagnum moss and periodically spraying all green parts with water using a hand atomiser or knapsack sprayer, depending on the size of the order. The entire order is then covered with black polythene which is weighted down, thus reducing transpiration and ensuring moisture conservation.

In some instances, for example when shrubs in bud are requested, it is necessary to resort to specialised storage. This is usually by refrigeration, a case in point being an



Tree ferns typify the demand for New Zealand native plants.

order of peach 'Bonanza' which were successfully stored for six weeks at 0°C. These plants were placed in boxes of wood shavings and sealed with polythene. Upon removal the first signs of flower bud movement were evident, thus showing a successful retardation programme which had no detremental effect on the plants. I have found too, that by adopting the practice of cooling evergreens by refrigeration (2.2°C to 5.6°C) immediately after packing for two or three days, transpiration is reduced and the plants are better adjusted to cool storage in transport.

Cool storage techniques are seldom used for such purposes in New Zealand but are a common practice in the U.S.A. and Europe to hold back material to suit the climatic conditions of the importing country. More experience with cool storage should lead to more widespread use of these techniques and the adoption of advanced methods.

4. Inspection
As well as inspection by a Department of Agriculture Quarantine Officer, it is advisable for the exporter to examine all material intended for export. By doing this he can remove any damaged leaves or roots, cutting these off cleanly and, where necessary, defoiliating completely. The latter procedure is necessary for certain plants such as *Pittosporum spp.* in which local discolouration often

New Zealand flax *(Phormium spp)* with its numerous cultivars is currently very popular.

accompanies damage giving the impression of disease. This treatment appears to have little effect on the subsequent growth and development of plants.

Such inspection may be carried out in conjunction with soil removal or as a further operation.

All plant material for export must pass an inspection by a Department of Agriculture officer. The appropriate health certificate and any special certificates or endorsements must be signed by this officer within twenty-one days of shipping. The plants are then ready for packing.

PACKAGING

The packaging of goods – whether it be plants or otherwise – serves two primary functions, those of protection and sales promotion.

1. Protection

Naturally, when plants are being transferred from one locality to another, some form of protection is necessary, not only to protect material from damage due to handling but also to ensure that the plants arrive in a fresh and healthy condition. Protective materials fall into two groups:

A External protection. This is provided by the container which must be durable, clearly labelled, lightweight and of a size which affords easy handlling. Insulative and water repellent qualities are worthy of investigation.

B Internal protection – usually in the form of packing materials which act as a buffer, protecting plants from bruising and breakages en route. Moisture conservation also comes into this category.

2. Sales Promotion

The outer container or package receives much visual contact from the time it leaves the producer until it arrives at its destination. The enterprising exporter will realise the advantages of having his product recognised at all stages during transport and will thus endeavour to mark all containers with a distinctive design.

We have then a considerable number of points to consider when packaging plants or plant material for export.

(1) **Durability**: Perhaps the most important point to mention under this heading, is that export cargo comes in for far more handling than internally-bound goods. Strong, durable containers are therefore essential and the exporter must be prepared to pay more for these requirements. Containers should be strong enough to enable stacking and water-proofing has obvious advantages. An example is the wetlock carton made of corrugated cardboard and immersed in hot wax to seal against moisture. Success has been achieved with polyurethane containers. These are exceedingly lightweight yet rigid and assist in protecting the contents from excessive heat.

(2) **Size and Weight**: To tie in with the economics of air freight considerable thought should be given to the type of container used. Wooden boxes though extremely durable. would be impracticable because of the weight factor and over-large cartons make handling difficult. The exporter should therefore seek to obtain a container that is both durable and lightweight, and of a size that is suitable for handling.

(3) **Suit Requirements of Importing Country**: This heading refers more specifically to the type of packing material around the plants, rather than the outer containers. It is vitally important that the correct packing materials be used otherwise loss of a customer may occur when the customs officer condemns incorrect material. A thorough knowledge of the requirements of the importing country prior to confirmation of an order should alleviate this

problem which is of particular importance in trial shipments. Woodwool, polythene and sphagnum moss are universally accepted packing materials. Restrictions on other materials are listed in the Quarantine Regulations.

(4) **Addressing**: Clarity is of prime importance, printing in block capitals being the most legible. A waterproof pen or pencil should be used and all necessary details incorporated.

When exporting to a foreign country, consideration should be given to using the language of the country concerned. As well as simplifying matters this shows the thoughtfulness and goodwill of the exporter.

(5) **Sales Promotion**: As already mentioned, the exporter should endeavour to develop a particular design, which enables his product to be easily recognised throughout the journey. There is a governmental incentive scheme entitling the exporter to a tax deducation of 50% on the cost of research on export packaging, providing the costs are incurred solely or primarily to attract export sales.

ADVANTAGES AND DISADVANTAGES OF VARIOUS PACKING MATERIALS

Sphagnum moss: This internationally recognised packing material is ideal for use around the roots of plants, as it provides both bulk and moisture conservation. Care should be taken however to ensure that only clean sterile moss is used and for this reason some firms prefer to have supplies fumigated – Methyl Bromide being used for this purpose. For best results moss should be moist only hand-wringing usually achieving the right moisture content. I have found it advantageous to alter the moisture content at varying times of the year. For example, deciduous material can be packed in much drier moss than evergreens. If a large amount of exporting is done, a wringer of the sort used in domestic washing may be suitably employed for the wringing out of moss, adjusting where necessary to achieve the required moisture content.

Polythene sheeting: In recent years this material has revolutionised plant packing and is now used almost exclusively for enclosing moss around roots. It has obvious advantages over previously used materials such as scrim and waxed paper. It is a cheap material available in black, clear or opaque shades and in varying grades. I have found that the thinner grades (0.0001) are easier to handle.

A further use of polythene sheeting is for lining cartons to ensure water-proofing.

Woodwool or Excelsior: A product of the timber industry, this lightweight material is used chiefly as a buffer, both between individual plants and between bundles within a carton, to prevent contact and subsequent bruising, at the same time allowing free air movement.

Other materials used for packing include vermiculite, peat, ground cork, charcoal and certain vegetable fibres, though little use is made of such materials in New Zealand.

Having discussed the type of materials available for packing it is now time to illustrate how they are put to use.

It is preferable to deal with orders individually to avoid confusion. If no special area is set aside for export packing it is best to select a clean bench, preferably of waist height to allow for easy manouvering.

Most exporters appear to pack plants in the standard method using moist sphagnum moss around the roots, while others maintain that dry packing with vermiculite or similar material is advantageous.

It is advisable to pack only one variety of plants per bundle, labelling the bundle clearly to that effect. However it is sometimes necessary for economic reasons – as in the case of a trial shipment where small numbers only are requested – to bundle more than one type together. Where this occurs it is best to seek out varieties of vary dissimilar appearance, taking extreme care in labelling.

Once bundled, the order is ready for final packing in the dispatch containers. Bundles are generally packed head to tail with liberal amounts of woodwool between bundles and around the edges of the container, this acting as a shock-absorber during transport. Depending on the type of container used, it may be necessary to strengthen the sides or corners. This is particularly applicable to the lighter weight cardboard cartons where thin wooden stakes can be employed successfully to strengthen the corners; the sides being strenthened where necessary with thin plywood or similar material.

A copy of the invoice and/or packing slip is placed at the top of the container and the lid closed, securing with staples or tape.

Finally, each container is clearly addressed, using a waterproof pen or pencil. The address of the consignee must be given in full and must correspond exactly with that shown on all documents. A number of the other details frequently required, are the permit number, the weight and contents, the order number and any special handling directions – all of which must be shown legibly, in addition to the address.

The completed order is now ready for shipment and, by working in close contact with the transport company, delay should be negligible.

DOCUMENTATION

Legislation varies considerably in different countries, making it imperative to ascertain the documentation requirements prior to confirmation of an order. All necessary information is usually available from the importer but full details are procurable from the appropriate Department of Agriculture.

Health Certificate

Every consignment of plants or plant material leaving New Zealand must be accompanied by one or more copies of an international health or phyto-santiary certificate, issued by the New Zealand Department of Agriculture and signed by an authorised Plant Quarantine officer, showing that the plant material is, to the best of his knowledge, free from known pests and diseases.

The certificate is written in English, French and German and is universally accepted as proof of the validity of a consignment. All plants in the consignment must be listed on the certificate and the exporter must ensure that the stipulated number only are included, as extras can cause delay on arrival.

In some instances the certificate must be endorsed to show that certain cultural requirements have been adhered to. These requirements may include treating with specified chemicals or proof of disease-free growing conditions."

Citations for the Award of Associate of Honour A.H.R.I.H.(N.Z.) 1973

Arthur Farnell

Mr Farnell was born at Bingley, Yorkshire on October 23, 1895. From his school days he was interested in horticulture and determined that one day he would work at Kew.

First, however, he went to Reginald Farrer at Rudgwick Fruit Farm. Then, for some twelve months he worked at the largest nursery in England, Slococks of Woking. While there, and at the age of only eighteen, he was appointed advisor to the Rhododendron Society at Slocum, thereby becoming associated with J. W. Bean and other great men of English horticulture.

On January 2, 1914, he was accepted as a second-class gardener at Kew and there, for 15 months, until he joined the army for war service in France, he was a journeyman specialising in grafting rhododendrons.

He came to this country in 1924. The Parakai Gardens are a tribute to Arthur Farnell's first ten years of work here.

The next 28 years, until his retirement, were spent with the Auckland Hospital Board. He was responsible for the gardens of 17 hospitals including those of Auckland, Middlemore, National Womens' and Pukekohe. Many, in fact, were laid out by him. During this period he built up his unique collection of native plants at Middlemore. There were eventually some 400 species and varieties growing together on the slopes above the stream behind the hospital. These plants were of very great interest, not only to botanists but also to natural history societies, schools, University students and others. The University collections themselves were enriched by numerous donations from Mr Farnell.

This great work on the indigenous flora was extended by the giving of lectures to numerous audiences from Whangarei to New Plymouth and the leading of varied field excursions. It was recognized in 1968 by the award of the Loder Cup.

Mr Farnell has introduced to horticulture a number of valuable coloured or variegated forms of native plants. Perhaps most notable are *Coprosma repens 'Silver Queen'* which he raised from a mutation he observed on a plant of *C. repens 'variegata'* in a friend's garden, and another most attractive and amenable form of *Coprosma* involving hybridazation among *C. repens* and two other species.

Since his retirement Mr Farnell has continued his work for horticulture on his own property at Panmure. There, in 1965, he produced his "All Doubles" strain of *Gerbera* by crossing double and single flowered clones in a breeding programme that was being directed at the control of white rust. In 1968 seed was sent for testing to the R.H.S. at Wisley and all plants grown in the trial grounds there produced double flowers. Not a single one of the thousands grown by Mr Farnell since 1965 has produced anything but true double flowers. There is a great demand from nurserymen and research stations in many parts of the world for "All Doubles" seed. Last year a single California nurseryman ordered six times the total number of seeds that Mr Farnell was able to produce. The seed has to be F1 seed since the "All Doubles" gerbera, homozygous for the "double" gene (J. A. Rattenbury) does not produce pollen. For this outstanding work Mr Farnell was awarded the Plant Raisers Award for 1971.

Mr Farnell has been an Executive member of the Auckland District Council, R.N.Z.I.H., for 15 years. He is a life member and several times Past-President of the Auckland Natural History Club. He has played a prominent part in the affairs of the Auckland Botanical Society and is a Past-President. As well, as a member of the Great South Road Beautifying Society he has long been a technical advisor to the Ministry of Works and he is a botanical member of the Kirks Bush Scenic Board.

Con Holyoake

Mr Con Holyoake joined the North Shore Horticultural Society in the early 1920's and ultimately became Treasurer, and then President. He saw the Society grow from infancy to robust maturity, and was elected a Life Member in 1944. During the 1939/45 war, he was a member of the Auckland "Dig for Victory" committee.

As a Takapuna Borough Councillor, he served for two years on the Parks and Reserves Committee and as chairman for part of the time.

Transferred to Wellington in 1945, the National Rose Society elected him to a committee charged with forming District Rose Societies. The N.R.S. was then only some 800 strong. Mr Holyoake aroused interest in many centres and in the next ten years was personally present at the inaugural meetings of more than half the twenty district societies then formed.

When N.R.S. headquarters moved from Auckland to Wellington in 1948 he became chairman of the executive committee and remained an executive officer of the Society practically continuously until his retirement on account of ill-health in 1964. He served two terms as National President, was secretary for some years, and also edited the Society's Newsletter for a period.

In 1955 Mr Holyoake became one of the first Life Members of the N.R.S. and in 1958 received the Stewart Memorial Award, which is conferred annually by the N.Z. and Australian Rose Societies for meritorious service to the Rose.

In 1958 he represented the National Rose Society of New Zealand officially at an International Rose Conference in London and judged at the English Society's Summer & Autumn Rose Shows.

In 1964, Mr Holyoake wrote the Rose Society's Cultural Handbook, which has gone into the homes of all members of the Society, and in 1970 he was elected President Emeritus of the Society.

Although Mr Holyoake has been a strong advocate of the 'Rose', it could never be said that his horticultural activities were unbalanced. Particularly in his early days, he won many prizes for vegetables, native specimens, and for horticultural exhibits generally. His freely giving of lectures and talks on general garden culture have been of assistance to many gardeners throughout the length of our land.

Mr Holyoake has been a member of the Royal N.Z. Institute of Horticulture for many years and in 1959 he was elected a Fellow. For some years he was a committeeman of the Wellington Horticultural Society, and, latterly has been President of the Waikanae Horticultural Society, and is still serving on the committee.

Mr Holyoake has been a welcoming host to many gardeners and has often opened his gardens to visits from horticultural groups which have always been educational occasions.

He has maintained his interest in roses and gardening in general through a long and active life.

Shadehouse Testing of Miticides for the Control of European Red Mite
(Panonychus ulmi Koch)

(Extracts from a thesis for the National Diploma of Horticulture (N.Z.), submitted by D. J. McKenzie)

INTRODUCTION

THE european red mite, *Panonychus ulmi* Koch (syn. *Metatetranychus ulmi)* (syn. *Paratetranychus pilosus* C. and F.) belongs to the class Arachnida, the order Acarina and the family Tetranychidae. First reported from Italy in 1877 (Dean and Lienk 1969) european mite was not confined to that country and in fact may well have been a sporadic pest of certain fruit trees for centuries.

The main hosts for the phytophagus european mite include the fruits apple, pear, peach, plum and walnut while a closely allied species *Panonychus citri* is found on citrus.

In North America the european mite was first reported in Oregon in 1911 (Dean and Lienk 1969). In England (Massee 1946) indicated that the species was unknown before 1923 except to specialists interested in the group. In New Zealand (Cottier 1934) described european mite as one of the most important pests of deciduous fruit trees in the country. He stated that it had undoubtedly been present in the Dominion for a number of years, but was then only recently (1934) recognized as being in large measure responsible for the injury ascribed to the "red-mite".

Another species of mite known as the two-spotted spider mite, (syn. glasshouse red spider mite or red carmine mite) *Tetranychus urticae* Koch (syn. *T. telarius* L., *T. bimaculatus* Harvey) is also a world wide pest of crops. The two-spotted mite is perhaps because of its wider host range throughout the world, of even greater significance than the european mite. This thesis relates only to testing miticides against the european mite, although the test method described has also been used successfully against two-spotted mite.

The european mite obtains its food by sucking up liquid including the chlorophyll from the leaves of the host plant resulting in plant water and nutrient loss, reduced photosynthesis and symptoms of bronzing of the leaves. This damage reduces the size and quality of the current season's fruit crop and also tree vigour. In addition the loss of effective foliage can reduce initiation of fruit buds required to produce the following season's crop.

On fruit trees untreated with chemical pesticides the european mite population is normally held at a low level reasonably well by predatory insects and mites. In New Zealand *Stethorus bifidus* Kapur is the main predator insect and *Typhlodromus pyri* Scheut and *Agistemus longisetus* Gonzales are the two main predator mites (Collyer 1964). In spite of the presence of these predators it is not yet practical to produce high yields of quality fruit, on a commercial scale, without recourse to various chemical pesticides. The reasons for this are outside the scope of this thesis.

The difficulty in maintaining effective and lasting control of european mite by the use of chemical sprays is due in the main to two factors:–

1. The reproductive capacity of the european mite: The number of eggs laid by the female mite is 16 – 20 (Cottier 1934. Dean and Lienk 1969). This is not large when compared to many insects, but whereas insects often have only 1 to 3 generations per season, the european mite in New Zealand has 5 to 6 generations. (Collyer 1964). It has been estimated (Dean and Lienk 1969) that in one year a single female mite and her progeny could theoretically produce in excess of 10 million eggs. Eggs which may be unfertilized still develop but into male mites.

2. The ability of the european mite to evolve populations resistant (tolerant) to the chemical miticides used against them. This development of resistant mite populations is a matter of selective survival and reproduction. Those mites in a population that are susceptible to a particular miticide perish whereas those that are inherently resistant to that miticide reproduce, transmitting the genes which give this resistance to

their off spring. Within the span of a few mite generations the entire mite population of a given area can therefore be changed from a susceptible to a resistant one. Individual mites do not become resistant to a miticide during their lifetime. They either do or do not carry within their genetical make up the factors which enable the individual, in a variety of ways to resist or tolerate a particular miticide.

The purpose of the work described in this thesis has been to develop a technique whereby up to 20 candidate miticide chemicals, formulations, or varying dosage rates can be tested simultaneously for their effect on a european mite population from a known source.

To enable results to be more closely related to actual field results, than is at present achieved with typical laboratory and glasshouse tests, reasonably standard conditions including a typical orchard environment should be provided. One of the main factors to be considered is the weathering of the acaricides. Following a study of techniques used by various workers a modified shade house environment was selected as being most promising.

REVIEW OF LITERATURE. TEST METHODS

Detailed information on the life cycle of the european mite and its natural predators in New Zealand are described by Cottier (1934) and Collyer (1964). This review of literature summarizes the principal methods of testing miticides for biological effectiveness against a particular mite population.

LABORATORY TEST METHODS

Leaf Dipping Lippold (1963) described a method for evaluating materials. Mite infested leaves were dipped into various concentrations of miticide for various immersion times. Test preparations and leaves were gently agitated for 5 seconds to ensure adequate homogeneity. Mites are best transferred from stock plants on to the test leaves and left for a few hours before treatment. This ensures good active samples of mite are used and that variations are reduced to a minimum. Following a post treatment period of 24 hours under constant conditions in a rearing room, the particular miticide under test is evaluated by counting dead and alive mites under a microscope.

Dittrich (1962) indicates that this leaf dipping method gave more variable results than either slide dipping or cage spraying methods. He considered variability may have been due to lack of complete randomization, the gathering of the test chemical along the leaf midrib which is the preferred location for the mites and also loss of mites from treated leaves.

Slide Dipping Voss (1961). A piece of double faced adhesive tape was pressed tightly to a microscope slide, avoiding any air spaces that would allow any of the test chemical to be retained between the slide and the tape. A moistened soft haired brush was used to transfer adult female mites on to the tape dorsal side down. About 30 mites were positioned in rows on the tape in this way. The slide was then dipped in the chosen concentration of miticide chemical and agitated gently for 5 seconds. After dipping, excess liquid was blotted from the slide with filter paper. Slides were then placed under constant temperature and humidity for 24 hours before surviving mites were counted. Mites were considered to be alive if they responded to prodding. With a fine brush when viewed under a microscope.

Vass (1963) stated that the leaf dip method could produce variable results under varying temperatures whereas the slide dip method overcame this factor. Elderaw *et al.* (1965) preferred the slide dip to the leaf dip method because of less variation in results.

Leaf Disc. This method was described by Siegler (1947) and also by Ebeling and Pence (1953). The spray was applied to mites already established on leaves. Leaf discs were then excised and held under controlled conditions. Alternatively a leaf can be sprayed, the leaf discs then excised and mites transferred onto these treated discs. The leaf disc was usually held on moistened cotton wool in a glass container which was stored in controlled conditions throughout the test period.

Cage Spray Dittrich (1961) described this method where mites were placed in fine perlon mesh cages which were glued to the under surface of primary bean leaves. The mites in each cage were sprayed with a constant quantity of liquid by spraying at 5 psi for 5 seconds. Subsequent treatment was the same as described for the slide dip method. Dittrich (1962) comparing this with the slide dip method stated that the cage spray method was the least variable but that it required more skill and more work.

Topical Application Harrison (1961) described the construction and procedure for use of an apparatus for topical application of insecticide solutions to mites and insects. The apparatus consisted of a self-filling micropipette mounted in the field of view of a steroscropic microscope. The doses delivered to individual insects ranged from 0.0005 ul to 0.00005 ul. Repeatable results have been obtained using this method.

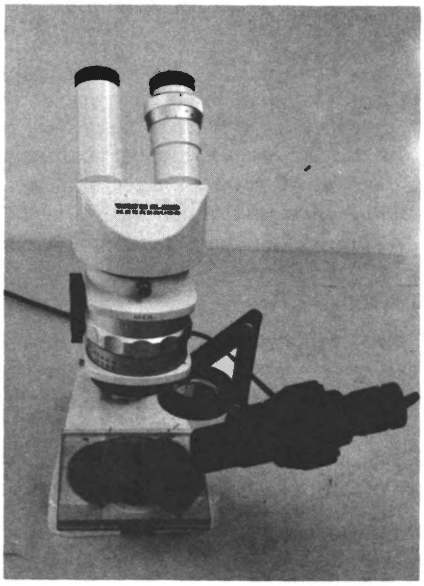


Plate 1:
A binocular microscope being used for the examination of apple leaves for mite infestation.

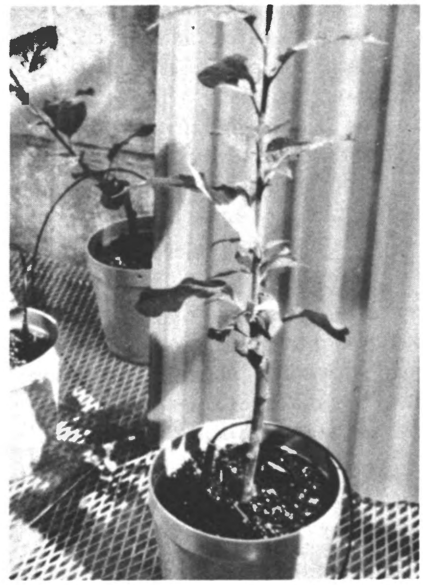


Plate 2:
Infestation of a pot grown apple is encouraged by attaching a section of twig infested with red mite.

Mites were shaken from their host plant and a suction holder used to trap the required individual. The whole procedure of treating an individual mite or insect occupied about one minite.

Earlier Metcalfe (1958) had summarised the advantages of this method as follows:

1. High degree of precision and replicability.
2. The small number of insects per replication to give uniform results.
3. Simple and inexpensive equipment.
4. Very small quantities of chemical required.
5. Comparison of results between laboratories proved identical conditions observed.

Lee (1967) found problems with the toxic action of some of the solvents used with the tact chemicals applied by this topical application method.

Macrodropping Technique Smith (1963) described a method developed for testing with commercially formulated pesticides. The technique was essentially an inverted dipping procedure whereby a drop of pesticide suspension was delivered from a hypodermic syringe at the required dilution and allowed to fall on to the test animal. The door were about 80 times the size of the test animals and they completely engulfed them on impact. Test animals were held on a filter paper for treatment and this absorbed the drops. While immobilized by carbon dioxide, a batch of animals was dosed one by one with successive drops and then allowed to dry before transfer to recovery cages.

Rose Leaf – Residue Technique. Jacklin and Smith (1966) described this method which was carried out partly in the field and partly in the laboratory. Both leaf surfaces of rose bushes were sprayed each week with the test miticides. 3 to 6 sample leaves per bush were removed 0 to 7 days after the last application. Each leaflet was taken to the laboratory and pinned upside-down on to a rubber disc 7 mm thick. The disc-leaflet assembly was placed in a petri dish filled with water so that the rose leaflet nearly floated. A portion of bean leaf. Infested with laboratory reared two spotted mite was then draped over the head of the pin holding the rose leaflet to the rubber disc. Each petri dish was placed under strong light. The bean leaf portions soon wilted and the mites moved down the pin on to the rose leaflets. The water kept the leaflets furgid and also prevented the mites escape. The numbers of live and dead mites on each rose leaflet were then determined at intervals of say 1, 3 and 5 days.

One of the advantages of the method claimed by the authors is that it allowed the spray residues to be exposed outdoors so that they were subjected to natural weathering influences.

FIELD EVALUATION

Method Utilized for Evaluation on Whole Trees. The various procedures adapted usually vary only in detail. Basically a minimum of 3 mite infested apple trees are usually used per treatment Oatman (1959), Chapman *et al.* (1962). These are often randomized throughout the trial area. Each test miticide is applied to run off by high volume methods using a hand gun at 250 – 400 psi depending on tree size and density of foliage. Methods of sampling and recording vary. A method used by this author involves observation with a 10x or 20x lens of a random sample of leaves from each treatment to assess the general pattern of kill at say 24 hours and 4 – 7 days after spraying.

12 – 14 days after spraying a total of 100 leaves are collected at random from each treatment and immediately scanned with a 20x binocular microscope and the number of live mites recorded per leaf on the following scale described by Slade (1966).

1 = No. live mites	4 = 6 – 8 live mites
2 = 1 – 2 live mites	5 = over 8 live mites
3 = 3 – 5 live mites	

From these figures for each 100 leaf sample, a mite index figure of from 1 to 5 is obtained for each miticide under test. Comparison of these mite index figures gives a useful guide to the relative effectiveness of the miticides under test.

This method has been used by this author on a number of occasions. It yields useful information which can often be related to the likely performance of a miticide under conditions of commercial orchard application. However, there are a number of disadvantages associated with the method. These are:

a. The availability of sufficient apple trees which are heavily and evenly infested with european mite.
b. The need to avoid spraying the test trees before and for the duration of the trial with any fungicides or insecticides which may have any miticide effect.
c. The quantity of fruit which may have to be destroyed where the test miticide has no set residue tolerance or waiting period to harvest.
d. Dependence on fine calm weather conditions throughout the spray application period which may involve a large number of separate treatments.
e. Time and labour involved in spraying, sampling and recording this type of trial.

Method Utilised for Portion of a Tree. Forsythe (1966) described a method whereby four replications of three miticides plus a control require only four mite infested apple trees instead of the twelve or sixteen which would be required in the method described under 2.2.1. The layout he described was basically a 4 x 4 latin square. The sources of variation being treatments, trees, and compass directions. Each treatment was applied to each of our apple trees from a different one of the four major compass directions on each tree. Four large branches 4 – 6 ft from the ground and on the periphery of each tree were tagged the branch facing each major compass direction. Tagged branches and the surrounding foliage were then sprayed to the point of run-off with a 3 gallon hand pump sprayer. Total area treated on each tree with one treatment was about 4 ft square.

Counts of mites were taken before treatment and at various intervals after treatment. Five leaves from vegetative shoots were collected from the centre of each sprayed area at each counting date. Counts of eggs and mobile mite stages were done in the field with a binocular microscope.

The author stated that as well as the reduction in the number of trees involved the time to apply miticide to 4 branches was decreased by ½ to ¾ of the time usually necessary to apply miticide to 4 trees.

LIMITATIONS OF LABORATORY AND FIELD WORK

Some of the major limitations of the methods described under 2.1 and 2.2 have been mentioned.

It became evident that a method was required which would incorporate the convenience of laboratory test with the desirable features, such as exposure to U V light weathering of spray deposits, of field evaluation. Any system that would eliminate the number of ineffective materials for final evaluation in the field through commercial spray equipment, obviously had many advantages. Chapter 3 describes the development of the shadehouse method.

THE DEVELOPMENT OF SHADEHOUSE TEST METHODS

A system of shadehouse testing has been developed to enable rapid evaluation of acaricides for european red mite control. Facilities must be available for producing host plants, mite for the tests, and conducting the tests. The one basic structure has been utilized for these three functions. Detailed recording and counts of mite may be undertaken in a laboratory and a standard system of record sheets has been devised.

SHADEHOUSE REQUIREMENTS AND CONSTRUCTION

Objects and Requirements. The object of the structure is to create within the shadehouse area an environment which resembles as closely as possible the type of micro-climate to be found among the sheltered inner branches of an apple tree during the summer months. This environment favours the build up and active feeding of a european mite population. The control achieved from miticides applied to mite populations established on test apple leaves held under these conditions will then resemble closely the control which can be expected in a commercial orchard.

To allow for the effective breeding, maintenance and isolation of european mite populations the shadehouse structure should incorporate the following features.

a. Shelter from strong winds.

b. Sufficient shading and air movement to prevent shade temperatures rising above approximately 29°C.

c. In the Southern hemisphere a North or North East open aspect to ensure sunlight on each part of the shadehouse area for part of the day.

d. No permanent overhead roofing so that mite populations are subjected to outdoor conditions of rainfall, sunlight, temperature and humidity.

e. Adequate drainage throughout the area for rapid disposal of storm water.

f. A fence or wall enclosing the shadehouse structure to prevent access by unauthorized persons.

Construction of Shadehouse used in these Studies. In constructing the shadehouse test area developed by the author in Hastings, Hawke's Bay a disused truck loading bay of a small warehouse was utilized.

The existing loading bay had brick or concrete walls on 3 sides with the open end facing N.E. This gave efficient shelter from the prevailing westerly and cold southerly winds which occur on occasions over the spring period in particular.

The floor area of the actual truck bay is concreted and sloped slightly to allow water drainage away from the area.

Suitable Alternative Construction. As a suitable area utilizing existing walls of buildings as described above would seldom be available, an alternative structure to protect the area from wind is suggested. This could consist of 3 walls 9 ft high of concrete blocks, bricks or some other permanent weather proof material.

THE HOST PLANT

Selection of a Suitable Host Plant

The plant host range for the european red mite being much more limited than that of the two-spotted mite, and because european red mite infestation of apple trees presents perhaps the greatest problem, it is desirable to use apple wood and foliage for test purposes. Vegetatively raised Malling 9 dwarf rootstocks were chosen for this purpose after seeing them in use in 1969 in glasshouse miticide screening work conducted by Dr Emmel, entomologist, with Hoechs A. G. at Frankfurt, West Germany.

Growth and Maintenance of the Host Plant. The unbudded Malling 9 rootstocks are potted one to each 6 inch plastic pot. The pot used has a wide base and therefore large soil capacity of approx. 1200 cc together with good stability when placed on a rotating turntable for spray application. The potting mix used is now standardized as a 50/50 peat and perlite mixture. A granular NPK fertilizer such as 'Floranid Nitrophoska' is either incorporated in the mix at the time of potting or placed on the soil surface of the pot shortly before bud burst. Approximately 5 grams applied per pot is normally sufficient for one complete season's growth. The growth from each potted stock is confined to a single near vertical shoot, other shoots being removed as they appear. This single shoot is eventually headed back at a height of 15 inches above soil level to hold it at the maximum convenient size for spray application. To keep the shoot growing vertically and to hold it vertical during spray application a thin steel stake is used as a support when required. Typically a plant headed at 15 inches carries 18 to 20 leaves on this single stem. Watering of the soil surface of the four pots held in each bin is by plastic tubing and 'jet wet' plastic probes supplied by R. E. Harrison & Co. Ltd. of Palmerston North. Each bank of ten bins can be watered in about two minutes by turning on a single tap. This is done perhaps once every three or four days in cool weather and every one or two days during the heat of summer. Because of the aluminium mesh floor fitted to each bin, surplus water drains from the pot on to the sloped concrete floor below the bins. This avoids waterlogged soil and plant roots.

Galvanized trays with 2 inch sides and filled with water are used to maintain the 300 – 400 extra plants held in pots on the floor area between the two rows of bins. Each tray has a drain hole and cork on one side so that trays can be left with drain holes open in case of prolonged wet weather which could otherwise lead to waterlogging of these pots.

These extra pots are shaded in summer with 'Kuralon' mesh 100 grade stretched over a portable pipe frame placed over this area. The height of the frame is approximately 4 ft above the floor.

When tests on the pots held in the bins are completed, the pots are removed from the bins and each plant is cut back to 1 – 2 inches above soil level and all leaves and the cut stem are removed and burnt. These cut back plants are then held in their pots in the galvanized trays on the floor area until they are repotted again the next winter for further use in the following year's test programme.

To date the same plants have been used successfully for two consecutive seasons and there would seem to be no reason why they cannot be used in this way for a number of years. The root development made by these Malling 9 stocks in pots during one season is very good.

A weekly spray programme is maintained on all pots in the trays but only where necessary on those pots under test in the bins. Wettable sulphur 80 WP at 4 grams/5 litres of water or EL-273 (triarimol) 4 WP at 4 grams/5 litres of water is used to suppress powdery mildew, the main fungous problem encountered. Carbaryl 80 WP at 4 grams/5 litres of water is included to control various caterpillars and also any mite predators which can otherwise interfere with the european mite populations. The predators present are usually *Stethorus bifidus* and occasionally *Typhlodromus pyri*. The spray chemicals used in these weekly applications do not interfere with the development of the european red mite populations on the test plants.

MITE

Collecting Test Populations. During June or July when pruning is in progress in commercial orchards in the Hastings area, a source of winter eggs of european red mite is decided upon. The eggs are obtained when possible from an orchard where the miticides used over the past several years are known. This gives a guide as to the likely mite resistance situation of the strain collected.

Early peaches are often a good source of winter eggs as growers seldom trouble to eradicate mite populations from early varieties once harvesting is finished.

Storage of Test Populations. Once an orchard carrying a suitable winter egg population is decided upon, prunings showing obvious european red mite winter egg infestation are collected. The infested portions are cut into short lengths of about 1 inch. Approximately 500 of these 1 inch infested twigs are placed in paper bags and stored in the bottom vegetable drawer of a domestic refrigerator. The temperature being approximately 3°C. The twigs are held in this way until required for infesting test plants throughout the October to December period.

Establishing Test Populations on Host Plants. A single 1 inch twig infested with winter eggs of european mite is attached with a 'Twist-em' wire tie to each potted Malling 9 stock to be infested. The twig is attached as that part of it is in contact with one or more of the lower leaves on the developing stem. The first batch of test plants each season is infested in this way when the plant stem of at least 8 inches in height and carrying from 8 to 10 leaves. For infestation of subsequent batches the plants have by then attained their full height of around 15 inches. Plate 1 illustrates the method of infestation

Until the end of December plants were infested from refrigerated stored infested material, whereas for the remainder of the season, January and February, infestation was achieved by attaching leaves carrying all stages of european mite to the test plant. Due to natural decline of the european red mite, testing after the middle of February is impractical.

The mite population is allowed to build up to at least 10 motile mites on each one of five leaves reasonably spaced up the stem of each plant. The five leaves are marked and then observed and recorded at various times throughout the test. As four single pot replicates are held in a block, this allows a total of 20 marked leaves per treatment for recording purposes.

THE TEST METHOD DEVELOPED

Design of Experiments. Two methods are suggested for use with the greenhouse system.

Method: Is used by the author and described in this thesis. It relies upon spraying and recording all for replicates of each treatment consecutively. The four single potted plants (replicates) used for each miticide treatment are placed in the same shadehouse bin throughout the test period. All four replicates of each treatment are therefore sprayed and recorded consecutively. To provide the information required by the author this method is considered to be of sufficient accuracy and to be less time consuming and less liable to errors in spray application or recording than method 2 described below.

Method 2: If greater accuracy is necessary than is possible by using Method 1 the following procedure is suggested. One pot only from each treatment is placed in each bin. Different replicates are therefore held in different bins but each bin must contain each treatment in the trial. When recording the treatments randomized within the bin should be removed and counted without knowledge of the treatment. This type of standard design eliminates any bias introduced by position effects. variation of materials and human error.

The normal rates of miticides lbs or pints/100 gals water/acre are calculated down to grams or millilitres /2.5 litres of water. This quantity of water was chosen as a means of ensuring accuracy of the spray mix. Only 150 ml of water was required to spray 4 single pots.

Spray application is carried out in an adjacent shed. This is necessary to avoid spray contamination with adjacent treatments. It also permits spraying regardless of the weather conditions. Accuracy is ensured by placing each plant singley on a turntable and setting the jet upwards at a 45° angle.

Counts are taken before spray application and afterwards at 24 hours – 5 days, 14 days. A sterioscopic microscope is used to aid accurate counting (Plate 2).

SHADE HOUSE–MITICIDE REPORT

PRODUCT: *UKLEEN*

FORMULATION: *EC*

TRIAL REF: *293/6*

BIN NO.: *E*

POT NOS.: *1-14*

CROP: *Malling 9*

'5 LEAF' DATA REQUIRED	LEAF NO.	REPLICATE 1	2	3	4	REMARKS A = adults N = nymphs L = larvae E = eggs
1. Mobile mites per leaf–before spraying	1	*20+*	*20+*	*20+*	*20+*	*All Summer*
Date. *17.1.72*	2	*20+*	*20+*	*20+*	*20+*	*stages present.*
Record as: 5+, 10+, 20+ mites per leaf	3	*20+*	*20+*	*20+*	*20+*	
	4	*20+*	*20+*	*20+*	*20+*	
	5	*20+*	*20+*	*20+*	*20+*	
2. 1st spray application date: *17.1.72*						
Product rate. *5.7 ml/625 ml water*						
3. 24 Hour–Control of mobile mites	1	+	+	+	+	*Occasional live*
Date *18.1.72*	2	+	+	+	?	*mite still*
Record as: + (near 100% control)	3	+	?	+	+	*active*
? (some control)	4	+	+	+	+	
- (no apparent control)	5	+	+	+	+	
4. 4 day–control of mobile mites	1	+	+	+	+	*Near complete*
Date: *21.1.72*	2	+	+	+	+	*control*
Record as: + (near 100% control)	3	+	+	+	+	
? (some control)	4	+	+	+	+	
- (no apparent control)	5	+	+	+	+	
5. 12–14 day–live mite count						*No apparent*
Date: *31.1.72*						*control now*
Record as: 1. (Nil mites per leaf)	1	*5*	*5*	*5*	*5*	
2. (1-2 mites per leaf)	2	*5*	*5*	*5*	*5*	
3. (3-5 mites per leaf)	3	*5*	*5*	*5*	*5*	
4. (6-8 mites per leaf)	4	*5*	*5*	*5*	*5*	
5. (over 8 mites per leaf)	5	*5*	*5*	*5*	*5*	

Mite Index

Summary. *The 24 hour and 4 day checks indicate good initial control of mobile mite stages. This is followed by a rapid build up in live mite numbers by the 14 day count. This result indicates poor control of the mite summer egg stage and the need for a second spray application 7-10 days after the first if lasting mite control is to be achieved.*

RESULTS

Interpretation

Mite Index The mite index figure arrived at 12 to 14 days after spray application needs to be considered in conjunction with the observations recorded 24 hours and five days after spraying.

A mite index below 1.5 indicates that the miticide at the dosage rate used definitely warrants further evaluation and development.

A mite index below 2.0 indicates further evaluation perhaps at slightly higher dosage rates is certainly warranted.

A mite index between 2.0 and the maximum of 5.0 can indicate one of two things:–

a. If the observations at 24 hours and 5 days indicate poor control at both these intervals then no further evaluation is warranted at the dosage rate used. Further tests at perhaps 2 and 4 times the original dosage rate are desirable before dropping the miticide from the test programme.

b. If observation at either 24 hours only or at both 24 hours and five days indicates good control but the mite index at 12-14 days is between 2.0 and 5.0 then this indicates a miticide with good initial control of motile stages but of short persistence. No effect on eggs is demonstrated. This characteristic can be useful where a mite infestation must be controlled close to the time of harvest without leaving unacceptable spray residues in the crop. Further tests to confirm this characteristic at varying dosage rates would therefore be warranted. If necessary in this situation the detailed count can be carried out at 24 hours or five days from spraying instead of at the 12-14 day interval normally used, and the effect of a second spray to control mite hatching from eggs can be investigated.

Examples of Shadehouse Test Results: To illustrate the types of result obtained in shadehouse tests the following report gives an example of an actual completed report sheet together with an interpretation of each test result.

CONCLUSIONS

Results obtained from approximately 125 separate tests carried out between 1970 and 1972 in the shadehouse suggest that the shadehouse method described in this thesis offers a reliable means of assessing the probable field performance of mite control chemicals. Subsequent field tests and observation of use by commercial growers has confirmed the pattern of mite control recorded in shadehouse miticide reports including those for Neoron, Shell Universal Oil and Kelthane AP. The acaricides Bts 27419 and Kelthane 35 have still to be field tested to check the shadehouse test performance reported in this thesis.

Up to 20 separate tests can be conducted at the same time under very similar conditions using this shadehouse method.

The method overcomes the major problem of locating sufficient numbers of naturally mite infested apple trees in an orchard situation suited to test work.

Provided potted test trees are kept under cover for a period before and after sprays are applied, treatments can be carried out using the shadehouse method when weather conditions make outdoor orchard test work impossible.

The shadehouse method can be adapted to investigate other aspects of mite control such as the effect of rainfall, natural or simulated, at varying periods after sprays are applied and testing mite population for resistance to particular miticides.

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Prospects for Intensive Vegetable Production in New Zealand

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WE are blessed in New Zealand with an equable climate which enables us to grow a wide range of of vegetables over a comparatively long season. Because of New Zealand's increasing population, and a steadily increasing export potential for vegetables there is likely to be pressure on land not only for urban development and recreational requirements, but also for the expansion of other horticultural and agricultural enterprises. Suitable land for vegetable production is not unlimited, and the purpose of this paper is to demonstrate ways in which consumable yields of vegetables can be increased on an area basis, with the result that pressure on land would be reduced, and land presently used for vegetables might become available for alternative enterprises.

Some 20,000 hectares of New Zealand is devoted to the commercial production of vegetables, and if potatoes are included the area is increased by a further 9,000 hectares. Of these 20,000 hectares about two-thirds is used for growing vegetables for processing, particularly peas (9,000 hectares) and about 1,000 hectares each of Asparagus, Green Beans, Sweet Corn, and Tomatoes.

The most important market vegetables (on an area basis) are the Brassicas, particularly Cabbages and Cauliflowers each with 1,500 hectares, and Carrots, Onions and Lettuce each with 1,000 hectares. The annual at the farm gate value of the vegetable industry has been estimated at $30 million (which makes it the most valuable sector in horticulture), with the most valuable vegetable being the glasshouse tomato. ($6 million).

In the main, market vegetables are produced only for local consumption, although there is an increasing export of Onions, and small quantities of fresh Asparagus, and other vegetables are also exported. It is, however, mainly process vegetables which earn overseas exchange, in particular peas (both frozen and dried), Green Beans (frozen and dried), Asparagus (canned), and Sweet Corn (both frozen and canned).

In process vegetable production high yields would appear to be within our grasp, as it is now well documented that yields per hectare of quality raw products can be considerably increased (perhaps by a factor of x 3 or more) by using higher plant densities, closer spaced rows, more efficient use of fertilizers and irrigation, better crop protection from weeds, pests, and diseases, and better programming of crop maturity, in order to improve the efficiency of mechanical harvesting.

For market vegetables the opportunities to increase efficiency may not be so good as for process crops, because of the uncertainity which exists at present on the return with the existing marketing system. Warburton (1973) has recently stated that 'Growers should be price makers, not price takers', but this is perhaps too idealistic.

Considerable efficiencies in production might be obtained by growing only what is required, using a system of contract growing, with short term storage to even out the inevitable gluts and shortages due to the weather. Such a method would have a number of attractions, one major one being that the grower would then have the opportunity to decide whether or not to grow a crop based on a negotiated contract price, before the crop is sown, compared with the present system where the price is not known until it is sold at auction. An alternative might be to develop some form of market intelligence, in which information on production areas, and intentions to plant are regularly published.

Clearly however there is a need for some improvement in the present system, if only to remove some of the producers price variations. Under a regulated system, the majority of production techniques mentioned for process crops, could then find a place in market vegetable production.

Plant spacing is one of the keys to increased productivity. Plant spacing comprises two distinct factors, *plant density;* the number of plants per unit area, and *plant arrangement* the spatial distribution of these plants. It has been shown by many research workers (e.g. Bleasdale, 1963) that as the plant density is increased, so the yield per plant will fall, but because of the increasing number of plants, the yield/unit area will probably increase. There are two basic yield-density relationships:

(i) An asymptotic one (Fig. 1) in which with increasing density, yield rises to a maximum and then remains constant at higher densities.

(ii) A parabolic one (Fig. 2) in which with increasing density, yield rises to a maximum, and then declines at higher densities.

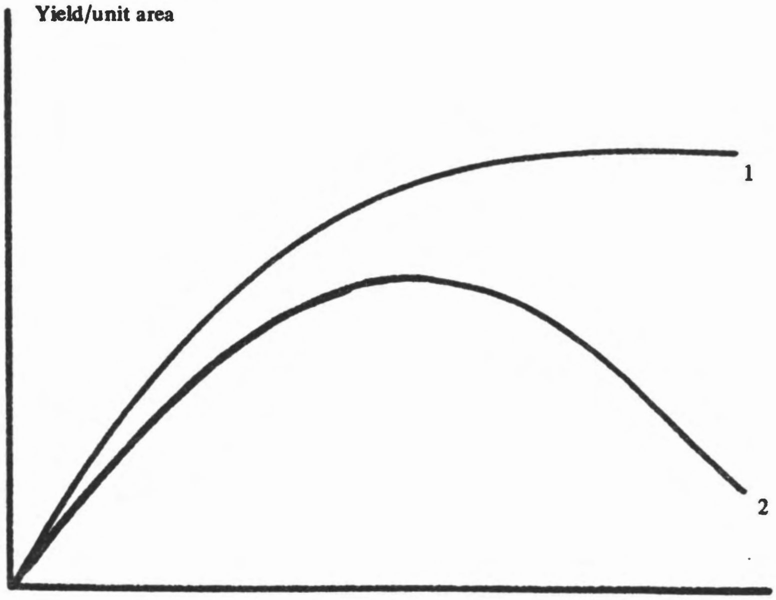
It has been found that for most crops total plant yield tends to follow on asymptotic relationship, and this has also proved the case when considering the effect of density on the biological yield of some plant parts, e.g. potato tubers (Saunt, 1960), carrot roots (Bleasdale 1969). It appears, however, that many of the biologically important plant parts which interest us, e.g. Sweet Corn cobs (Nichols, 1974), Tomato fruit (Nichols, Nonnecke, and Phatak, 1973), Beetroot (Frappell, 1968), etc. show a parabolic yield-density relationship. and as Bleasdale and Thompson (1966) have shown that a parabolic relationship exists when we consider some form of size grading (even when the biological yield-density relationship is asymptotic) it is clear that it is the parabolic yield-density relationship which must have our attention when we consider agronomic yield.

Changes in plant density can affect the maturity characteristics of a crop and this is an area which should be further exploited. At high densities, dwarf green beans (Jones, 1968) produce a crop with a concentrated maturity highly suitable for mechanical harvesting. This is due to the failure of lateral growth to develop because of competition. Similar effects have been found to occur with tomatoes, and with peas. Increased plant density may also affect the time of maturity, for example it delays the maturity of cabbages, but makes onions mature earlier.

The reason why the yield per plant falls with increasing plant density is due to competition, mainly for light, soil moisture, and soil nutrients. There is little that can be done regarding competition for light, but both soil moisture, and soil nutrients can be supplemented by either irrigation or fertilizers.

Lang et al (1956) has shown for grain yield of maize that where there is competition for a limiting soil nutrient (Nitrogen) that supplying this factor not only increased yield at all densities, but the greater the application rate of Nitrogen, the greater the density at which the maximum yield was achieved. (Fig. 2). Salter (1961) has shown similar responses for marketable yield of cauliflowers, when comparing irrigation with no irrigation.

Further ways of increasing yield could involve improvements in the crop canopy structure by breeding



Plant Density

Fig. 1 An asymptotic ((1)), and a parabolic ((2)) yield density relationship.

to make the uppermost leaves more upright, so that light is able to penetrate deeper into the canopy. This has been with Corn (Maize), but not, as yet, with any vegetable crop. Increasing the proportion of the economically important part of the plant might also increase yield.

Plant arrangement may also exert a considerable influence on yield and quality. An uneven plant distribution may not have much effect on total crop yield, but because uneven plant spacing will lead to uneven competition, and therefore a wider range in the size of individual plants it may be a major factor in determining marketable yield. Bleasdale (1963) has shown with carrots that with a constant plant density, by reducing the between the row spacing from 89 cm to 13 cm resulted in an increased yield from 55-105 tonnes/ha.

Table I Effect of between the row spacing on yield of carrots at a constant plant density (110 plant/m^2). After Bleasdale 1963).

Between the row spacing (cm)	Yield (t/ha)
89	55.0
63	62.5
51	70.0
38	75.0
25	87.5
13	105.0

One reason why reducing the between the row spacing tends to equalise the space available per plant is because seed drills (even precision drills) are only able to space seeds in the row at a certain accuracy, and any inaccuracies will tend to be magnified at wide row spacings.

Table II Effect of reducing the between the row spacing on area per plant.

Distance between the row (cm)	Distance in the row (cm)	Area per plant (cm^2) (Drill accuracy + ¼ cm)
16	1	12-20
8	2	14-18
4	4	15-17

Needless to say, reducing the between the row spacing can pose problems in weed control, and it is essential that if the between the row spacing is reduced so that mechanical cultivation is no longer possible, then an efficient, and reliable herbicide must be available.

In many crops we are restricted to relatively wide between the row spacings due to the design of the machine used for mechanical harvesting (e.g. Sweet Corn, Dwarf Green Beans), but if an advantage could be shown for a particular crop in reducing the row widths, then no doubt the machine could be modified, as has been the case with Dwarf Beans, where a Dutch machine has been developed which will harvest in any direction (i.e. even across rows).

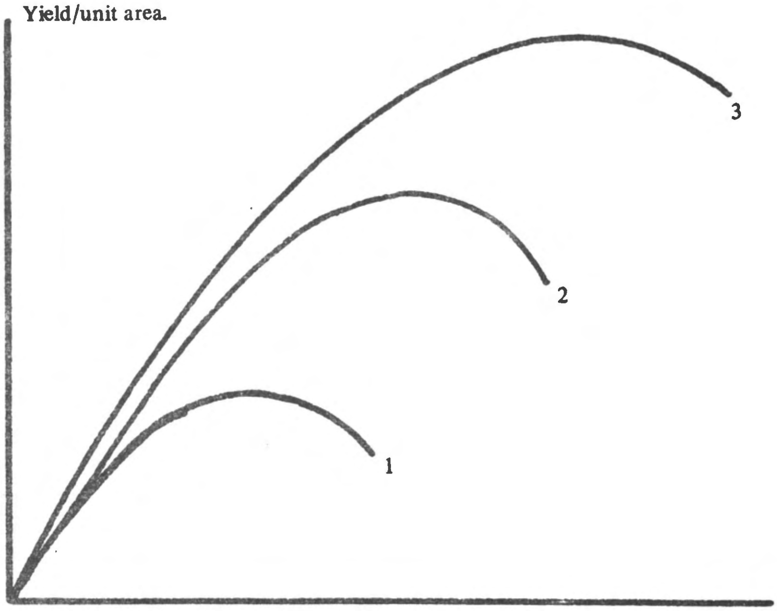


Fig. 2. The effect of increased fertilizer (1, 2, 3) (or water) on the parabolic yield density relationship.

Table III Effect of irrigation on yield of peas in mid-Canterbury in two seasons (from Stoker, 1973).

	1970	1971
No irrigation	3910	2400
3 irrigations	10870	7830

Thus it is clear that considerable increases in marketable yield are possible, using only existing knowledge and technology, i.e. increasing plant density, narrower rows, more efficient use of fertilizers and irrigation.

A good example of this might be with peas for processing, where because of soil borne disease problems it is considered necessary to have a 3-4 year rotation between pea crops. Thus, a 5,000 hectare per annum pea area really requires 15-20,000 hectare of land availability.

It is well documented that just irrigation alone can lead to considerable increase in the yield of peas (Table III) in New Zealand, and when this is combined with the use of higher plant densities, narrower rows, higher fertilizer rates, precision drilling, and improved varieties, it is clear that the national average of 3000 kg/ha of peas could be increased by a factor of x 3 or x 4, as well as producing a higher quality more even row product.

Many of the constraints to this approach, i.e. the slow speed of precision drills, and the high capital and labour cost of irrigation are disappearing, the first with the development of the 'Stanhay' Jumbo precision drill which will sow at 6 mph, and the possible introduction into New Zealand of central pivot irrigation plants, which will irrigate up to 100 hectares over 24 hours, with minimum labour content.

Weed control in peas is normally by post emergence application of a hormone and a dessicant herbicide (usually DNBP and MCPA). More efficient pre-emergence materials have been developed, but on account of costs have yet to gain favour. The prospect of higher yields opens the door to the use of these new materials because cost per unit area is the same irrespective of yield, but if yields can be doubled then the cost of the herbicide per unit of raw product would be halved. With better weed control yields might be still further increased.

With intensive production, pest and disease control, so long restricted to the skills of the plant breeder because of the low (per hectare) value of the crop, will become feasible by means of therapeutants.

The return in terms of fertilizer applied may also be increased with intensive production.

Yields might be further increased by research on crop nutrition, as fertilizer programmes can at best be considered as no better than hit or miss. We still have little information on the total nutritional requirements of many of our vegetables, without even considering the question of nutritional requirements with respect to specific stages of crop development.

Table IV Effect of application of serpentine superphosphate on yield of bulb onions at 4 plant densities. (After Nichols, 1967).

Density (Plants/m^2)	Yield without fertilizer (t/ha)	Yield with fertilizer (t/ha)	Difference (t/ha)
172	65.1	85.7	20.6
97	55.4	67.4	12.0
62	46.5	52.8	6.3
43	38.8	41.8	3.0

Miniturisation has not been restricted solely to the electronics industry, as in the vegetable industry considerable interest has been shown in mini carrots, mini cauliflowers, and mini cabbages. Mini carrots have been developed, because of a demand for whole frozen carrots, which because of limitations in freezing, must not exceed a certain root diameter. Mini cauliflowers have been developed to provide a single cauliflower as on individual plate portion, whilst mini cabbage, have been introduced because of the need to provide the consumer with a family size cabbage rather than a cabbage suitable to feed an army. All these techniques should help to reduce waste, but perhaps the key will be the provision of adequate refrigerated and controlled atmosphere storage, combined with satisfactory programming of sowing and planting to ensure a regulated supply of vegetables both to the processors and the fresh market. Work carried out by Salter (1972) at Wellesbourne with Cauliflower has shown that it is possible to ensure a regular supply by using a combination of varieties and sowing dates.

Mechanical harvesting, irrespective of whether the vegetable industry becomes more intensive, is likely to become the norm for most vegetable crops. The main requirement, will be to concentrate maturity, in which, ideally, all the crop matures on the same day. This will put further emphasis on seed grading, seed germination characteristics, and the even growing of crops. In this respect the cold treatment of Cauliflower seedlings, just prior to transplanting, demonstrates that with some 'difficult' crops, maturity characteristics can be adjusted culturally, (Salter and Ward, 1972).

Table V Effect of storing selected cauliflower seedlings of two plant ages at 2°C for 2 weeks on the length of the harvest period (days). After Salter and Ward, 1972).

Variety	Plant age (weeks)	Untreated	Treated
Le Cerf 'B'	6	24	7
	8	23	17
South Pacific	6	16	18
	8	26	7
Hylite	6	30	14
	8	25	24

although the timing of the treatment may be critical, e.g. in this example for best effect, Le Cerf 'B', and Hylite required treatment at 6 weeks, and South Pacific when the seedlings were 8 weeks old.

In conclusion it is hoped that this paper will stimulate some interest in the intensification of vegetable production, rather than the present system of increasing the area being grown when an increase in crop is required.

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A Viewpoint

Horticulture in Greenhouses: Spearhead of an Industrial Revolution in Horticulture

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Ministry of Agriculture and Fisheries
Levin Horticultural Research Centre

Horticultural crop production is now thriving in greenhouses of glass and rigid and film plastics in climates varying from sub-arctic to hot deserts. The ability of horticulturalists to produce economic crops in such widely differing and frequently hostile climates is a good measure of their current ability to control greenhouse environments to suit crop requirements. This implies two distinct things, one, a detailed understanding of the environmental requirements of the crops being grown and, two, the ability to produce this optimum environment. The former has resulted from a great deal of research in plant physiology and more particularly in recent years to the integration of the many different aspects of plant physiology (i.e. photosynthesis, assimilation, translocation, water relationships, growth control and respiration etc) into horticultural and agronomic research. The ability to control environment has resulted from the application of developments in engineering to horticulture. In New Zealand we do not suffer from a particularly hostile climate but we can still profit from this ability to control greenhouse environments. If growers can control the major factors of the greenhouse environment, and have the necessary knowledge of the physiology of their crops to optimise each of the controlled factors for maximum production, then they are manufacturing a product in a similar way, from a business point of view, to any other manufacturer. The industrial revolution resulted from a dramatic improvement in manufacturing. There has been an equally dramatic improvement in our ability to produce greenhouse crops. I believe that we stand today on the threshold of a revolution in horticulture, which will be just as important for horticulture as the industrial revolution was for manufacturing. This revolution has already started and like the industrial revolution, has important technical economic and social implications which are reviewed in this paper. Greenhouse crop production has expanded considerably in recent years (see Fig. 1), largely as a result of greater technical ability and if we can meet the challenge of this revolution even greater expansion will be possible.

Characteristics of Manufacturing

The important characteristic of manufacturing industries, which has set them apart from horticulture and agriculture up to now has been their reliability, that is their ability to deliver a stated quantity of a product of a standard quality at a given time. I believe that greenhouse crop production can meet these objectives, if not now, then in the very near future.

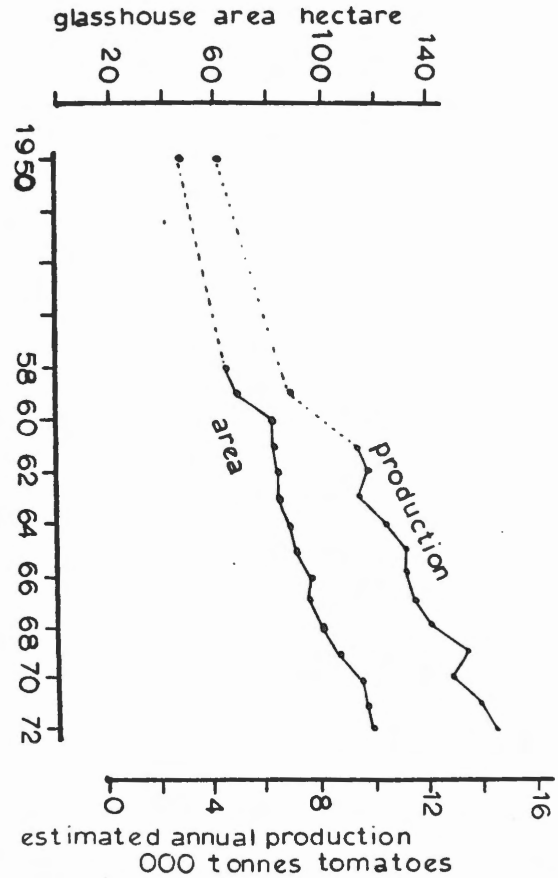
MEETING THESE OBJECTIVES

1. Reliability of Yields

If greenhouse growers have sufficient knowledge of the factors controlling yield in a given crop plant, and the ability to control these factors, then every crop of this plant should produce the maximum yield possible. It is now possible to control temperature, photoperiod, water, nutrient and CO_2 supplies in greenhouses and these are the most important factors controlling yields. Even though our knowledge of the optimum combination of levels of each factor for maximum possible yields is imperfect, given levels of these factors will produce known yields. The amount of light reaching the crop is the major uncontrolled growth factor (see Fig. 2) but since most greenhouse crops integrate effects of light over fairly long periods of time (usually more than three months) I would expect that effects of variations in light supply on yield in otherwise controlled environments would only be of the order of 15%. I believe therefore that we should be able to provide controlled and reliable crop yields at least within ±10%.

2. Controlled Quality

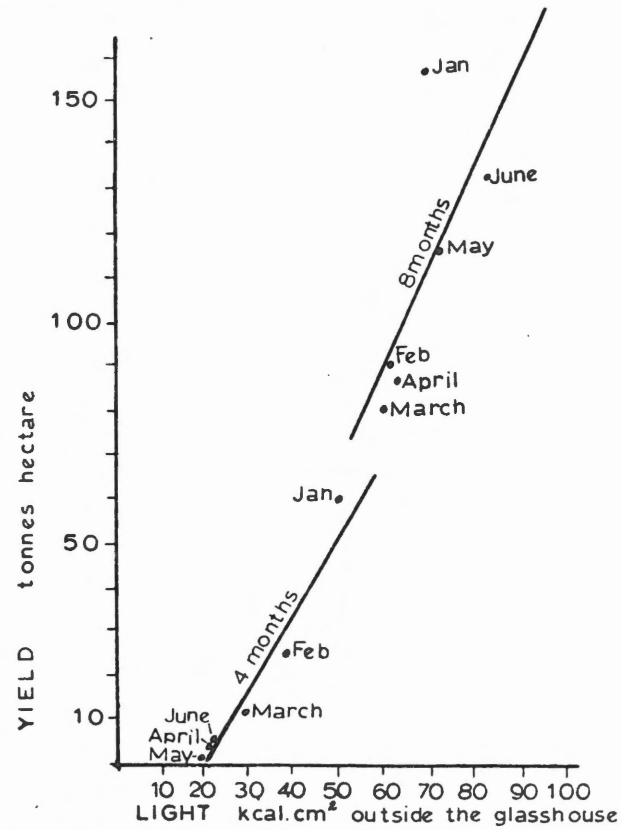
Environmental factors are just as important for quality as for yield. Properly controlled environments can improve both the quality and uniformity of greenhouse produce. There have been other equally important



· **Growth of the N.Z. Glasshouse Industry as illustrated by area of glasshouses growing tomatoes, cucumbers, grapes, and beans. Data for plants for sale and cut flowers in glasshouses is only available for 1967, and the total glasshouse area is probably 20 to 30 hectares larger than shown. Production as measured by the estimates of glasshouse tomato production is increasing even faster than area, (Source: N.Z. Horticulture Statistics, Ministry of Agriculture & Fisheries, 1972).**

developments enabling greenhouse growers to improve quality. For example, varieties of tomatoes free from greenback and less susceptible to blotch, of cucumbers free from bitterness and of lettuce which heart uniformly in short days are now common. The use of growth regulators in controlled environments has enabled short pot chrysanthemums and poinsettias to be produced at any time of the year. The last two crops would be of quite unacceptable quality as pot plants, were it not for this ability to control their height. Quality in living materials can never be as tightly defined as in manufactured products because of variability of individuals, but stock uniformity (of seeds and cuttings, bulbs etc) can be controlled and I am sure we can grade our products to meet the quality standards required by sellers and consumers.

Yields of tomatoes (cv Eurocross BB) sown at monthly intervals and planted in glasshouse (with controls set at 17°C night heat, 19°C day heat with ventilation at 21°C) were closely correlated with the amount of solar radiation recorded outside the glasshouse over the periods of four and eight months from sowing in one Levin experiment.



3. Timing

Industrial manufacturers are not limited by season or time of year and it is worth noting that the most valuable greenhouse crops are those which supply year round markets. Tomato, cucumber, lettuce, rose and carnation crops are harvested continuously over long seasons and plantings can be arranged to ensure continuity of supply and if necessary a steady rate of production. Certain other crops have a single brief harvesting period which may occur naturally only once per season. Detailed knowledge of the physiology of such crops allows the time of harvest to be controlled so that carefully scheduled plantings in controlled environments can achieve continuity of supply or production for specified marketing dates.

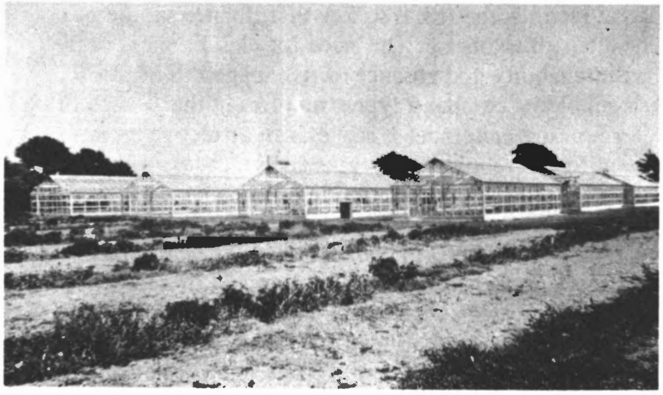
In almost every case environmental control, usually in terms of temperatures of photoperiod or light supply, is the key. Detailed knowledge of the interaction of photoperiod and temperature allows chrysanthemum to be grown as a year-round crop. In a few cases it is possible to trigger flowering with growth regulators. The list of year-round crops must now include antirrhinums, azealeas, begonias, poinsettias and lilies and, in the food crops, capsicums or peppers. In most of these year-round crops it is possible to control harvesting dates with some precision, i.e. in tomatoes in controlled environments to within ± five days, in year-round chrysanthmums to within a week.

4. Control of Risks

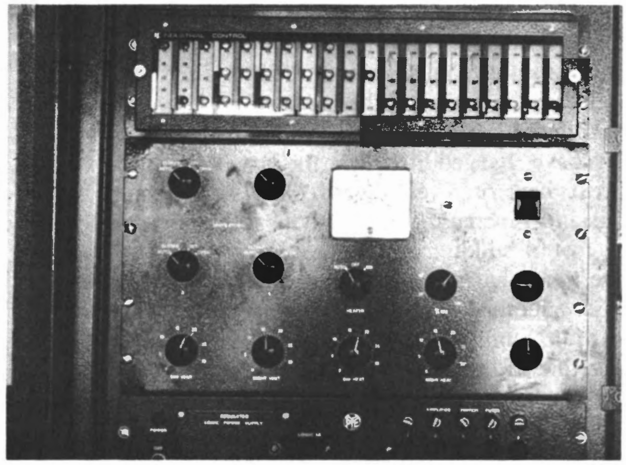
In industrial businesses there is usually little or no risk attached to the manufacturing process; risks lie in marketing. In agriculture and outdoor horticulture there is always the risk of complete crop loss due to unseasonable weather, frost, flood or drought but in the controlled environment of the greenhouse the risk should be limited to the yield reduction caused by variations in light supply or to disease. It is not possible to completely control light economically at present but in areas where winter light is frequently very poor, considerable developments in the use of growth rooms and supplementary lighting are occuring as means of reducing this risk factor.

I believe that the disease risk is now avoidable, due to recent developments. Plant breeders have been most successful in breeding food crop varieties with genetic resistance to disease; the list of known disease resistances in tomatoes (Table 1) is most comprehensive. Breeding for disease resistance in ornamental crops is less important since so many of them are vegetatively reproduced clones but the work of plant pathologists in producing clean stocks of most important clones has been invaluable. It is up to the grower to ensure that he avoids any possible risk by planting only in clean, disease free or sterilised soil or in isolated and clean rooting media and using rigorous post-planting hygiene. The difficulties of ensuring a completely pathogen free and non isolated soil for ground grown glasshouse crops has stimulated work on purely synthetic media such as strawbales and peat modules and both these techniques are now widely used in Europe. New insecticides and fungicides, particularly systemics, are very powerful tools for controlling any disease or pest outbreaks which occur and application techniques are being steadily improved and generally made easier. All the tools to control disease and avoid this risk are available but they do require knowledge and skill to be properly and effectively used but when they are, the risk from disease is extremely low.

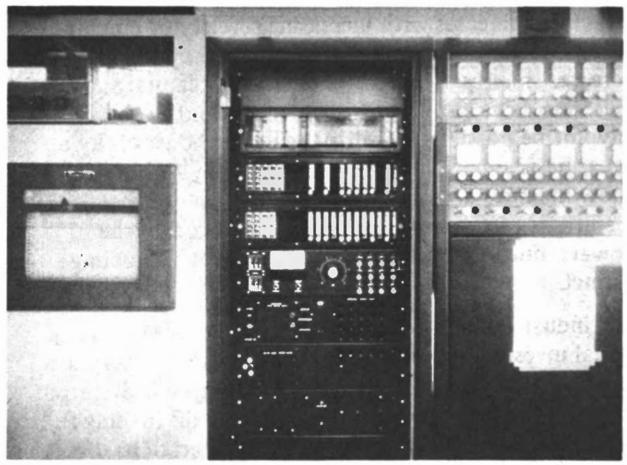
Reliability of equipment and plant used to maintain the controlled greenhouse environments is of course essential but expensive.



12 identical glasshouses used for environmental research at the Levin Horticultural Research Centre.



Temperatures and CO_2 levels in 12 glasshouses are controlled and recorded by this larger unit.



This unit automatically controls temperature (by heating and ventilation) and relative humidity in a single glasshouse.

Table 1: DISEASE RESISTANCE IN TOMATOES

A Commercially acceptable tomato cultivars are available with resistance to:

Leaf Mould, *Cladosporium fulvum (Cke)*
Verticillium wilt, *Verticillium spp*
Fusarium wilt, *Fusarium spp*
Tomato mosaic virus

B Tomato breeding material is available with resistance to:

Bacterial diseases:
Bacterial canker, *Corynebacterium michaganense (E.F.SM)* Jensen
Bacterial wilt, *Pseudomonas solanacearum (E.F.SM) E.F.SM*

Fungus diseases:
Corky Root, *Pyrenochaeta lycopersici (Selineider and Gerlach)*
Didymella, *Didymella lycopersici (Kleb.)*
Early Blight, *Alternaria solani (Ell and G Martin)*
Gray leaf spot, *Stemphyllium solani (Weber)*
Late blight, *Phytopthora infestans (Mont. de Bary)*
Septoria leaf spot, *Septoria lycopersici (Speg.)*

Virus disease:
Tomato spotted wilt virus

Pests:
Root knot eelworm – Meloidogyne spp
Potato root eelworm – Heterodera rostochiensis

IMPLICATIONS OF THE REVOLUTION

1. Marketing

In the past, when production quality and timing were unreliable, growers' marketing was simply a matter of offering the product and accepting the best bid. This contrasts stronglv with the generally orderly marketing of industrial products. Industrial goods can be stored indefinitely which greatly assists marketing. All horticultural products are perishable but considerable progress is being made towards better means of short term storage, using techniques including refrigeration, gas storage and control of ethylene levels in flower stores. Development in cool storage of flower buds, followed by controlled flower opening, is just one of the exciting new developments which must ultimately affect marketing. However, given the reliability of greenhouse production now available, changes in marketing are almost inevitable and possibly it is in the growers' best interest to actively seek a better marketing method.

2. Economics

While it is obvious from the above that technical ability to achieve reliable controlled production of greenhouse crops is available, the big problem is whether or not doing so is profitable. Prices for horticultural products have changed little over the last 20 years but all costs have risen very considerably. In these circumstances increasing productivity is the only answer. The cost of building greenhouses has increased to about three times that of 20 years ago and the cost of greenhouses equipped for control of temperature, water supply, nutrition, humidity, CO_2 and photoperiod is probably twice that of the bare greenhouse.

The grower who uses only unheated greenhouses suffers from severe limitations on his production. Even in the mildest climates, he can only grow a limited range of crops and under these conditions he only has a marginal seasonal advantage over the outdoor grower. This advantage increases with increasing severity of climate but risk of very poor crops or complete crop failures increases sharply. Such growers have low capital and operating costs but are relatively inefficient in that it may not be possible to utilise their greenhouses fully on a year basis and even then yields are likely to be well below maximum possible yields. Furthermore their operations carry such a high degree of risk that the growers must be possessed by a very strong gambling instinct.

The 'industrialised' grower by contrast has a very heavy capital investment and high running costs but a very low risk. He has to be extremely efficient, with a high output per unit of investment, which usually entails making full year round use of his greenhouses. His operations too must be efficient in their use of labour. The situation is not without its challenge, however, and as inflation and rising costs appear to be an endless situation, there has to be a steady improvement in yield and efficiency in order to be able to maintain profits on steady market prices against these rising costs.

In this respect, the willingness of the increasingly affluent public to recognise greenhouse products as a year round commodity, rather than occasional out-of-season luxury, has been a major factor permitting growth in the greenhouse industry.

The low-cost, cold greenhouse grower frequently combines greenhouses with other horticultural operations and is often able to provide the relatively small capital for greenhouse development from his profits as a speculative investment. The costs of 'industrialised' greenhouse production are so high that loan finance in some form is usually necessary. However, in the case of growers with good records, the risk is so low that finance should not be difficult to obtain. This need for high finance coupled with reliability and absence of risk suggests a need for shareholding company type structures in this branch of horticulture and, indeed, suggests an attractive investment for shareholders. There is no evidence, so far, for development in this direction in New Zealand but overseas relatively giant horticultural enterprises, based on greenhouse production, are now appearing. The situation is attractive too for vertical integration and there is some risk of growers losing control to their customers. This risk increases as the marketing of horticulture produce is slowly but surely moving from large numbers of small retail outlets to a very small number of huge retail chains.

The products of cold greenhouses, with their unreliability of quantity, quality and timing of production, can only be sold on the open market system but the 'industrialised' grower can regulate the quantity, quality and timing of his produce to suit the demand. He is therefore in a position to deal (if necessary by contracts) with the big buyers and there is a danger that if these growers insist too rigidly on adhering to the open market the large scale buyers may be forced into greenhouse production themselves in order to secure their supplies.

3. Social Implications

Horticulture is frequently described as a way of life, but so is gambling. Certainly, the thought of working hard in the warmth of an unheated greenhouse crop, which only grows in the winter and spring months, and being able to spend the summer in more leisurely outdoor work or recreation is attractive, if you can afford the risks involved. The 'industrialised' grower has to face a carefully planned, year-round schedule of work but he must accept the fact that he cannot and must not be tied to his crops twenty-four hours a day, seven days a week, even though he formerly managed to do this in the past for the critical four or six months of his cropping period. Automation is essential for environmental control in the modern greenhouse, not only because it can maintain the environment better than most growers but also because it frees his time for more efficient management and leisure, enabling him to lead a similar life to other workers.

It is pointless for the cold house grower to seek perfection, for the most perfectly grown crop can be suddenly ruined by a disastrous heavy late spring frost. The 'industrialised' grower, however, has to be a perfectionist in every detail of the work to ensure the highest possible yield and lowest risk. The future is going to require a great deal more professionalism, education and specialisation amongst greenhouse growers. The grower of the future will have to be fully conversant with the physiology of his crop; he will need to be extremely precise in controlling the environment and in using very potent growth regulators, fungicides and insectides on his crops. He will need near perfection in the control of soil borne and aerial pests and diseases to avoid risking his heavy investments and will need to be a very good business manager. The breadth of experience, education and skills required is such that I think most growers will have to specialise in only one or two crops. The meticulous management of the detail of every crop operation that is necessary is, I feel, the biggest bar to large scale operations in large company type organisations and I think it is the ability of the good small grower to out-produce the larger scale operator which will maintain the traditional family unit structure in greenhouse operations.

This then is the challenge to the younger generation about to enter the greenhouse industry; the technological basis, economic and social factors are all pointing to industrialisation, firstly of greenhouse production and later to the whole of horticulture. Can you make it? The greenhouse industry is the spearhead of this revolution because of its ability to meet the demands of consumers for horticultural products on the same basis of availability, standardised quality, convenience and reasonable cost as other consumer goods. All branches of horticulture will have to meet the same demands in future, or take a secondary role to processed foods, artificial flowers and other alternatives to horticultural produce.

4. Research and Extension Requirements

Sufficient knowledge is already available to 'industrialise' several of the major greenhouse crops and in fact, of course, there are many growers who have already been 'industrialised' without realising the fact, particularly amongst tomato growers and year round chrysanthemum, carnation and rose growers. In these crops the main research aim should be to increase the upper limits of yield. The efficiency and knowledge gap between the best and worst growers, even in these crops, is extremely wide and more intensive use of modern communication methods are required to close the gaps. This effort can only improve the lot of the unwilling gamblers; the inveterate gamblers will continue gambling for as long as they have greenhouses over their heads. However, as production of the 'industrialised' crops increases as a result of industrialisation, so will the economic competition between producers force diversification into new crops. Research has an important function in extending the list of 'industrialisable' year round crops, so that these diversions will be profitable. There will be a particular need in New Zealand to encourage post harvest research in greenhouse crops so that production in New Zealand can be for export as well as home consumption. Exporting in the past has been difficult because of unreliability of production amongst other factors; 'industrialisation' and reliability increase export possibilities.

CONCLUSION

I have been employed on research into greenhouse food crops production over the last twelve years and this paper arises from my need to take stock of the situation and my concern that the present situation is largely unrecognised. It is my hope that this viewpoint may provide food for thought and stimulate argument.

Air Pollution Damage to Plants

by Dr G. T. DALY

The lethal effects of sulphurous atmospheres on plants has been evident for centuries. Heavy metal smelting from sulphur bearing ores released sufficient sulphur dioxide to wipe out vegetation around and for miles downwind of large smelters. For example at Sudbury in Ontario, Canada, many square kilometres of bare, blackened rocks and lifeloss ponds surround one of the World's largest nickel, copper and silver mining and refining smelters. Another area of spectacular plant damage is the Copper Basin in Tennessee. About 3000 hectares of once rich deciduous forest were completely destroyed and another 7000 has replaced by some resistant grasses following destruction of native forest trees. Such destruction was considered the price inevitably paid for progress and wealth. However, in the years following World War II, air pollution and its biological and physical effects began to be noticed more generally in city and industrial regions throughout the World.

By far the most pervasive sources of the air pollution are the petro-chemical fuels—coal, petroleum, dieseline, kerosene, among others. Often assisted by particular weather conditions such as temperature inversions and cold air lakes, toxic pollutants are concentrated in the ambient air which man breathes and plants absorb. To these must be added the hydrocarbons, nitrogen oxides and ozone of vehicle exhausts and a bewildering array of gases and dusts as waste products of metal, chemical and plastics industries and agriculture.

The first review of the damage caused to plants by pollutants in the air was published by Thomas in the 1951 Annual Review of Plant Physiology. His references went back for many years indicating that it was not a new subject even then. Much investigation and many reviews have followed and today there are several periodical journals devoted entirely to pollution research. An appreciation of the extent and complexity of air pollution and its effects on plants, animals, man and materials can be gained from the second volume of Stern's "Air Pollution" published in 1968.

Most of the damage and therefore much of the work on air pollution occurs in North American, Europe, Scandinavia and Japan. However, even in Australia and New Zealand there are significant amounts of air pollutants emitted in cities and industrial works. Detailed attention has been given to the effects of past and present levels of airborne pollutants on property and people but little has been written on the diagnosis of plant injury from specific aerosols. The aim of this article then, is to describe the effects of the most important air pollutants on plants. Overseas examples will be given for the most part but these will be related to the situation in this country. In particular, it is hoped to show that plant injury by air pollution can be recognised and evaluated in the presence of effects from insect, fungal, bacterial, viral pathogens and the symptoms of nutrient and evironmental stress.

All plants are more or less affected by toxic gases and metals such as lead absorbed from the air. Many observations have established that for each plant and each pollutant there is a critical concentration above which damage occurs, and below which growth is normal. However, recent experiments have established that certain phytotoxic gases such as fluorides and ozone do retard plant growth without visual chlorosis and secrosis.

In order of importance and interest the airborne pollutants include smoke and particulates, sulphur dioxide (SO_2), and acid mists fluorides (HF, S_2F_4), photo oxidant smog (PAN), nitrogen oxides (NO_x), ozone (O_3), lead, Carbon oxides and particulates, chlorides.

1. Smoke and Particulates

Dense smoke reduces light intensity and plant growth may be retarded. Much of the early interest in smoke pollution was due to the almost universal presence of highly reactive SO_2 released at the same time in the combustion of coal and fuel oils. The effects of SO_2 are here treated separately. Nevertheless the accumulation of heavy deposits of smoke and larger particulate emissions can be quite striking. Evergreen species in heavily polluted areas have substantially reduced rates of leaf transpiration. In addition leaves senesce and fall much earlier. Conifer leaves often live for up to eight years and by photosynthesis contribute to growth for all that time. With moderate pollution deposits the leaves may fall annually causing ill thrift and final death. Deciduous trees which lose their leaves each winter are often less susceptible to injury for these leaves can perform their photosynthetic and transpiration functions before being put out of action. In northern temperate cities, parks staff are well aware that pines, spruces and firs are less likely to succeed than larch, oak and maples. In New Zealand significant amounts of smoke and particulate pollution occur in Christchurch, Dunedin and close to some industries such as cement works and iron and steel works. The most voluminous air-borne materials in this country have always been the naturally-occuring nor-west wind-blown silts called loess, sea breeze salts, sulphurous geothermal gases and volcanic ash. All these materials dominate soil and plant nutrition over much of our landscape.

2. Sulphur Dioxide

Atmospheric pollution by SO_2 is tending to become worse even where strict smoke control is operating. The air in European cities commonly contains 0.1 parts per million that in rural areas 0.01 ppm. Under particular weather conditions contents as high as 1.0 ppm may occur in localized areas even several kilometers from point sources. Experimental fumigations and many observations have shown that most flowering plants are undamaged by 0.1 ppm SO_2 even for long exposures. High concentrations do cause damage, however, and leaf blotching causes economic losses in yield. Though large scale crop losses are clearly due to SO_2, moderate concentrations can be beneficial in at least three ways. Firstly, this is the absence from industrial regions of several fungal pathogens such as rose mildew. In a similar vein the normal luxuriant moss and lichen cover on buildings is severely reduced in the city. Finally, sulphur–an essential nutrient for plants–is often in short supply in areas remote from the sea. Consequently, the sulphurous fall-out in and around sources of air pollution may even stimulate the growth of crop plants, especially if ambient concentrations are not often high enough to cause damaging fumigations.

More has been written on responses by plants to SO_2 than for any other air pollutant. Even with emission control apparatus operating on smelters, power stations, boils and fertilizer factories and smokeless housing zones there are often episodes in which sulphur dioxide fumigation causes significant plant damage. As mentioned earlier, certain "leafy" mosses and lichens are killed by average ambient SO_2 levels as low as 0.02 ppm winter average. The most sensitive higher plants include all varieties of pumpkin and squash, the leaves of which will show SO_2 markings before any

There are so many symptoms that develop on leaves of plants which resemble those due to SO_2 that weight of evidence is required in order to correctly diagnose it. Foliar symptoms and other evidence needs to be considered. These include:

(1) The presence of suspected sources of SO_2
(2) Species of plants which develop markings
(3) The type of markings observed
(4) The pattern displayed by the severity of leaf markings and locations of occurrence. For example most severe near suspected source on species known to be sensitive and decreasing with distance from that source. Several species varying in sensitivity and characteristic leaf injury pattern need to be examined in the area where SO_2 injury is supected.

Upon entering leaf mesophyll tissue SO_2 is converted to the sulphite ion which is slowly oxidised to the sulphate ion. Sulphate is then converted to organic forms. Both sulphate and sulphite are toxic to plant cells if present in excess. Accumulation of sulphite produces two types of leaf injury–chronic and acute. If accumulation rate is slow, cells may continue to oxidise all the sulphite and no injury will occur until sufficient sulphate has accumulated to produce a salt effect. This is chronic injury and is seen as general chlorosis or yellowing of leaves. Undersurface silvering may also be present due to collapse of cells immediately beneath the epidermis. While many plants have ivory or white chronic markings, other species having red, brown or purple pigments normally concealed by chlorophyll will display these colours following injury.

Acute injury following absorption of lethal amounts of SO_2 appears as marginal and intercoastal areas of dead tissue which have a dull, water-soaked look. After these dry out bleached ivory, white, brown, orange, red or black colours may be dominant. After a time these areas of dead tissue may drop out giving leaves a ragged appearance. If most of the leaf is damaged it may be shed early. In pinnate and palmate veined plants the necrotic areas are irregularly shaped between side veins and closer to the central or main vascular tissue. Marking in parallel monoctos such as grasses and gladioli occur as necrotic streaks developing from near the tip down toward the base alongside the midrib. In grass leaves which bend, e.g. wheat, oats, barley and maize, the injury will usually begin at the point of bending.

Sulphur dioxide enters the plant through leaf stomata. Consequently, the resistance to injury increases with moisture stress since wilted plants are most likely to have closed stomata. Conversely plants tend to be most sensitive to ambient SO_2 at high humidities above 70%. Young fully-expanded leaves are more likely to be damaged by SO_2 followed by old leaves and those expanding are the last to show injury.

Many markings on leaves bear similarity to those caused by SO_2. Damage can be due to frost, high temperatures, permanent wilting, windburn, saltburn.

3. Fluorides

Since the Second World War losses to agriculture and forests caused through fluoride emissions have greatly increased with industrial expansion. Industries such as aluminium refining, phosphate fertilizer manufacture and ceramics are heavy users of materials high in fluoride. This element is widespread in the earth's crust as a constituent of soil, rocks and minerals such as fluorospar, apatite, cryolite, micas and hornblendes. When heated to high temperatures these substances release fluorides into the atmosphere.

Fluoride injury to vegetation occurs when reactive gases such as hydrofluoric acid and silicon tetrafluoride are absorbed and accumulated by plant leaves over a period of time. Symptom expression is not related strictly to F dosage (which is the product of concentration and time) because of such factors as rain wash and convertion into non-reactive forms within leaf tissue. Severity of leaf marking may therefore be relatively higher in highly concentrated ambient fluorides for short times.

Plant species, varieteies and clones may differ widely in sensitivity to fluoride. For example chinese apricot and gladioli may be marked by F concentrations below 0.1 part per billion. Most other species show no effect from absorbtion of ten times that level.

The most recognisable symptom of toxic fluoride uptake is necrosis at leaf tips and margins. A dull grey-green, water-soaked appearance occurs within 24 hours of fumigation with several parts F per hundred million of air. These affected areas turn to dark brown within two days in hot weather. A narrow, dark reddish-brown band produced by deposition of resins and tannins in the peripheral cells delimits the necrotic zones. The dead tissue frequently separates and drops out in windy conditions.

In pines and other conifers tip burn due to fluoride is most common, particularly in young and growing needles. Fluoride-induced necrosis in monoctyledonous plants is often reddish-brown and similar to that in dicots. But cereals such as barley display almost white bleaching of leaf tissue.

4. **Photochemical Oxidants**

These are chemicals produced in sunlight by reactions between the products of internal combustion engines. Included are nitrogen oxides, ozone and peroxyacyl Nitrates (PAN). Maximum concentrations occur in summer and autumn and rise to alarming levels in centres of vehicular traffic. This is the 'Los Angeles Smog' which irritates the eyes and nose, reduced visibility and damages vegetation over thousands of hectares each year.

Young growing plants are the most sensitive to PAN and damage usually consists of a white to bronze flecking —photo-oxidant stipple. Commercial damage is extensive in leafy vegetables. In addition, conifer forests are at risk from PAN and in California many pine forests are suffering drastic decline through the so very reactive aerosols.

In New Zealand measurable quantities of PAN occur near dense traffic in Christchurch, Wellington and Auckland. Only in the latter city is there concern about possible damage to plants from this source.

Fumigation and field evidence from the U.S.A. indicates that species vary in sensitivity to PAN.

5. **Other Air Pollutants**

So much interest has been taken in biological effects of air pollution that many minor compounds have been observed. These include ethylene, chlorine, hydrogen chloride, hydrogen sulphide, mercury and particulates including metals such as lead. Most of these are carried to plants in toxic amounts only when industrial accidents occur. In this country spray drift from aerially applied herbicides would be much more significant in terms of accidental plant damage.

In the case of lead there is clear evidence for substantial accumulation in plants growing near major roads and centres of traffic. Tetraethyl lead discharged in exhaust fumes of motor vehicles is accumulated by roadside vegetation but no significant plant damage is occurring at present despite a tenfold increase in lead content. Should the lead content of leafy plants increase to over 1000 ppm their consumption by man and domestic animals over a prolonged period might be hazardous to health.

Field Surveys and Vegetation Monitoring

Controlled fumigations of a wide variety of plants and field observations have allowed a clear picture to be formed of air pollution damage. However, expertise in the diagnosis of such damage is developed gradually. For instance, the pollutant-caused symptoms can be altered by genetic makeup, stage of plant growth, moisture supply, nutrient levels, for climatic factors. A competent observer must also be able to recognise symptoms induced by nutrient deficiency, temperature and water stress, pathologic disease and insect grazing. Periodic observations are usually made at set sampling stations positioned in order to show patterns of pollution and other damage.

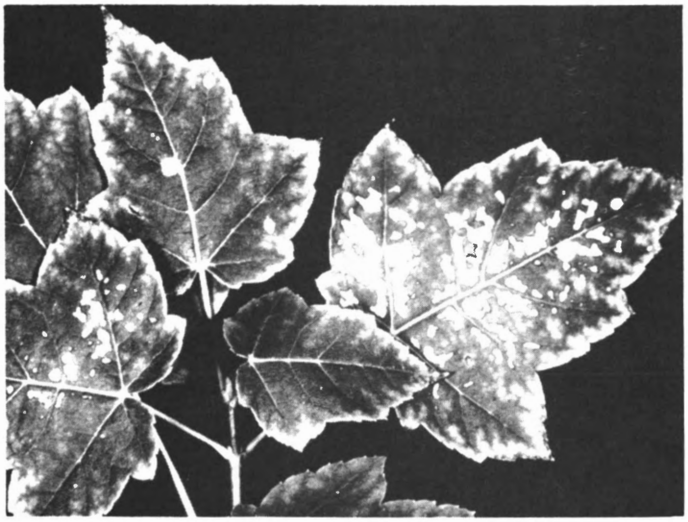
The clearest patterns are those occurring along the prevailing wind bearing from point sources of air pollution, e.g. smelters, thermal power stations, large fertilizer works. Others are exhibited by valley and depression air drainage basins, and in cities where temperature inversions are common. For example, Challenger mapped the severity of air pollution damage to trees throughout the Tees Valley in North Eastern England. He found the severity of damage to conifers and to deciduous hardwood species to be highly correlted with ambient SO_2 levels. These SO_2 and smoke levels were in turn patterned on coal-burning towns and industrial complexes and on topography within the Tees drainage basin.

In severely polluted cities of Europe the lichens and mosses on trees and buildings are small and few in number. Many square kilometers are virtually devoid of these small plants because they are so prone to lethal absorbtion of even small concentrations of SO_2. Maps of the distribution patterns of mosses and lichens have been used to monitor air pollution levels. The patterns are so clearly defined that school pupils are able to map them in field laboratory classes.

The air pollution which has characterised Christchurch winters for a hundred years can also be monitored by lichen and moss distribution. Though the short-term maxima for SO_2 levels may be quite high, the average winter levels are just high enough to kill the most sensitive lichens and mosses. But whatever there is vegetative shelter or abundant moisture or alkaline media these leafy lichens mosses and liverworts still survive.

In local areas of New Zealand industrial emissions of air pollutants are sufficient to warrant restrictions. In most cases emissions are controlled by the individual factories by the best practicable means available. Plant damaging levels of pollutants do still occur through breakdown or faulty operation. Intensified by particular meteorological conditions, such emissions occasionally cause plant injury patterned clearly downwind of the source. Although most common in the U.S.A., severe damage to plants is thankfully rare here. The situation is even more optimistic in this country because of the co-operation possible between Government, local bodies and these industries. Department of Health's chemical inspectorate reports that progress is being made in the reduction and control of air pollution from existing sources.

Environmental issues are fully considered in any industrial expansion and the siting of new industry is now influenced by the likelihood of biological damage from waste emissions. For siting of industry and power stations as well as for their emission control, base-line evaluations are carried out. This involves field ecological surveys and the estimation of extent of plant damage around existing industrial operations in order to know the responses of plant populations to air pollutants.



Maple damaged by sulphur dioxide.

Pollution effect on oak.

Smog injury on Romaine lettuce.

New Zealand Theses presented in 1972 of Interest to Horticulturists

Year Presented Thesis	Name	Diploma	Thesis Title
1972	G. V. Jensen	ND (fruit)	A study of bird damage in a commercial orchard in the Auckland district.
1972	D. J. McKenzie	NDFC	A shadehouse method for testing miticides against motile and summer egg stages of the European red mite *Panonynchus ulmi Koch.*
1972	G. M. Walton	N.D.Ap.	The economics of the two-queen and single-queen systems of colony management.
1972	H. H. G. Ryan	N.D.H.	Trees and shrubs suitable for street planting in Palmerston North and problems associated therewith.

Theses presented at Universities
(Taken from 1973 university calendars)

M. Barthelmeh	Tinwald domain landscape development. Dip. L.A. (Linc.)
Chai, T.B.	"Physiological and breeding studies using tomato varieties and their derivatives". Ph.D. (Mass.)
G. H. Densem	Suburban Christchurch proposals for a residential subdivision. Dip. L. A. (Linc.)
T. C. Emmitt	Tekapo. An appraisal of the region with specific emphasis on planning of the domain. Dip. L.A. (Linc.)
R. C. Goldsborough	Endogenous gibberellin-like substances in relation to short day induced flowering in the strawberry variety. "Cambridge Favourate". M.Hort. Sc. (Linc.)
Hor, Yue Luan	"Some aspects of seed infection and control of the collar-rot complex of peas (Pisum sativum L.) caused by *Mycosphaerella pinodes* (Berk and Blox). Verstegv, *Phoma Medicaginis* var. pinodella (Jones) Borema, and *Ascochyta pisi* Lib". Ph. D. (Mass.)
C. P. Irwin	The Germination of seeds Ph.d. (Waik.)
D. J. Lucas	Sandy Joint Domain, Invercargill. Dip. L.A.(Linc.)
D. H. Menzies	Recreation in Makara, A study of the recreation potential of Makara Ward, Wellington, N.Z. Dip. L.A. (Linc.)
C. T. Mortlock	A preliminary investigation of the diseases of willow (Salix spp.) M.Ag.Sc. (Linc.)
Ng, A. T.	"A study of the floral morphology of Alectryon Excelsum Gaertn (Sapindaceae". M.Sc. (Vic.)
P. D. King	Studies on the toxicity of insecticides to the light brown apple moth. Epiphyas Postuittana Walker. (Lepidoptera Tortricidae). M.Hort. Sc. (Linc.)
P. Rough	An examination of the landscape local to Wanaka with particular reference to the development of Pembroke Park. Dip. L.A.(Linc.)
E. G. Sage	Cheviot Hills. The development of a landscape past, present and future. Dip. L.A. (Linc.)
T. Shein	Studies on the effects of hormones and their interactions on apical dominance of dwarf bean. M. Hort. Sc (Linc.)
P.E. Smale	Distribution of carbon assimilates in tomatoes.
M. Vickers	Chemistry "Studies of Early Reactions Occurring in Germinating Sinapsis Alba Seeds". M.Sc. (Vic.)

Key: Mass.—Massey University; Linc.—Lincoln College; Waik.—Waikato University; Vic.—Victoria University

N.B. N.D.H. theses are now being held at Lincoln College library. If you have a spare copy you wish to donate or can lend one (permanently!) to help future students, please send it to the Editor (Act.).